Chapter 2
Academic Organization and Scientific Productivity

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Abstract The chapter is an attempt to trace those features of Ben-David's work that appear attractive from a structural—or science propagation—point of view and are pertinent for an understanding of the systemic aspects of higher education. This tracing of Ben-David's corpus of ideas has an economic bent: it covers adaptation and science diffusion-diversification processes, science cultures as well as issues pertaining to effectiveness and survival, and it might serve as a sketch for a—as yet to develop—reinterpretation of Ben-David's sociology of science.

Early in his academic career Ben-David published a sociology of science paper that was to foreshadow his major research orientation (Ben-David 1960b). This paper followed his initial explorations into sociological concepts of professions, social structure, class and role, and it related organizational aspects of academia to its productivity. Ben-David addressed this relationship with the conceptual apparatus and the tools of the social scientist steeped in history and sociology, but it is clear that he also addressed a central economic question. In the following, I shall introduce the major tenets of his system of thought—and the major aspects this anthology is, directly or indirectly, dealing with. In doing so, I shall try to follow Ben-David's own historiographic path to explain the system, with occasional excursions into philosophy of science, economics, and the management sciences.

Diffusion, Role-Hybridization, and Diversification

If one looks at the growth of science, one may distinguish a number of phenomena. Starting with the industrialization in the late 18th century, there was a manifest need for professionals in technical fields (mining, civil engineering, mechanical engineering, *génie rurale*, surveying, architecture, etc.). These professionals were to be educated and trained in newly established poly-technical schools and *Bergakademien*

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and, in the 19th century, in *technischen Hochschulen* and institutes of technology. Parallel to this development, there was also a demand for an educated class beyond the clergy (law, philology and philosophy, medicine, etc.) to fill positions in public administration or service, industry, and educational institutions, and existing universities broadened their curricula, or new institutions of higher education were founded.[1] This was the actual start of the growth of higher education around 1800.

Ben-David tied the initial ignition of growth in science to the emergence of a new role, that of the scientist. He used the concept of role, and the role of the scientist,[2] to explain the emergence and partially the growth of modern science. Role is an early notion of Ben-David to concentrate on: he used it in his initial studies on medicine (Ben-David 1958, 1960a), the concept was an outgrowth of his earlier studies of professions (Ben-David 1955, 1956, 1957, 1958a), and role was accompanied by a professional ethos. In looking at science as a profession, the 'role' of the scientist was linked to other sociological concepts like recognition, status, stratification, position, et cetera.

Scientific growth manifested itself by a number of related—co-evolutionary—developments:

- the geographic diffusion, propagation and dispersion of science, i.e., the growth in the number of higher education institutions and an associated growth in the number of faculty positions, or enrollments of students, in given fields;
- the disciplinary differentiation and diversification, and the growth in the number academic—disciplinary—fields (see also pp. 197f).

In the 19th century, this evolution was particularly fertile in the cultural sphere embracing Prussia and the Austrian-Hungarian Empire for a range of reasons which Joseph Ben-David had pointed out: professional development tied to polytechnic institutions and other schools found a complement in the new research orientation of universities; the institute, the laboratory, became the sustaining locus of research in the natural sciences; and regional competition fostered the geographic diffusion of research and the formation of new academic foci or disciplines. In fact, the German university[3] of the 19th century became the role model, the ideal-type, to be emulated (Schwinges 2001).

[1] I do not distinguish here between the various 'layers' or 'orientations' of higher education, that is, between professional schools on the one side and universities on the other, a distinction with fuzzy boundaries that has persisted until now.

[2] In what follows, I shall use the concept of 'scientist' in a loose way, unless I specifically depart from this convention. Under scientist I understand the person who does science (primarily, but not exclusively, in a formalized research setting, e.g. a university), irrespective of the merit that is attributed to this activity—and irrespective of the perception whether said activity does in fact conform to scientific standards as defined by this or that party. My notion of science embraces not only the natural sciences but also various professions (e.g. law, medicine, engineering), the social sciences (including the humanities), as well as the sciences of the artificial (e.g. mathematics, computer languages, theoretical operations research).

[3] When we talk of the 'German' university, we talk of a ahistorical generalization of a university concept that we associate, today, with Wilhelm von Humboldt (1964a), one of the founders of

Diffusion and diversification were linked in an overlapping two-step process. Once an academic field was created with a corresponding scholarly following and associated academic chairs or faculty positions, the field diffused to institutions (and nations) where such chairs had to be established. The diffusion process slowed down—or even came to a temporary halt—when there were no higher education institutions left without corresponding open positions. The slowing down of the diffusion process, in Ben-David's notion, fostered a diversification process that he linked to 'hybridization' in two varieties: role-hybridization and idea-hybridization. Once new hybrids of scientific fields were established, the process of diffusion could start *de novo*.

Ben-David's notion of the diffusion and diversification of scientific disciplines was developed on the basis of two new sciences, bacteriology (developed by Louis Pasteur and others, in the 1850s and 1860s) and psychoanalysis (initiated by Sigmund Freud and others in the 1880s and 1890s)[4] (Ben-David 1960a). In both cases, he reasoned, the particular impulse to develop a new avenue of investigation and to innovate was initiated by 'outsiders' of the scientific establishment, that is, by practitioner-scientists interested more in curing illness, more in solving practical problems, rather than in furthering the scientifically accepted ways of their time. In doing so, both Pasteur and Freud gave up the established role of the career scientist, perhaps involuntarily, to assume a new role that fused their old orientation to achieve new aims: they applied their old role—"exact observation and isolation of factors through experimentation or clinical reasoning"—to the new role of practitioner and innovator (Ben-David 1960a, 566). Ben-David called this move role-hybridization.

Ben-David, as a sociologist, places great weight on the motive to change a role to explain role-hybridization: "Freud attempted to maintain his status by trying to raise medical practice into a form of scientific research, and as a result created psychoanalysis. Similarly, Pasteur gave raise to bacteriology by maintaining his theoretical perspectives after moving into research on wine fermentation, and elaborated his discovery into a new speciality" (Ben-David and Collins 1966, 459f). The general underlying idea of role-hybridization, and to "raise status [...] through [...] innovation", is described in the following (Ben-David and Collins 1966, 460):

> "Mobility of scholars from one field to another will occur when the chances of success (i.e., getting recognition, gaining a full chair at a relatively early age, making an outstanding contribution) in one discipline are poor, often as a result of overcrowding in a field in which

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the University of Berlin (1809). This concept of the university, rooted in various implicit rules and regulations (March et al. 2000), or in a specific culture, affected research universities in the German speaking regions or neighboring countries of the 19th century (or, in today's terms, in Eastern Europe, Germany, Scandinavia, Holland, Belgium, and Switzerland).

[4]In reference to what I had said in footnote 2, we should note here that Karl R. Popper (1962, 33–38) regarded psychoanalysis, in the context of his demarcation of the sciences, as a classic non-science because it was not falsifiable. Ben-David (1960a, 564) himself was not taken aback by various attacks on Freud: "There was a great deal of non-scientific elements in Freud's thinking [...]; "prophetic overtones were not that unusual among nineteenth-century scientists, and—at least in the early writings of Freud—they are not difficult to separate from the scientific elements of his work".

> the number of positions is stable. In such cases, many scholars will be likely to move into any related fields in which the conditions of competition are better. In some cases, this will mean that they move into a field with a standing relatively lower than their original field".

Furthermore,

> "[...] the chances of [...] major innovation occurring in a discipline into which there is mobility from a high-status discipline are considerably greater than in a discipline into which there is no such mobility, or which stands higher in status than the discipline from which mobility takes place".

In other words, Ben-David makes three claims: first, scholars leave their original discipline to find a new role in an associated field if the conditions for career advancement in the old field are constrained and the corresponding prospects in an associated—new—field appear better; second, innovation is often a byproduct of role-hybridization and is used to raise status; and third, new fields profit the most when their progenitors originate from a high-status discipline.

While Ben-David sees in role-hybridization the primary motor behind disciplinary diversification, he sees in idea-hybridization, i.e. "the combination of ideas taken from different fields into a new intellectual synthesis", a similar force.[5] This force, in Ben-David's reasoning, "does not attempt to bring about a new academic or professional role, nor does it generally give rise to a coherent and sustained movement with a permanent tradition". But the two forces, role-hybridization and idea-hybridization, can be seen to be linked: in the words of Gad Freudenthal (1987, 138), "role hybridization gave rise to [a] corresponding 'idea hybridization' ".

It is unclear to what extent Ben-David's distinction of role-hybridization and idea-representation needs to be maintained, and Ben-David's exposition—or model—of the diffusion and disciplinary diversification of science, one of his major contribution in his *œvre* from my point of view, does not hinge on his concept of role-hybridization (nor on the three claims mentioned above).[6] Role-hybridization is clearly not the only reason why scholars trained and acculturated in one field will create—or move into—another; furthermore, it cannot be considered as the dominant reason to initiate a paradigm change.[7]

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[5]We would call these forces, today, cross-disciplinary or trans-disciplinary.

[6]In his later monograph on 'role', Ben-David (1984/1971) appears to have abandoned the use of the concepts—or the terms—of role-hybridization and idea-hybridization (the terms are not listed in the index).

[7]In the case of Albert Einstein, one can speculate as to whether he would have produced his major papers had he not been forced to leave the university (ETHZ) to assume a position of relative low prestige at the patent office (*Patentamt*) in Bern. The case of Ludwik Fleck, as Freudenthal and Löwy (1988) show, appears to confirm Ben-David's notion in that particular case. But there are many instances where scholars have produced idea-hybridization in the past without role-hybridization—or, at least, without the particular motive that Ben-David claims to induce role-hybridization.

Center, Periphery, and Diversification of German Science

Following the reasoning of Joseph Ben-David,[8] sketched above, scientific growth is attributable to two major currents: disciplinary diffusion, and disciplinary diversification. Diffusion is regulated by rules that specify the particular roles of scientists as well as the creation and succession of scientific positions. Diversification, in turn, is regulated by a disciplinary specialization and hybridization process.

In his historiographic studies regarding Germany of the 19th century, Ben-David observed that diffusion as well as diversification of scientific activities took place, thus establishing Germany as the world center of science (Ben-David and Zloczower 1991/1962; Ben-David 1977a). German science was in a position to expand, to grow. Diffusion was not only regulated by the adopted rules, it was specifically fostered by those. The rule, for instance, to have each discipline at a given institution represented by one single chair-holder (and head of an institute) forced young scholars (*Habilitierte*) to look for new turf.[9] They had to move to an institution where the corresponding discipline was not yet established (or where the position of the incumbent was to be vacated).[10] The root of this rule lies in the specific social contract that bound universities to the state (*Länder*); the social contract, in turn, is based on the *Allgemeines Landrecht* of the 18th century—see Paulsen (1902, 88). The social contract that regulated the interplay of universities and state stipulated that the university was autonomous with regard to teaching and to the research of those who were members of the corporation of scholars, but that appointments of faculty were the domain of the state.[11] In this way the state assured that the university that was under its jurisdiction was paying attention to the spectrum of sciences that the state thought necessary. It was also a safeguard against inbreeding or aloofness of the community of scholars. Other rules, such as the unity of teaching and research, or role conceptions or norms that were directly linked to the status of faculty members, unique in a sense to the German system, can be seen as a co-requisites that worked to foster diffusion and diversification (Schwinges 2007).

Rules, regulations and cultural norms, together with the decentralized state structure that was characteristic of the German university, and the ensuing competition among the various *Länder* and states, were directly responsible for the disciplinary diffusion and, in due course, also for the disciplinary diversification.[12] The particu-

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[8]And, in particular, of two of his associates and co-authors, Randall Collins and Awraham Zloczower.

[9]I call this the "ecological argument" of Ben-David; see p. 198.

[10]In the case of a vacated position, the new chair-holder was called the *Nachfolger* (successor) of the Emeritus. In this way, lineages of chair-holders could be drawn (like those of royalty). The term *Nachfolger* is still in use today.

[11]In the case of appointments of successors of existing chairs, the faculty had the right to suggest three candidates (but the state was not obligated to limit its search to those suggested); in the case of positions that were to be created *de novo*, the corporation of scholars (limited to the ranks of full professors [*Ordinariate*]) was not involved in the decision at all (Paulsen 1902, 95–102).

[12]The diffusion of German science was not accidental or unintended. In his petition to found the new University of Berlin, Wilhelm von Humboldt (1964a, 30) claims that, in contrast to technical

lar orientation of the German—Humboldtian—university and the extended cultural sphere in the 19th century placed German universities in a position of comparative advantage *vis-à-vis* French and British universities[13]: French higher education institutions were primarily concentrated in Paris, and in Britain the old, established colleges dominated. In contrast to the situation in France and Britain, German institutions of the periphery profited from the center, in that the provincial universities where in a position to attract young faculty educated at major German universities; and the center profited from the periphery in that German universities were in a position to appoint faculty who had served in the "waiting room" of provincial universities (Ben-David 1991b, 66).

This comparative advantage of German science fizzled out with the beginning of the 20th century. The specific rules, regulations and cultures which had fostered scientific growth throughout the 19th century started to have the opposite effect. They had become, in the words of Ben-David and Zloczower (1962), a "strangling noose". To understand this 'strangling' effect, one has to bring to mind the original fostering force: (i) the diffusion of disciplinary orientations, brought about by the rule that, at any given institution, one field was represented by a single chair[14] (and aspiring scholars had to look for corresponding positions elsewhere); and (ii) disciplinary diversification which took hold after crowding effects in an established field became pronounced (whereupon aspiring scholars founded or moved to a new field). This two-legged force, diffusion followed by diversification, started to reach a ceiling when growth was eventually constrained by funding (or the willingness to fund).

Because laboratories or institutes were run by (or subordinate to) chair-holders, and because the successful laboratories were large (and expensive),[15] the funding of new chairs—particularly in the experimental sciences—would eventually become difficult. This constrained diversification and the "sellers market" of the 19th century, as Ben-David (1984/1971, 123) called it, came to an end. The funding of new individual chairs had become expensive; and there were not enough resources around to continue to fund the system in the manner it had been funded in the past. In short, "the competitive mechanism which had previously ensured the

(special) schools or high-schools (*Gymnasien*), "only universities are in a position to exert influence across the borders, and to affect education and formation in regions where the same language [i.e. German] is being spoken" (my translation). In particular, von Humboldt also voiced the advantage to attract foreigners.

[13]Paulsen (1902, 210) cites Lot (1892, 30) who speaks of a "scientific hegemony of Germany in all fields", and of "the fact that Germany alone produces more [research] than the rest of the world together" (my translation).

[14]Ben-David (1984/1971, 139) observes that the prevailing culture "encouraged professors in experimental sciences to regard their respective fields as personal domains". But in fact, the rule held in almost all fields, with the exception perhaps of mathematics and theoretical physics.

[15]"Toward the end of the century the laboratories of some of the professors became so famous that the ablest students from all over the world went there for varying periods of time. The list of students who worked in such places often included practically all the important scientists of the next generation" (Ben-David 1984/1971, 123).

prevalence of purely scientific considerations in the establishment of new fields was impaired". Where growth occurred within a relatively stable system of chairs, it "led only to a swelling of the ranks of assistants" (Ben-David 1984/1971, 131).[16] Growth based on the described two-legged force was still possible in relatively inexpensive fields, such as mathematics and (theoretical) physics (these were the times before CERN or similar installations of high energy physics), and it was in these fields that German science retained a relatively dominant position that was to last until about 1933.[17] To cope with the expanding costs of research in the laboratory-intensive natural sciences, and in response to the new American competition, the "Kaiser-Wilhelm-Institutes"—i.e. non-university research institutes—were formed in 1911.[18] With this move, the old Humboldtian ideal of the unity of teaching and research, still upheld today in the American universities, was left behind.

We are now in a position to summarize Ben-David's concept of scientific growth. Growth started with the institutionalization of the scientist's role and the transformation of a pre-modern science into a modern science around the time of the end of the *ancien régime* (or the founding of the University of Berlin in 1809). After the first third of the 19th century, German science was in a particular position to diffuse and subsequently to diversify, after which the process of diffusion and diversification could start again. The diffusion-diversification process was active throughout the entire 19th century and brought German science into a hegemonic position. The end of this process at the beginning of the 20th century was self-inflicted. The same rules, regulations and cultures which were responsible for the unprecedented growth of German science brought science of this sphere into—comparatively speaking—a state of stagnation (where it practically has remained ever since).[19]

[16] This is still the situation as we find it today. The swelling of the ranks of assistants has found a counterpart in the swelling of the ranks of students (Herbst et al. 2002).

[17] Because mathematics has subdivided and specialized early and does not require large ranks of assistants, mathematics flourished (and still flourishes) in countries like France, Great Britain, Russia, Hungary, et cetera with a mathematical culture and tradition.

[18] Now "Max-Planck-Institutes". Prior to 1911, the *Physikalisch-Technische Reichsanstalt* was founded in 1887 in Berlin-Charlottenburg, but this Institute was conceived to adopt a service function to unify measurement standards, not a research function.

[19] Ben-David ties this stagnation to the organization of German higher education, and to the specific 'feudal' form of its setup. He writes, "It is doubtful [...] that academic self-government contributed positively to the adaptability of the German system" (Ben-David 1984/1971, 120); furthermore, "[r]ather than change their structure so as to be able to take full advantage of the expanding opportunities, the universities adopted a deflationary policy of restricting the growth of new fields and the differentiation of old ones. Although the number of students and staff increased, and although there was an even greater increase in the expenditure of the universities because of the steeply growing expense of research, no modifications were made in the organization of the university" (*op. cit*, p. 129).

Diversification, Departmental Structure, and Anglo-American Science

Thus far we have concentrated on German science which had occupied a central place throughout most of the 19th century. German science, as Joseph Ben-David reasoned, entered a state of relative stagnation before World War I and definitely before 1933. The main competing spheres of German science at the beginning of the 20th century were those of Britain and the US: Britain had a range of well established universities that continued to be attractive and that had served, together with the German university, as role models for the newly established graduate schools which were starting to be founded in the US in the last 30 years of the 19th century.[20] Because US higher education and science were underdeveloped, a fair number of American students and scholars had been attracted to German universities to pursue training or advanced studies.[21] Upon returning to their homeland, they attempted to emulate the German university, at least insofar as they were able to exert influence on their own institutions, but this emulation proved to be imperfect. The college system imported from Britain was retained and fused with the newly formed graduate school introduced from Germany. In fusing the British with the German system of higher education institutions, the old British influenced college as well as the associated departmental system were kept, and the German chair system was not adopted.

By 1870, the time the first graduate schools were formed in America, US science was very far behind the development of German science. But the subsequent spurt in higher education during the years of the Gilded Age, funneled by a rapid industrialization and urbanization that was to spread across the continent, was impressive indeed. As in Germany before, US higher education and science were in a position to expand, to grow. Colleges were founded, existing colleges consolidated or upgraded into universities, universities and institutes of technologies were formed, standards of education and scholarship raised, and professional organization established. By the time of World War I, Anglo-American higher eduction and science had become a serious contender to German's dominating role in science.

The exact dating of the period during which the baton of the leading science nation was handed over to the US is not important in the present context. Important is Ben-David's observation that US science was in a position to expand and to grow continuously, without subsequently falling into stagnation. This ability to grow is attributed by Ben-David to the specific setup of the US university, public or private, and in particular to its departmental structure. It appears evident that the departmental structure, as opposed to the German chair system, formed a necessary condition for the ability of the US higher education and science system to expand, but it was not sufficient. A range of other factors was necessary as well.

[20] Harvard University founded its Graduate School of Arts and Sciences in 1872; Johns Hopkins University, the first fully fledged new university with a graduate school, was founded in 1876.

[21] See e.g. Schwinges (2001), and in particular Turner (2001).

One of the basic factors that distinguished the US university from its German counterpart was its autonomy that extended beyond the three established 'freedoms'—the freedom to learn, the freedom to teach, and the freedom to do research—with implications regarding governance, management, staff and personnel recruitment, funding, and the admission of students.[22] The exercise of these extended freedoms, plus an early notion that teaching implied a close interaction of teacher and student, brought about a higher education system that differed markedly from that of the German university. Institutional diversity became pronounced, and decent faculty-student ratios were the norm. Hence, once the US research university entered the scene around 1870, diffusion of the research university concept was associated, practically from the beginning, with a disciplinary diversity as well as an institutional diversity, both of which were in a position to develop in parallel, in a permeable system of higher education. Compared to the German university this new system of higher education turned out to be far less constricting as far as the growth of science was concerned.

The fate of German science was not shared by American science. Indeed, US science had laid the groundwork in the later portions of the 19th century through its formation of research universities, molded as they were on the German model, but fused with the idea of the British college. US, like German, higher education spread by the first two processes indicated above (p. 16f), but it did not experience the constraining, strangling effect implicit in the German development. US higher education developed into a diversified system (Clark 1997; Trow 1997), with few but highly successful research universities.[23] These research universities, like all universities in the US, held onto their early teaching orientation in their organizational setup, and they retained—from their inception in the late 19th century until today—decent, practically non-varying, faculty-student ratios. The implication was that the US research university was not replicating the internal structure of the German university nor the status and role of the German professor. It opted quite naturally for a collegial, departmental structure (which did not have to obey the rule of one field, one faculty member). Ironically, perhaps a century later, the initial teaching orientation of US institutions proved decisive with regard to their research productivity (Herbst 2004).

[22]The fourth freedom, initiated through the decision of the US Supreme Court Justice Felix Frankfurter in 1957 (in the Sweezy vs. New Hampshire case), namely the freedom of a university to select "who may be admitted to study", was not that important in the 19th century, and it may have had the effect of a *numerus clausus* used to exclude Jews who where highly overrepresented at the universities of that time (Paulsen 1902, 195f), at least in the German context. Frankfurther's edict became constructive in light of the various anti-discrimination laws. See in this respect also Oren (2000) and Karabel (2005).

[23]Research universities in the US constitute only roughly 2–3 % of all tertiary education institutions. In addition, there are selective undergraduate institutions, or colleges. In contrast, almost all universities in Europe aspire to be research universities, but fail to reach the necessary effectiveness.

The Missing Link

Ben-David had observed that the center of science had moved from Europe to the US, and it has remained there ever since.[24] In order to reflect on this, I shall try to spell out factors (beyond the forces that were already mentioned) that may be seen to have brought about and sustain this situation.

I shall start with the sustaining forces within Europe. The prospects are that we cannot expect a basic change in European science or higher education policies in the near future, but in order to assess such an observation we may speculate about its underlying cause. European nations, or Europe as such, may have learned that it does not pay to be first in science. While it was difficult to regain the coveted position of the premier science region of the world after World War II, this now emerges as a goal not worth pursuing. Europe seems quite content playing a second fiddle, in spite of all the declarations of the various commissions of the European Union (see pp. 203f). It appears more important to retain historically grown academic cultures than to adapt those to improve productivity or proficiency.[25]

Economic growth and prosperity are said to be linked to science (and higher education) in the form of a "linear model" (Hands 2001, 364): science → technology → improved or new products → social benefits or prosperity (or: higher education → knowhow → entrepreneurship and inventions → social benefits or prosperity). However, science, it appears, is not directly tied to prosperity. The relation between scientific development on the one hand and economic well-being or prosperity on the other is rather tenuous.[26] There are regions that profit from the existence of strong universities (Saxenian 1994; Moscovitch et al. 1997). In Israel, and perhaps also in Singapore and Switzerland, there are conscious and largely successful policies designed to link science and higher education on the one hand and economic development on the other. However, an *avant-garde* in scientific development, a center of science in Ben-David's terms, cannot easily be translated into socio-economic advantages. Indeed, because the relationship is tenuous, it may pay to jump on the bandwagon and play a second fiddle: the center invests and explores, and because information, findings or know-how travel that easily, because information is a non-rivaled—public—good, the periphery may be in a position to cash in on the development and the insight of others.[27]

[24]This observation is in large measures undisputed by leading scholars and major institutional rankings; see e.g.: Da Pozzo et al. (2001), CEST (2002, 2004), www.leidenranking.com and www.scimagoir.com.

[25]See footnote 19.

[26]Prosperity is the result of various factors and related to a range of layers of educational achievement within a society. Higher education forms just one of these layers, and scholars and scientists are a mere subset of people associated with higher education. Germany's present relative economic success does not appear to be related to its relatively week science achievement, and Britain's week economic performance does not appear to be related to the relatively strong performance of its major universities.

[27]A rigorous privatization program for information (and associated extended patenting practices) would do more harm than good: it would greatly stifle economic development.

Next, I should like to address the question of why it appears that the departmental structure and the diversified nature of the US university has become instrumental in fostering productivity—or 'progress'. Progress, in the notion of Philip Kitcher (1993, Chaps. 4 and 5), is linked to content: to some form of 'truth'; to the idea that scientific theories evolve so that the more recent versions have generally more explanatory power than those that came to be replaced; and that newer theories tend to incorporate older forms as special cases. Truth, in this reading, need not refer to a matching of some external phenomenon and corresponding explanatory, descriptive theories; the search for truth need not be confined to the natural sciences. Truth may also relate to problem solving, to engineering or the sciences of the artificial. In that case, truth can easily be conceptualized and tested[28]; and in a practical sense, truth may also refer to a good portion of the social sciences and the humanities.[29]

I should like to continue the discussion on Kitcher's notion of progress, because it has bearing on our review of Ben-David's ideas but, for brevity in this introductory note, I need to abandon the focus on content. Instead, I shall dwell on proxies of content, namely on scientometric indicators, knowing, of course, that a replacement of content by indicators is, at best, a crude approximation. A more elaborate, i.e. economically or structurally operationalized handling of the link that ties progress to content might actually call for an entirely new line of research.[30] Kitcher pursues an inquiry which is central to Ben-David's legacy, namely the organization of cognitive labor (Kitcher 1993, Chap. 8). In this context, Kitcher raises questions regarding the role and function of authority, cooperation, entrepreneurship, prestige and credit, and regarding their effects on innovation and progress. He reasons

> "[. . .] that there are advantages for a scientific community in cognitive diversity. Intuitively, a community that is prepared to hedge its bets when a situation is unclear is likely to do better than a community that moves quickly to a state of uniform opinion" (p. 344).

And, in a different section within his treatise, he observes that

> "[s]ometimes in the history of science, fields split, merge, or give birth to hybrid progeny" (p. 91).

In other words, Kitcher's notion of progress and Ben-David's idea of growth are related, and they are both tied to scientific—or cognitive—diversity: diversity breeds growth or progress.

Both Ben-David and Kitcher maintain that diversity can be seen as a necessary condition for scientific growth or progress. Furthermore, various aspects native to the US science and higher education system appear to serve this end[31]: a diver-

[28] In the way engineering can conceptualize or test the load bearing of a bridge, or theoretical operations research can conceptualize or test the efficiency of an algorithm. Beware, however, that a test is never final: the notion, in antiquity, of a flat world was in line with tests available and did not contradict experience.

[29] Namely to those parts that can reasonably be conceptualized—or operationalized—and tested.

[30] Indeed, this entire anthology can be understood as such a call.

[31] Tendencies come into view that work against this 'native' tradition, with possibly deleterious effects which need not be spelled out here.

sified higher education system with relatively few, but effective, research-oriented universities; the departmental structure and the collegial culture on which research universities are based; the funding of scientists, rather than institutions, for research work (see Chap. 8); the substantial autonomy of institutions or institutional systems; the freedom to recruit and select, and an associated culture to include and serve, students, rather than to screen them out to protect standards; decent faculty-student ratios (and, by implication, also decent faculty-staff ratios); implicit policies guarding against an overpopulation of PhD's (and an associated lowering of academic standards), including the spread of signaling effects; et cetera. Hence, it can be hypothesized that what we have termed the 'native' aspects of US higher education and science[32] does serve diversity, and that diversity in turn serves growth and progress.

A broadened sociology of science, an economically or structurally operationalized system of theories, linking science institutions with scientific growth or progress, as alluded to above, has yet to be developed. But major elements of such a system of theories do exist in the works of classical sociology of science or the economic investigations on research and development. Economic issues regarding science cover a number of foci which could be dealt with here,[33] and they cover roughly three domains that pertain to (i) the individual researchers, (ii) research institutions or institutional systems, and (iii) societies or nations of which higher education or research systems are part. Not all these aspects appear equally relevant in the context of a reflection on Ben-David's research, and I shall concentrate my focus on the second domain, with only occasional forays into the first and the third.

Productivity Issues

The general focus of research which is loosely covered by an economics of science does not concentrate on the domain that is in focus here. My anecdotal impression is that most research pertains to domains (i) and (iii), and the domain (ii) is the leased researched. With regard to issues within (i), there are many studies covering the interplay between the research productivity of scholars and individual attributes like age, life cycle, gender, motherhood, ethnicity, and basic training, most of which have only scant systemic impact. Furthermore, many links between research productivity and attributes of individuals are pretty much self-evident. A good basic training early on in life translates into a decent research productivity later on, motherhood (or heavy teaching loads) may reduce research volume but not necessarily the quality

[32]To be found also, at least partially, in select non-US institutions or institutional systems.

[33]Paula E. Stephan (2012) refers e.g. to incentives and reward systems, to competition, to inequality, to academic salaries, to the relationship of salaries and productivity, to financial fruits of inventive activity, to patenting, to start-up companies, to the cost of equipment and infrastructure, to the support from industry, to nonprofit foundations, to self-funding, to fund allocation systems, to the educational market, to earnings of graduates, to the relationship between science and economic growth, and so on, and there are a host of publications which deal with each of these individual areas of interest.

of research, vital results in mathematics or physics are normally obtained during the early stages of a scientific career, et cetera.[34]

The other domain where one can observe relatively heavy research activity is the third. Here, studies link the *Zeitgeist* with research output: the Cold War with the heavy US federal support for basic and applied sciences; science funding, public or private, with economic prosperity; public support for higher education with achievements in science; the interlinking of higher education and society with progress or knowledge production; et cetera. Many of these studies are more or less historiographic, but their focus is on economies—or on policy sciences.[35] Other inquiries are of an econometric nature, linking input (manpower and capital) with output (patents, publications, citations). Exemplary in this respect are those of Zwi Griliches (and his associates). However, not all of these treatises are without their pitfalls, and some are easily misleading. There is a range of studies by international organizations that fall into this category in which nations are compared on the basis of a broad spectrum of indicators pertaining to educational achievement or research performance.[36]

Focusing on the second of the three domains mentioned above, I shall concentrate on a number of theses and associated corollaries. While organization concepts have been around for some time, economics started to look into the black box of organizations with the advent of the theory of games (von Neumann and Morgenstern) and the theory of communications (Wiener and Shannon). Early in the 1950s, Jakob Marschak (1955) and Roy Radner (1955) postulated elements of a theory of teams that were subsequently expanded (Marschak 1957; Marschak and Radner

[34]In an unpublished paper (Herbst 2000) I had claimed that gender equality in higher education is indicative of quality in higher education in general: quality implies equality, and equality implies quality (that is, gender issues have a systemic dimension). My argument here is that although gender issues have a systemic dimension, their impact (on institutional performance) is relatively difficult to measure. My own hunch is that as long as gender equality is not really implemented and 'lived' in an institution, the research environment—its setup, and governing or management structure (discussed as part of the second domain)—is suboptimal for everyone (i.e. not only for women).

[35]See in this respect also Burton Clark's concept of a "Triangle of Coordination" regarding state authority, market, and academic oligarchy (Clark 1983, Chap. 5) or Etzkowitz' and Leydesdorff's "Triple Helix" concept of university-industry-government relations (Etzkowitz and Leydesdorff 1997). Gibbons et al. (1994) postulated even a new mode of science ("Mode 2"). It is true that higher education has changed dramatically during the past decades (this is why Martin Trow is a co-author in Gibbons' book); but the claim that science moved from a Mode 1 to a Mode 2, i.e. from an academically and disciplinary focused science to a more practice-oriented, commercial, context-driven and trans-disciplinary oriented endeavor, is not only bold but perhaps also oversimplified: it appears that both modes were present—and interlinked—in modern times (see also Chaps. 4 and 5).

[36]The drawback of these studies is that the link to the institutions or the institutional systems get lost (or that normalization was performed in an inappropriate way) and that they compare averages that pertain to nations of grossly dissimilar weight, where the small countries (e.g. the Scandinavian nations, Israel, Switzerland) are likely to show up comparatively well. If one were to compare small countries with regions within the US, e.g. with California or the Boston metropolitan area, the results of such comparisons would most likely be very different.

1958a,b, 1959). This theory was to look at various members or 'agents' of a 'team' (e.g. a firm, an organization) who had different tasks (or roles to play) but worked for a common goal; and it was meant to suggest optimal informational structures when knowledge and decision-making powers were unevenly dispersed among team members (Arrow 1985). In the 1970s and 1980s, team theory was further developed in the context of systems or control theory (Basar and Bansal 1989).

The idea to look into the black box of organizations was quickly absorbed in a Germany concerned with *Wiederaufbau* and the reformation of its research apparatus (Krauch 2006).[37] However the focus there, following Marschak, was not on abstract firms or organizations but on the work of scientists (Bahrdt et al. 1960). Research was portrayed as 'work' that had passed historically through different stages[38]: the stage where research was basically produced by the individual researcher; the stage of a hierarchically organized and laboratory based research that was characterized by a division of labor (in the sense of a manufactory); and eventually the stage where research was to be collaborative, inter-disciplinary, and team based.[39]

Bahrdt et al. (1960) saw modern society as being confronted with many complex problems of vital importance, and they were looking for organizational forms within which such problems could be addressed. The sciences themselves diversified to address new problems (atomic energy and space technologies, operations research and management sciences, technological forecasting and assessment, environmental sciences, cybernetics, general systems theory, et cetera),[40] but the framework within which the problems were to be addressed remained untouched. They argued against hierarchically (or bureaucratically) structured research groups that were frequently the norm at the time (at least in Germany), they decried the corresponding pseudo-feudal work arrangements which bound together student apprentices, research assistants and principal investigators (see Chap. 6), and they favored heterogeneity and inter-disciplinary approaches (or complementary expertise among researchers).

Horst Rittel (1965) followed the lead of Marschak to focus on the organizational *interna* of research groups and their associated embedding in the wider context. In Bahrdt et al. (1960, 27–32) he already listed various features of team work[41]: teams

[37]The reformation efforts were short-lived.

[38]The emphasis here is slightly different from that of Ben-David: whereas Ben-David tied (modern) science (and research) to the emergence of a new role (i.e. that of the scientist), research (and science) is tied here to the labor associated with that role. Bahrdt et al. (1960, 19) also perceive, following Max Weber, a certain parallelization between bureaucracy and research (or science), and they see close connections between the emergence of the modern state bureaucracy and the "emancipation" of European science (in Ben-David's sense).

[39]The ideas here were formulated before the notions of trans-disciplinarity became fashionable—and way before Gibbons et al. (1994) and the "Mode 2" concept.

[40]This was also a time when faith in progress, and the belief to rectify or solve societal problems through the use of science, was strong and firmly embedded in the community of scientists and politicians.

[41]This was formulated 60 years before the rise of social media like Facebook or Twitter.

are often more productive than the corresponding number of individuals combined; team judgement is frequently better than that of individuals; information is economically spread and fed back; inter-disciplinary teams profit from an extended toolbox which is at their disposal; teams engage naturally in organizational learning[42]; teams are subject to corrective social control and are usually more focused in their work than individuals; teams can more easily use and share scientific appliances and equipment; teams benefit from a collective power of imagination.

Rittel's list appears to pit the team concept against the work of individuals rather than against hierarchically organized research groups, but it was only meant to be a list of features propagating team work (historically the third stage of research work). Unfortunately, the research questions of decades past have remained pretty much in obscurity, in spite of their relevance today for higher education management and research funding.[43] In the following, I should like to take up this line of thought and to dwell on one aspect of group work that relates to productivity issues and, implicitly, to questions of scientific growth and progress (idea diversity, innovation, etc.).

Scale and Agglomeration Economies

Consider a research unit with associated input and output.[44] Two theses might be addressed: that research is characterized by (i) economies of scale and by (ii) agglomeration economies (Saxenian 1994; Cooke 2002; Fujita et al. 2001; Fujita and Thisse 2002). The first of these economies is present when larger units exhibit higher productivity than their smaller counterparts, and the second is present when a clustering of research units benefits individual units and enhances their productivity. Economies—or diseconomies—of scale are said to be associated with the micro levels of institutions, whereas agglomeration economies are seen to be tied to the meso or macro levels of the respective environment.

Research performance is dependent on a range of factors or circumstances pertaining to individuals or institutions. Such factors may differ depending on the aim of research. Applied research generally calls for working conditions that differ from those for 'pure' research or basic science; some research is dependent on large infrastructures; and crash programs similar to a "Manhattan Project" are altogether a different matter.

In the setting of a university, research takes place as an extended and intergenerational form of learning. Experienced scholars, faculty members, tutor junior

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[42]This is my 'modern' interpretation of what Rittel wrote under the titles of "Addition der Informationsfelder" and "Verbesserung der Lernfähigkeit".

[43]Rittel himself had abandoned this research line to deal with other aspects which were closer to his assigned tasks in Berkeley and Stuttgart (Rittel 1992; Protzen and Harris 2010).

[44]Under a research unit we can imagine an individual, a research team, an academic department, a university, a country, or a supra-national entity. In the present context, I shall confine my remarks to the levels of a research team, the academic department, or the university.

scholars, doctoral or post-doctoral students, and the learning takes place in a team (Ehrenberg and Kuh 2009). Advanced research never has the form of a simple know-how transfer in one direction, from teacher to student. All in the team profit from working together, junior and senior members. Junior members profit from the experience and guidance of their doctoral parent or senior research associates, they profit from interacting with each other, and senior members profit from the seeming naiveté and the unconventional, unmediated questions of junior members, or from their know-how in new technologies and their possibly different disciplinary backgrounds.

Inter-generational research is a native form for universities in that these are charged to educate and train future professionals, scholars and faculty members. But it appears not at all clear if that form of research is also the most proficient. Not all research cultures adhere to an inter-generational model centered in research universities. In some countries dedicated research institutes (DRI) are the locus of research, and universities are often seen primarily as training institutions. In such cultures, research institutes (DRI) or academies are meant to assemble the more experienced researchers. Dedicated research institutes are less encumbered by the burden of teaching and they work, by their design, with more mature professionals. But they are also likely to suffer from inherent subordination problems, restricting the autonomy and creativity of a good portion of researchers, and the constant inflow of fresh blood and turnover of talent is comparatively constrained.

The question which of the two models presented is better suited to foster research, the inter-generational model of the research university, or the intra-generational model of the dedicated research institute or academy, is difficult to answer. Obviously, the aims of research, pure or applied, and the type, 'big' or 'small', play a role. Furthermore, there is the question of the extent to which the two models are exclusive and to what degree, and under what circumstances, an overlap appears possible and advisable. In countries where the second model has (or had) some credence (in the USSR or Russia, in Germany, France or Italy), there is a certain tendency to link research institutes (e.g. CNRS or Max-Planck-Institutes) with universities, and in countries where the first model is prominent (US, UK, Israel, Switzerland) dedicated research institutes exist. Lastly, where research is 'big' and 'pure', a sharing of a science infra-structure (CERN, for instance) is common.

If the question regarding inter-generational (that is, university-based) versus intra-generational (i.e. academy or dedicated research-institute-based) research were insignificant, differences in research organization would not impact on research productivity, and the observed differences in research organization could be seen as stylistic, brought about by the different histories of nations and higher education or research systems. On the other hand, if differences of research productivity can be observed (National Research Council 1995; CEST 2002),[45] they might be attributable, in part at least, to the way higher education and research is organized (Herbst et al. 2002; Herbst 2004). If such a link is hypothesized, ways have to be

[45] See also footnote 24.

found to attribute differences in research productivity to the organization of research (Hurley 1997).

The remainder of this section shall focus on this question. Specifically, the role of economies of scale and agglomeration economies shall receive attention, and other factors, mentioned partially above, shall be ignored. The question shall be addressed as to what extent economies of scales and agglomeration economies are discernible. The question is relevant in a management context because research units have a size which is not regulated by 'natural' forces and only imperfectly regulated by market forces, and it is difficult to conceptualize 'optimality'. In fact, the forces that regulate and effect the size of research units—the appointment of faculty, tenure policies, grantsmanship, funding and ranking cultures, et cetera—are shaped by local mores and may have more to do with a guild system than with the fostering of research. Specifically, we shall focus on the following issues:

- economies of scale at the level of nuclear research groups;
- intra-departmental agglomeration economies;
- inter-departmental agglomeration economies as they pertain to the university as a whole.

There are only few studies that address these issues, but available data indicate that all three economies have their impact (National Research Council 1995; Ostriker et al. 2011). In light of these studies,[46] economies of scale at the level of nuclear research groups show an optimum which is generally reached with a group not exceeding 5–10 members[47]; larger groups tend to suffer from diseconomies.[48] Intra-departmental agglomeration economies are clearly visible for good sized departments, comprising roughly one to three dozen faculty members[49]; and inter-departmental agglomeration economies, as they pertain to the university as a whole, are visible as well: good departments profit from other good departments in various ways.

If one contrasts these findings with the picture of European, and specifically Humboldtian higher education institutions (Herbst et al. 2002; Herbst 2004, 2005, 2012), we obtain the following impression: US nuclear research groups tend to be smaller than research groups at corresponding European (i.e. Humboldtian) institutions[50]; US departments tend to be larger than their corresponding European counterparts[51]; and US research universities tend to play the role of an intellectual center

[46] Which refer to US research universities.

[47] Doctoral and post-doctoral students, plus the principal investigator. Optimal group size is dependent on the research field.

[48] Various factors are responsible for this phenomenon (Herbst et al. 2002). Larger groups may also have members who are 'active' as researchers, and those who are not, affecting (negatively) average output.

[49] That is the size that allows for proper inter-personal communication among faculty; smaller departments do not reach a critical mass; larger departments may profit from specialization and subdivision.

[50] Size of the group is defined by the number of researchers.

[51] Departmental size is defined by the number of principal investigators.

much more naturally.[52] The implication is that US institutions are characterized by higher research productivity[53] and by a higher thematic research diversity which is tied to growth (Ben-David) and progress (Kitcher).

That is the backdrop of the primary legacy of Ben-David yet to be developed: we need a sociology of science and higher education studies which address the link that ties the morphology of the institutions of science to their performance. A focus on research networks (see Chap. 9) ought to be seen as complementary to, not as a replacement for, such a course. In order to follow this path, it is necessary to develop a deeper understanding of the various science systems.[54] To negate Ben-David's seminal contributions to the study of science because of his purported antiquated views of science and society is shortsighted, as Ilana Löwy has pointed out (Chap. 4), and amounts to *das Kind mit den Bad ausschütten* ("empty the baby out with the bath water").

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[52]Larger research groups coupled with smaller departments (Scheme H) versus smaller research groups coupled with larger departments (Scheme D) are based (roughly) on the same number of researchers. One could claim, therefore, that the two setups are associated with the same research productivity (publications or citations per researchers, etc.). But this is not the case: diseconomies (associated with larger research groups) are coupled with reduced agglomeration economies (of smaller departments); and productivity advantages (associated with smaller research groups) are coupled with increased agglomeration economies (of larger departments and the greater diversification of the university). Hence, Scheme D tends to outperform Scheme H (Scheme D is portrayed here as the ideal-type of the US research university; but it can also be found in research universities of other nations, e.g. in Canada, the UK, and Israel).

[53]The notion of 'research productivity' needs to be operationalized properly. I have mentioned "publications or citations per researcher" as possible measures, but occasionally one finds also the measure "publications or citations per principal investigator", a possibly improper normalization in the context of research groups of unequal size, with misleading incentives in favor of large research groups.

[54]As Merton has already observed more than half a century before (see p. 192), there is a clear lack of research focusing on the workings of science and higher education systems, particularly in Europe. Introspective sciences, i.e. the sciences of science (meta-sciences), insofar as they would focus—in the tradition of Joseph Ben-David—on the working logic of science as a system, remain quite undeveloped. Few scientists show that focus, the corresponding scientific orientations are less quantitative and empirical than they could be, and current research has a tendency to dwell on (perhaps even irrelevant) details rather than on central aspects.

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