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# A national systems view of university entrepreneurialism: Inferences from comparison of the German and US experience

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ABSTRACT

Examining parallels in the long-term evolution of the German and US university systems, this paper formulates hypotheses about the rise and decline of university entrepreneurialism at the national level. Three macro-level antecedents of university entrepreneurialism are identified: (1) decentralized competition; (2) latitude in mission and revenue mix; (3) a nationwide, diversified bidding system for the funding of large-scale university-based research. Of these, the third is real lynchpin of university entrepreneurialism. Arguing for a multidimensional understanding of such entrepreneurialism (i.e. beyond just the commercialization of scientific discoveries), the paper identifies three developments within universities emanating from a favorable national environment: (1) organizational innovations for achieving economies of scope; (2) an institutionalized capacity for strategic selection of research foci; and (3) a capacity to contribute to the development of new industries. The analysis suggests that as national university systems grow and run into cost containment problems, political pressures for reform increase, leading to system homogenization; system homogenization weakens the contextual sources of entrepreneurialism and triggers a process of decline.



## 1. Introduction

The modern university represents an evolutionary paradox. Observed up close, most universities appear to be paragons of inertia: bureaucratic, inefficient, and much less flexible organizations than private sector firms. Yet from an evolutionary perspective, universities demonstrate remarkable longevity, with histories often extending back to the medieval or Renaissance era. While it may appear tempting to ascribe this to a stable environment, the environment in which universities operate is actually quite dynamic. Not only do universities have to contend with rapidly expanding frontiers of knowledge (Ben-David, 1977; Clark, 1993), but they also engage in an expanding array of tasks beyond teaching and research, including cooperation with industry, technology transfer, and new firm creation. This has given rise to an extensive, albeit heterogeneous body of research on the "entrepreneurial" university (Etzkowitz, 1983; Clark, 1998; Siegel et al., 2003; Lockett et al., 2005; Rothaermel et al., 2007).

This contribution addresses the following question: What are some of the basic drivers and characteristics of entrepreneurialism within national university *systems*? Departing from the usual focus on individual universities, we adopt a national perspective on the entrepreneurial roles that universities play (Casper and Kettler, 2001; Rosenberg, 2003; Gittelman, 2006). The analysis illuminates parallels between two national university systems – in Germany before 1914 and in the US after 1940 – that were particularly "entrepreneurial" not only in the narrow sense of seeking commercial exploitation of scientific discoveries but also in a broader dynamic sense: capable of self-development, adaptable to the changing nature of science, and an agent both in the performance of "open science" (Dasgupta and David, 1994) to expand the frontiers of basic scientific knowledge *as well as* in the transfer of this knowledge to industrial application. Germany and the US featured the world's leading national university systems in these respective eras, and we believe that entrepreneurialism, as defined below, constitutes a useful category for understanding the ascendancy of national university systems – and their decline.

It might be objected that the German university system before 1914 and the US university system after 1940 reveal considerable dissimilarities. Yet this is precisely why study of the remaining parallels is an instructive exercise, facilitating a conceptualization of university entrepreneurialism that transcends specific and current incarnations of the phenomenon. Based both on historical evidence and on theoretical grounds, we posit three indispensable contextual factors for entrepreneurialism in national university systems,

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of which the third is particularly crucial and difficult to implement effectively:

(1) decentralized competition;
(2) latitude in mission and revenue mix;
(3) an institutionalized, diversified bidding system at the national level for public funding of large-scale research projects.

Erosion of these same factors can, according to the same logic, contribute to the decline of entrepreneurialism within a given national university system.

Discussion is organized as follows. Section 2 proposes a framework of entrepreneurialism in national university systems. Sections 3–5 provide a theory-based historical retrospective using this framework. Section 3 highlights key structural characteristics of the pre-1914 German university system, leading to ascendancy of this system. Section 4 reviews how broadly similar characteristics emerged in the ascendant US university system after 1940. Section 5 shows that within Germany many of these structural characteristics were eroded by well-intentioned reforms, leading to a loss of vigor in both basic science and in the commercialization of science. Rather than attributing this development to shortsighted policy-making, the analysis imputes the relative decline of the German university system to a life cycle effect which, as suggested in Section 6, could play itself out in broadly similar ways in the US and elsewhere.

## 2. A framework of national university system entrepreneurialism

In some treatments of university entrepreneurialism, "entrepreneurial" is largely synonymous with "dynamic" (Clark, 1998; Röpke, 1998; Etzkowitz, 2003). The antipode to an entrepreneurial university is a bureaucratic or otherwise static university that carries out a narrow purpose with little view to self-development or adaptation to changing circumstances. In other treatments of the topic, "entrepreneurial" is largely synonymous with "commercial": the antipode to an entrepreneurial university in this sense is a university that engages in scientific discovery but fails to follow up on it by engaging in technology transfer, incubating new firms, or networking with industry (Siegel et al., 2003; Lockett et al., 2005).[1]

Our contribution builds squarely on the former and broader definition of the entrepreneurial university in order to flesh out the macro systemic conditions that facilitate adaptive self-development in universities. Nonetheless, commercial activities are one indicator of such self-development and, moreover, one that varies substantially among different national university systems (Nelson, 1993; Freeman, 2004). As an illustration, the EPO patenting statistics collected by Malik (2006) and excerpted in Table 1 reveal striking variation in university systems as they affect the vital scientific area of biotechnology, which requires deep capabilities in both basic and applied research (Rothaermel and Deeds, 2004).

While US and UK universities filed 5626 and 362 biotechnology patents respectively during the years 1994–2005, French universities filed five and German universities nine during this same period. Variation in country-level university entrepreneurialism in explaining these differences has been amply demonstrated (Casper and Kettler, 2001; Lehrer and Asakawa, 2004; Gittelman, 2006). But where does such entrepreneurialism come from? And how can one explain differences in the depth, breadth, and adaptability of activities among national university systems in the first place?

**Table 1**
EPO biotechnology patents (K-1, K-2, K-3) filed by universities, 1994–2005.

| Country | Number of patents | Patents per million inhabitants |
|---|---|---|
| **US** | **5626** | **18.9** |
| UK | 362 | 6.0 |
| China | 210 | 0.16 |
| Israel | 112 | 17.5 |
| **Germany** | **9** | **0.11** |
| France | 5 | 0.08 |

*Source*: Malik (2006).

A framework of national university system entrepreneurialism is depicted in Fig. 1. While the framework does not purport to specify all of the factors that make one national university system more entrepreneurial than another, it provides a theoretical synopsis of the historical analysis that follows and serves as a point of departure for considering the broader factors affecting the ascendancy and decline of national university systems.

The framework postulates that the emergence of entrepreneurial universities depends on a structured interface between the invisible hand of market forces and the visible hand of public R&D funding. The interface consists of three contextual factors at the national level. The first of these, and the real lynchpin of university entrepreneurialism, judging by the systems considered here, involves *a nationwide, diversified bidding system for public funding of large-scale university-based research projects*. A well-funded "marketplace of scientific ideas" helps direct resources to the most innovative groups and individuals, ultimately increasing overall public-sector support for science (Ben-David and Zloczower, 1962; David, 2004). Like other markets, academic markets do not work well if they are entirely regulated or deregulated, but instead require the construction and maintenance of specific market institutions. The postulated bidding system is a market and diversified in the sense of not only a diversity of possible recipients, but also a diversity of public funding sources (as opposed to a monopsonistic one); this is consistent with the findings of national comparisons of public science systems highlighting the adverse consequences of concentrating public R&D funding in a single agency (Whitley, 2007; Whitley and Gläser, 2007). As suggested below, the construction of an effective and efficient national bidding system for funding of university research is a non-trivial challenge.

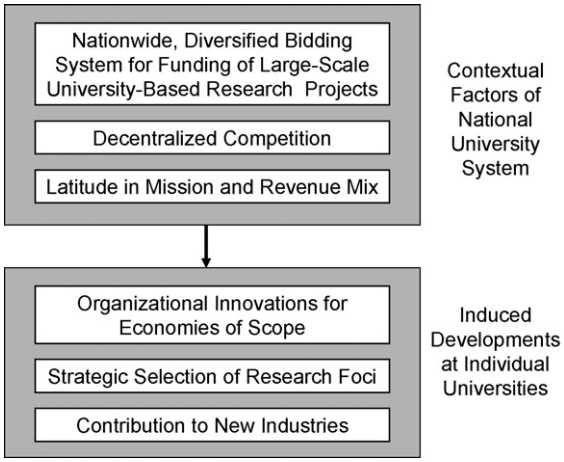


**Fig. 1.** National university system entrepreneurialism.

[1] The growing dominance of the latter conception is indicated by a recent review by Rothaermel et al. (2007), who found that technology transfer offices, new firm creation, and networks of innovation (plus other aspects of the larger environment) constitute three of the four major categories of work on the entrepreneurial university.

The framework of Fig. 1 specifies two further prerequisite contextual factors at the national level. The first, *decentralized competition*, is conducive to "open science" predicated on peer review as opposed to an insider system (Dasgupta and David, 1994; Nelson, 2004). Beyond just open science, however, decentralized competition among universities, as between polities or regions (Frey and Eichenberger, 1999; Dohse, 2003), promotes institutional innovation and competing concepts of just what a university should be. Decentralized competition combats institutional rigidities and "institutional sclerosis" (Olson, 1982; Dohse, 2000).

The second additional factor can be summarized as *latitude in mission and revenue mix*. As already indicated, decentralized competition among universities is necessary but not sufficient. For efficient resource allocation processes to make much of an impact, universities require the autonomy and liberty to become resource-rich in the first place. The historical record suggests that entrepreneurial university systems allow individual universities to raise revenue from multiple sources (including students), which of course they can only do by engaging in multiple types of activities. Managing economies of scope, in other words, is a core feature of university entrepreneurialism (Hopkins, 1990; Etzkowitz, 2003). Many nations, however, severely constrain the range of activities and revenue sources that their universities are allowed to pursue.

While both the German university system at the beginning of the 19th century and the US system at the beginning of the 20th featured high levels of decentralization and competition, the real "takeoff" of both systems depended heavily on the subsequent construction of a resource-rich marketplace for higher education as well as for university-based research ideas: after 1850 in Germany and after 1940 in the US. To be sure, these two university systems were very different. Each system involved an emergent and unique response to the stage of development of science and the economy in the 19th and 20th century, respectively. Yet even these seemingly disparate adaptive responses share certain underlying features.

If decentralized competition, latitude in mission and revenue mix, and a diversified bidding system for funding of large-scale research in combination promote university system entrepreneurialism, one can conjecture that the erosion of these factors might result in a certain decline of such entrepreneurialism. Moreover, we believe that the German university experience during the 20th century provides confirmatory evidence of this hypothesis (and we present evidence that the brain drain was at most a partial explanation in the process). Implicit in the following analysis is therefore a life cycle model of national university development, e.g. a model of ascension and decline.

The Nobel Prize counts in Table 2 encapsulate the rise-and-decline accounts given in the following sections: the rise of the German national university system (Section 3), the rise of the American university system (Section 4), and the relative decline of German university dynamism after 1945 (Section 5). The statistics in Table 2 do, of course, concern basic science rather than the commercialization of science. Yet the reason we subscribe to the very notion of the entrepreneurial university is the conviction that vigor in basic science is compatible with vigor in other university activities, a point broadly supported by prior research (Zucker et al., 1998; Poyago-Theotoky et al., 2002; Van Looy et al., 2003; Gulbrandsen and Smelby, 2005) with, to be sure, some noteworthy skeptics (Rosenberg and Nelson, 1994; Guena, 1999).

**Table 2**
Total number of Nobel Prize winners by institutional affiliation.

| | 1901–1932 | 1933–1956 | 1957–2005 |
|---|---|---|---|
| German universities | 27 | 11 | 4 |
| US universities | 4 | 34 | 189 |

*Source*: own calculations.

**Table 3**
Mobility of 19th-century German university professors.

| Percentage of professors departing for appointment elsewhere (entire19th century) | |
|---|---|
| University | Departure rate (%) |
| Kiel | 60 |
| Giessen | 53 |
| Marburg | 41 |
| Heidelberg | 30 |
| Bonn | 20 |
| Göttingen | 19 |
| Munich | 9.6 |
| Berlin | 6.3 |

*Source*: Baumgarten (1997).

Finally it should be noted that the statistics in Table 2 cannot be attributed to differences in funding levels for academic R&D. In recent decades, the percentage of GNP devoted to university-based research in Germany and the US has been comparable at 0.4% (OECD, 2003).[2] Most academic research in both countries is funded by the state, thus furnishing a noteworthy natural experiment in national R&D policy.

As encapsulated in the framework of Fig. 1, the German and US experience suggest that the three macro-level contextual factors cascaded down into the emergence of three developments within the university sector: (1) organizational innovations for achieving economies of scope, e.g. for achieving synergies between basic and applied research, teaching, and cooperation with industry; (2) an institutionalized capacity for strategic selection of research foci; and (3) a capacity to contribute to the development of new industries. These developments involved different kinds of "entrepreneurial" characteristics, underscoring the multidimensional nature of university entrepreneurialism. The following sections flesh out the way in which these three developments emerged from – or were eroded by – their respective national environments.

## 3. The ascendance of the German national university system

*Decentralized competition, latitude in mission and revenue mix, and a national bidding system for funding of large-scale research in 19th-century Germany*. A major structural characteristic underlying the German university system in the 19th century was the decentralization and interregional competition resulting from the co-existence of multiple German states. These states' universities competed for students, professors, and prestige. This competition remained intact after 1871, for the newly founded German Reich was really an amalgam of the existing states that continued to administer their universities separately. The turnover rates for professors in Table 3 are an indication of the active market for academics in 19th-century Germany in which high-flyers could move up the ladder to attractive locations like Berlin and Munich (Baumgarten, 1997). Another telling symptom of academic market fluidity in pre-1914 Germany was the complaint of Prussian delegates to the German–Austrian University Conference of 1907: enforcing even the three-year minimum stay requirement for newly hired professors was difficult, as other states were willing not only to pay their moving costs out of but also reimburse their previous

[2] This is confirmed by other sources. In 1995, US universities colleges performed about $21.6 billion worth of R&D, about 12.6% of total US R&D (Abramson et al., 1997: 91). In that year, German universities performed DM 14.9 billion, i.e. €7.5 billion or about $9 billion, fully 19% of national R&D in Germany (Abramson et al., 1997: 249 and 276).

moving costs to Prussia (vom Brocke and Krüger, 1994: 159). When professors changed jobs, they usually changed states as well.

Before 1800 German universities mainly provided education to wealthier families and students paid fees directly to their teachers; indeed, a whole layer of university teachers without a professorial chair (*Privatdozenten*) had to live off of such fees. As laboratory research increasingly demonstrated the capacity to produce theoretical as well as practically useful knowledge in the 19th century, Germany inaugurated an unprecedented role for universities as research centers. Students continued to bear most of the costs of their education, but the German states increased funding for research on a vast scale.

It was the appetite of German states for high-profile research centers that constituted the institutionalized, diversified bidding system for public funding of university-based research projects. While only a handful of university research institutes and specialized seminars existed before 1850, the international acclaim generated by some of them – e.g. Liebig's laboratory in Giessen and Neumann's mathematics seminar in Königsberg – resulted in a widespread demand for high-profile university units across the German-speaking world after 1850. Thus, by 1870 research institutes at the University of Berlin absorbed more costs than faculty salaries, whereas 50 years before institute costs were negligible in comparison. In the years 1882–1907 Prussia alone established 77 seminars and institutes in the "philosophical" faculties (including natural sciences), 86 medical laboratories and clinics, 9 seminars in law and 4 seminars in theology (Clark, 1995: 31). In this distinctly German paradigm, professors negotiated directly with state ministries over resources, bypassing the weak university level of administration based on professorial self-governance. In other words, the central actors in this bidding system for large-scale research (large-scale by 19th-century standards, that is to say) were dynamic professors and activist state education ministries rather than the universities themselves.

In 19th-century Germany one must emphasize that entrepreneurialism was a feature of the overall system and not of individual universities. Looked at individually, German universities consisted of islands of dynamism (i.e. high-profile institutes) co-existing with mostly traditional elements that were largely conservative and resistant to change (Ringer, 1983; Muller-Camen and Salzgeber, 2005). Reform at German universities consistently had to be imposed from above (Hoffacker, 2000: 33; Morkel, 2000: 143), for example through the founding of new universities, such as in Göttingen (1736) and Berlin (1810). Yet despite undeniable organizational rigidities, the German university system witnessed the following "entrepreneurial" developments: (1) organizational innovations for achieving economies of scope; (2) an institutionalized capacity for strategic selection of research foci; and (3) a capacity to contribute to the development of new industries.

### 3.1. Organizational innovations for achieving economies of scope

The modern research university is a German invention (Ben-David, 1977; Freeman, 2004). The multitasking developed by German universities is summarized in the famous dictum of the "unity of research and teaching" (*Einheit von Forschung und Lehre*) which traces its roots back to Wilhelm von Humboldt and the University of Berlin (1810). The original premise for the Humboldtian synthesis was the philosophical open-endedness of inquiry; perceiving clearly that top-down instruction was a poor method for imparting the capacity to think originally, the University of Berlin's founders advocated an interactive form of classroom learning in which teachers and students engaged jointly in original thinking.

Laboratories formed little part of the Humboldtian conception. In actual practice, Humboldt's philosophy-based synthesis gave way to the laboratory-based synthesis of teaching and research most often associated with the pioneering work of chemist Justus von Liebig (1803–1873). Liebig's laboratory, founded in 1826 at Giessen with doctoral students working in a team-based environment, evolved by the 1840s into a harbinger of the new era in scientific research combining systematized experimentation with theory-building (Fox and Guagnini, 1999; Mokyr, 2002). Although Liebig's model of hands-on doctoral training and laboratory experimentation faced substantial opposition prior to 1848, its widespread emulation in the second half of the 19th century institutionalized a new paradigm of scientific investigation integrating teaching and research (Holmes, 1989). Hundreds of foreign PhD students streamed into Germany in the 19th century to receive training in scientific research methods unavailable elsewhere.

The specific German organizational innovation that created synergies across teaching and research, then, was the specialized "institute" or "seminar" (Clark, 1995) in which a highly successful or promising professor received sustained state support for extensive laboratory and/or seminar rooms to conduct organized research with groups of doctoral students. These institutes and seminars built upon the pre-existing institution of autonomous professorial chairs (*Lehrstühle*) in which chairholders enjoyed wide-ranging academic freedom (*Lehrfreiheit*) in the subject matter they pursued and virtually complete control over their academic unit. During the years 1850–1870, even prior to the increase in student enrollment that took place after this period, German states funded a rapid expansion of research units centered around a chaired professor who served simultaneously as a teacher and as a research director (McClelland, 1980).

### 3.2. An institutionalized capacity for strategic selection of research foci

The comparatively high cost of laboratory facilities obliged state ministries to invest strategically in selected scientific fields. For example, Saxony elected to place its bets on medicine by bringing together two top minds in the fields of pathology and physiology, Karl Wunderlich and Carl Ludwig, to create an interdisciplinary, science-based medical research institute (Lenoir, 1997). Baden expanded its research base in chemistry at the University of Heidelberg with a view to increasing agricultural productivity (Borscheid, 1976).[3] Interregional competition for top 19th-century German scientists translated into almost unequaled laboratory facilities (Landes, 1969). This was especially true in research areas that were "hot," notably chemistry (Beer, 1959) and experimental psychology (Lenoir, 1997). The principle of competing for "star scientists" (Zucker et al., 1998) was already well established in Germany. For example, the hiring away from England of the great organic chemist A.W. von Hoffmann by German universities (first Bonn, then Berlin) capped England's decline and Germany's ascendance in the organic chemical industry (Beer, 1959); Prussia offered laboratory support that was exorbitant for the time and well beyond what British institutions could afford to offer.

The selection of strategic research foci was led by state ministries rather than by universities themselves. The apogee of ministry activism in German higher education was probably the *System Althoff* in Prussia (the largest German state) in the years 1882–1907, so named after Prussia's indefatigable ministry official in charge of higher education, Robert Althoff. In the single-minded effort to

[3] As the century progressed, the German states invested more aggressively in the expansion of technical colleges and universities than other European countries (Fox and Guagnini, 1994); in 1899, despite embittered opposition from the universities, the technical colleges won the right to dispense their own PhD titles. The synthesis of teaching and research was transferred to technical fields.

**Table 4**
Prussian university specialization in the Althoff era (1882–1907).

| University | Specialization |
|---|---|
| University of Göttingen | Mathematics and physics |
| University of Berlin | Archeology, art, history |
| University of Halle-Wittenberg | Protestant theology |
| University of Marburg | Archival sciences, experimental medicine |
| University of Kiel | Scandinavian languages and literature |
| University of Breslau | Slavic languages and literature |
| University of Bonn | Dutch languages and literature |

*Source*: Vereeck (2001: 53).

recruit the best scientists irrespective of their political or religious affiliations, Althoff voyaged and communicated incessantly with leading experts (vom Brocke, 1991). Thanks to Althoff's organizational genius, the quality of Prussia's university system blossomed and other German-speaking states felt the pressure to follow Prussia's meritocracy-based hiring policies (Vereeck, 2001: 43). Althoff also promoted specialization among Prussian universities, for the sake of both local excellence and overall system efficiency (see Table 4). Althoff was guided by the vision of bureaucracy, not in the derogative meaning of the term, but in the Weberian sense of large-scale system rationality (vom Brocke, 1991) in which efficiency was achieved by top-down ministerial management of the entire national university system.

Arguably the *System Althoff* bore the seeds of its own demise so long as research initiatives had to come from the ministry rather than from the individual universities. This could only work if ministry officials had the requisite knowledge and authority to make bureaucratic management work.[4] The increasing complexity of science was bound to strain the limits of ministry-led guidance of universities over time. The establishment of large-scale independent research centers by Prussia on the eve of World War I, as explained in Section 5, was in part a response to perceived limits of what could be accomplished within the confines of the German university system.

### 3.3. Capacity to contribute to the development of new industries

Prior to 1850, the main benefit that German states derived from hiring talented professors was prestige (Landes, 1969; David, 2004). In the course of the 19th century, industrial development took on increasing importance. Starting in the 1850s several German states sought to upgrade their chemistry departments in order to aid agriculture and industry (Lenoir, 1998). Although universities were not the primary vehicle of Germany's industrial catch-up with Britain (this role fell more to vocational schools and polytechnic colleges), certain university-based research areas had industrial applications for what we would today call "high-tech" companies. Ultimately, Imperial Germany's dominance in industries based on organic chemicals (synthetic dyestuffs, pharmaceuticals, synthetic fertilizers) derived largely from Germany's supremacy in the corresponding scientific areas (Murmann and Landau, 1998; Freeman, 2004).[5] Not only were German universities central to the supply of the key factor of production in organic chemicals – namely trained chemists (Haber, 1958; Beer, 1959) – but leading professors, such as A.W. von Hoffmann and Adolf Baeyer, cooperated extensively with industry and were major figures in the formulation of key intellectual property rights provisions in German law that were critical for the growth of the chemical industry (Murmann, 2003).

North (1990) identifies the Second Economic Revolution of mankind not with the industrial revolution of the 18th century but with the scientific revolution of the 19th. The scientific revolution consisted in the systematic organization of science to deliver an elastic supply of technologies able to outweigh the Malthusian resource constraints feared by earlier economists. The German university system was no small participant in this revolution, for the German university paved the way for the emergence of the corporate R&D laboratory. Such laboratories, first established around 1870 at firms like Hoechst and BASF, simply emulated the set-up of the collegial university laboratory, in particular the model of Liebig (Beer, 1959). Thus, although the German university was not entrepreneurial in the sense of commercializing technologies directly, it nonetheless had a four-fold importance for new industries based on the synthesis of teaching and research: (1) supplying of large numbers of doctoral students trained to conduct scientific research; (2) supplying the most up-to-date scientific knowledge and know-how; (3) permitting expansive research funding for top professors via the state and, in selected instance, via participation of industry; (4) furnishing a model of laboratory organization. Freeman (2004: 559–560) summed up the matter as follows:

> Perhaps the most important invention of the nineteenth century was the discovery of the method of invention itself – the professional research laboratory. It was an invention that was made in Germany. The German universities were the first to institutionalize a system of science laboratories and postgraduate training through laboratory research, which later became characteristic of science education generally.
>
> This was especially important for the nascent German chemical industry and it was this industry, which was also the home of a major social innovation – the 'captive' in-house industrial R&D laboratory in the 1870s. The link between these R&D laboratories, especially in Bayer, Hoechst, and BASF, and the subsequent astonishing success of the German dyestuffs industry (and later other branches of chemical production and exports) is a story which has often been told.

## 4. The ascendance of the US national university system

*Decentralized competition, latitude in mission and revenue mix, and a national bidding system for funding of large-scale research in the 20th-century United States.* While Mowery and Rosenberg (1993) barely refer to the existence of the 50 individual US states in their discussion of the US national system of innovation, the federalist structure of the US is arguably key to any analysis of the American university system, analogous to the federalism of the German states in the 19th century. Federalism significantly enhanced the level of decentralized competition among US institutions of higher learning. The impact of federalism is hard to measure and prove precisely because this impact is dynamic rather than static. The US states constantly experiment with the institutional arrangements governing the public universities, which are partially subsidized by the state but are partially self-financing and have to compete against private universities (Rosenberg, 2003). This encourages innovation and allows institutional arrangements to change dynamically over time. Within the state of Pennsylvania, for example, the University of Pennsylvania changed from a state university into a private institution, whereas Temple University did just the opposite, receiving increasing support from the Pennsylvania state legislature and becoming de facto a state university.

[4] As an example of the prerogatives enjoyed by ministries at the time, Althoff paid his professors an average of 4000 Marks around 1900, yet top performers could earn as much as 15,000 (Vereeck, 2001: 63); such 4:1 salary differentials became unthinkable in later more democratic eras (albeit still possible in the US today).

[5] Just how industrially effective this model was is illustrated by the ca. 90% world market share of German firms in dyestuffs and dyestuff patents prior to 1914 (Murmann, 2003). Similarly, two German firms, Bayer and Hoechst, produced 44 major pharmaceutical innovations in the years 1880–1930, more than the entire US (30) and UK (12) combined during this period (Achilladelis and Antonakis, 2001).

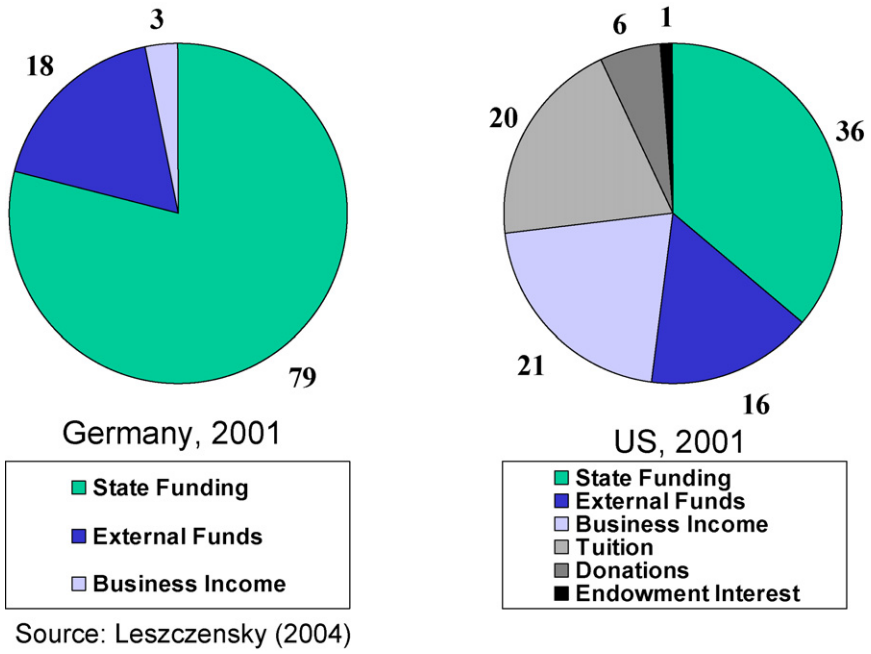


**Fig. 2.** Income sources of public universities in the US and Germany.

Whether public or private, American universities enjoy broad latitude to pursue a wide variety of activities and revenue sources (Calhoun, 2000). A comparison of US and German university funding (Fig. 2) illustrates how US university funding has come to diverge from that of the German university. To make the differences meaningful, Fig. 2 includes only public US universities in the comparison. The more diversified funding mix that prevails at US universities than at their German counterparts (Leszczensky, 2004) mirrors the greater range of financially vital activities they engage in.

Nonetheless, the decentralized and unshackled American university system arguably only reaped the full benefits of inter-university competition in the wake of the "internationally unique" R&D system of the United States (Mowery and Rosenberg, 1998: 12) that developed in the 1940s. Until 1940, the national R&D system of the US "resembled those of other leading industrial economies of the era, such as the UK, Germany, and France" (Mowery and Rosenberg, 1998: 44). Mobilization for World War II changed this. During the 1940–1945 period, tight linkages were forged between the federal government, universities, and industry (Dupree, 1957; Hart, 1998). Under the powerful political and intellectual leadership of Vannevar Bush, such linkages became institutionalized in the post-war era through a large-scale system of competitive grants from the federal government that became the key source of university research funds – far more important, even to this day, than grants from industry. Contrary to Bush's original intention of concentrating such funding in a single agency, however, multiple funding agencies were established[6]; in other words, the national bidding system for R&D that emerged after 1945 was a diversified, "pluralistic" one (Whitley, 2003).

It was, above all, the sheer scale of federally funded R&D carried out by US universities that made this university system unique. In the 1990s, for example, universities and their associated R&D centers performed about 60% of all US basic research, and well over half of this research was funded by federal agencies. While many other countries (including Germany) relied on specialized state research institutes to carry out "big science" after 1945, in the US federal research establishments performed just 10% of the country's basic research (Abramson et al., 1997; Mowery and Rosenberg, 1998).[7] Large federal grants for academic research dramatically accelerated the drive by American universities to seek outside research funding, thereby enhancing competition among US universities and their respective regions. In contrast, the MIT-Stanford model of regional entrepreneurial development (Etzkowitz, 2002), though much admired and envied, has not diffused throughout the US system to nearly the same extent.

Fig. 3 provides an overall indication of the extent to which academic research in the US is funded by agencies that allot funds on a competitive basis. Whereas in many countries, including post-war Germany, the level and distribution of university research funds is based largely on ongoing contractual obligations, the distribution of research funding among professors and universities in the US is largely a function of their competitive success in securing grants from federal sources, of which the single largest – by far – is the Department of Defense. The continued heavy reliance of US university research on Defense Department funding is a special characteristic of the US system, reflecting an enduring institutional legacy of World War II.

Understanding the entrepreneurial university in the US as a partial product of historical contingency is vital to comprehending both why the US model of the entrepreneurial university is unlikely to become a universal model and why it should not be taken for granted – and especially why it should not be regarded as immune from decline.

[6] These include dedicated R&D funding agencies like the National Science Foundation and the National Institute of Health along with mission-driven R&D funding provided by federal agencies with national executive responsibilities like the Department of Defense.

[7] This divergence between the US and the rest of the world repeated itself in hospitals: while US medical centers combined facilities for treating patients with laboratories for medical research, the rest of the world generally bifurcated such activities (Henderson et al., 1999).

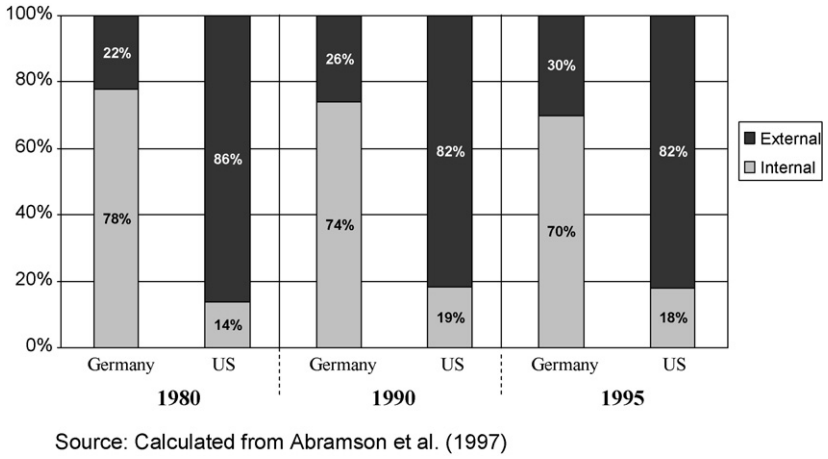


**Fig. 3.** Proportion of research funding from sources internal and external to universities in the US and Germany.

### *4.1. Organizational innovations for achieving economies of scope*

It has become customary to view the entrepreneurial university in the US as a "triple helix" (Etzkowitz, 2003) of teaching, research, and economic development. Historically, this triple helix built upon the German model. A handful of US universities, beginning with Johns Hopkins in 1876, began offering doctoral programs in the late 19th century. From its inception, however, the American PhD program diverged from its German ancestor and constituted an organizational innovation in its own right.

The first major US innovation was the graduate school (Ben-David, 1971). Graduate study was instituted as a separate program at a departmental or college level, quite distinct from the much more atomistic German institutes that were organized around a single chaired professor. In the US, graduate study ceased to be a personal apprenticeship, as it essentially was in Germany. This had far reaching consequences. First, the separately organized training of doctoral students was a "scalable" activity, allowing a larger corps of graduate students to span a wider range of scientific areas than could be accomplished within the confines of a single professorial chair; over time, this made greater interdisciplinarity possible (e.g. in chemical engineering, an interdisciplinary field that developed first in the US and only much later in Germany). Second, the innovation of the graduate school in the arts and sciences was followed by the founding of further professional schools in other areas, especially engineering and medicine; US universities could pursue areas of applied inquiry at a time when German universities resisted many types of problem-oriented research that seemed to conflict with the university ideal of devotion to "pure" science – a resistance that was a motivating factor behind the establishment of separate research institutes in Germany. Ben-David (1971) uses the term "quasi-disciplinary" to describe various fields of applied research that were emerging in US universities at the same time that they were being resisted by or excluded from German ones.

The late 19th-century experience of Johns Hopkins University reveals some of the various "entrepreneurial" issues involved with the establishment of graduate schools. Although Johns Hopkins was founded explicitly to promote science for its own sake and remains to this day more adverse to commercial ventures than other peer institutions, the university was exposed to commercial temptations from the start (Feldman and Desrochers, 2004). In 1879, one of its scientists, Ira Remsen, participated in the discovery of saccharin yet steadfastly refused to pursue patenting options. This refusal even became a moral tale for telling to later Johns Hopkins students about dedication to pure science that many other US universities in this period had no qualms about compromising on. Nonetheless, even Johns Hopkins did on occasion make compromises; in 1898, the Rowland Telegraphic Company became the university's first true "spin-off" company, founded by a university physicist, Henry A. Rowland. Yet the most important compromise of all was the establishment of professional schools in which the distinction between basic and applied research hardly existed. The Hopkins' Hospital and Medical School (founded in 1889) became a leading institute of medical research, while its Engineering Department (in 1912), later expanded into an Engineering School (1919), entered into extensive cooperative agreements and consulting relationships with industry and the military from the beginning (Feldman and Desrochers, 2004).

This vignette bears out the thesis that the basic contours of the US entrepreneurial university were in place by 1920 (Ben-David, 1971: 153). These contours included a further organizational innovation that Etzkowitz (1983, 2003) refers to as the "research group." The research group is a self-organizing, problem-focused entity headed by a professor of any rank (in contradistinction to Germany, with its uniquely privileged chaired professors). The group leader acts as a scientific director and as a manager, responsible both for directing the team and for securing financial support on an ongoing basis. The entrepreneurial significance of the research team as an institutionalized fact of life in US universities lies especially in the fact that it provides scientists with a certain degree of experience in playing the role of a manager; this facilitates their ability to interface with industry and even to start their own firms (Etzkowitz, 2003; Gittelman, 2006).

Yet it was not industry but the expansion of federally funded R&D since the 1940s that sparked the proliferation of research teams within American academia. Federal R&D made grants and grant-writing into annual routines of US research scientists, distinguishing them fundamentally from most of their foreign counterparts until relatively recently. The need for researchers to organize themselves into teams and formulate a research agenda capable of garnering external support, so core to the entrepreneurial university (Kenney, 1986), received its main impetus from these new government funding sources. Gittelman (2006: 1058) remarks that "perhaps the most entrepreneurial feature of the careers of American research scientists is the emphasis on raising grants to further one's standing in the scientific community." Some 30–40% of a researcher's time may be spent in writing grant proposals (Rabinow, 1996).

The main prerequisite for research groups whose leaders often describe themselves as "running a small business" (Etzkowitz, 2003: 111) is therefore not an interface with industry, but a large-

scale system of competitive grants. The share of university R&D in the US funded by industry was 4% in 1980 and 7% in 1990; the share funded by federal agencies, in contrast, was 68% in 1980 and 60% in 1990 (Abramson et al., 1997).

Thus, while the basic structural features and organizational innovations of US entrepreneurial universities emerged straightforwardly out of the decentralized US context, the mass diffusion of research teams reflects an element of historical contingency: it is unlikely that a large competitive federal R&D system would have flourished on the scale that it did without World War II and the powerful influence of university administrators like Vannevar Bush and Harvard president James Conant in the Roosevelt government (Hart, 1998).[8]

### 4.2. An institutionalized capacity for strategic selection of research foci

At a governance level, competitive R&D grants accentuated another kind of entrepreneurship one might call "administrative entrepreneurship." Whereas universities in many countries stand in a tradition of corporatist self-governance by faculty, administrators at both private and public universities in the US enjoy wide-ranging discretion in the allocation of resources (Calhoun, 2000; Rosenberg, 2003). This discretion, in conjunction with a competitive national system of research grants, influences not so much the direct allocation of internal R&D funds (which are comparatively meager) but rather choices about where to hire new faculty. US university administrators can decide which areas to target for major hiring of research faculty and which areas to target for "benign neglect."

As a result, administrators at most research universities in the US typically select a few strategic areas for systematic development, since highly ranked departments are most able to obtain external R&D funding and provide special visibility to the university as a whole. While elite universities are one well-known feature of the US university system, less widely appreciated is the fact that in almost all scientific areas one will find a few non-elite universities nurturing top-ranked programs that these universities have targeted for special development. Table 5 presents a list of *non-elite and public* universities that offer a top-ranking academic and/or research program (usually among the top five nationally) in a carefully nurtured area.

A key issue is critical mass. Specialization in targeted areas leads to a virtuous cycle, in which top researchers attract highly gifted graduate students to help with grant-writing, laboratory research, and undergraduate teaching; successful graduate students in turn help diffuse the research results, prestige and contact network of their professors.

### 4.3. Capacity to contribute to the development of new industries

Although the actual level of industry funding in US and German universities has always been low (as shown above), both university systems have historically cultivated linkages with industry that were of some economic importance, especially to new industries (Krücken, 2003; Miozzo and Walsh, 2006: Chapter 3). In the US, a small number of universities, such as MIT and Stanford, developed these linkages to such an extent as to become veritable motors of regional development even before World War II (Etzkowitz, 2002; Rosenberg, 2003).

**Table 5**
Highly ranked departments or programs of non-elite public US universities.

| University | Highly ranked school, department, or program |
|---|---|
| U. of Illinois, Urbana-Champaign | College of Engineering (multiple departments) |
| U. of Minnesota | Department of Chemical Engineering |
| U. of South Carolina | International Business Program |
| U. of Arizona | College of Optical Sciences |
| Georgia Tech | School of Industrial and Systems Engineering |
| U. of Rhode Island | School of Oceanography |
| U. of California, Davis | Department of Viticulture and Enology |
| Colorado School of Mines | Department of Petroleum Engineering |
| Rutgers University | Department of Philosophy |
| U. of Washington | Department of Mathematics |
| U. of Massachusetts, Amherst | Department of Linguistics |

*Source*: own compilation, various sources.

Nonetheless, a new watershed in the role of universities for new industry formation occurred around 1980, when high-tech spin-offs from university research in key areas (biotechnology, information technology) attracted a virtually unprecedented level of venture capital and with it a new level of financial temptations for university researchers to participate in commercial ventures. During the 1980s, the compatibility of academic research and commercial profit became a subject of widespread controversy on American campuses (Etzkowitz, 1983). Yet the temptations were irresistible. The increasing marketability of university research in conjunction with stagnating state subsidies for college education ushered in what has been called the "second academic revolution" (Etzkowitz, 2003) and "academic capitalism" (Slaughter and Leslie, 1997). In general, US research universities poised themselves to support the commercial relevance of faculty research while enacting measures to ensure themselves a share of the profits.

The formal commercialization activities of universities have become the focus of much recent work on the entrepreneurial university: technology licensing offices (Owen-Smith and Powell, 2003), technology transfer offices (Siegel et al., 2003), university spin-offs and start-up incubators (Di Gregorio and Shane, 2003; Lockett et al., 2005), and formal partnerships with industry (Poyago-Theotoky et al., 2002). The pros and cons of this kind of university entrepreneurialism have been the subject of a long-standing debate of which Guena and Nesta (2006) provide a useful overview.

We would argue, however, that these kinds of activities, while an important and growing trend, are not nearly as central to the US entrepreneurial university as deeper structural components like the graduate school, research teams, and the ability of university administrators to select research foci strategically. In point of fact, few university-based technology transfer offices make a significant contribution to university finances. Only a small number of the American universities that have established technology licensing offices actually earn significant revenues (Owen-Smith and Powell, 2003). Similarly, a handful of eminent US universities generate the lion's share of major innovations and important start-up companies in what appears to be a self-sustaining "Matthew effect" (Di Gregorio and Shane, 2003; Van Looy et al., 2003). Indeed, the best argument for encouraging scientists to commercialize their discoveries may reside in the complementary knowledge that is

[8] The same element of contingency applies to the post-WW2 nurturing of the fine-tuned evaluation systems needed to make such a national bidding system operate effectively; replicating the ethos of organizations like the National Institute of Health and National Science Foundation, not to mention the Department of Defense, is no mean task for other countries and perhaps beyond the realm of possibility for organizations like those of the European Union. On the EU's limited progress in R&D harmonization to date, see Whitley (2007: Chapter 3).

**Table 6**
Total number of Nobel Prize winners by institutional affiliation.

| | 1901–1932 | 1933–1956 | 1957–2005 |
|---|---|---|---|
| German universities | 27 | 11 | 4 |
| German R&D institutes | 6 | 6 | 16 |
| US universities | 4 | 34 | 189 |
| US R&D institutes | 2 | 8 | 41 |

*Source*: own calculations.

generated in the process (Lockett et al., 2005); the existence of feedback loops from applied to basic research appears to be undeniable (Rosenberg, 1994; Mokyr, 2002).

## 5. The decline of the German national university system

*The erosion of decentralized competition, latitude in mission and revenue mix, and the diversified bidding system for funding of large-scale research in 20th-century Germany*. In his search for entrepreneurial universities in Europe, Burton Clark (1998) ruled out German universities from the very start. Whereas the German university of the 19th century became the success model emulated by the US and many other countries, it has progressively evolved into a bureaucratically administered entity in which the kinds of entrepreneurship outlined by Clark (1998), Etzkowitz (2002), and others is largely unfeasible. The following analysis emphasizes that the relative decline of Germany's universities was not just the result of inertia. It followed from active national policy choices for the sake of rationalizing national R&D and the overall organization of higher education. Thus, these are policy temptations that are instructive for other countries, including the US.

The German policy choices did not purposely set out to erode these key contextual factors set out in Fig. 1, namely decentralized competition, latitude in mission and revenue mix, and a publicly funded marketplace for ideas. At the same time, the consequences were not entirely unintended. Beginning at the latest with the *System Althoff* in Prussia before 1900, German policymakers have consistently confronted bottlenecks emanating from the increasing size, complexity, and cost of the higher education system. In response to the "demand overload" (Clark, 1998) on universities caused by increasing enrollment, expanding frontiers of knowledge, and cost and complexity of scientific investigation, Germany has looked less and less to decentralized solutions and relied instead on systemwide reforms.

### 5.1. Decline of the national bidding system for large-scale research: the rise of specialized R&D institutes

Given the unparalleled success obtained by the German teaching-research synthesis at university institutes in the course of the 19th century, the question arises as to why the publicly funded marketplace for university ideas declined. For declined it undoubtedly did. Surprisingly, the two world wars had little long-term effect. Instead, the gradual decline can be dated as far back as the late 1800s with the growing reliance of Germany on specialized R&D institutes – not as a complement to university research but as a substitute for it. Although the German R&D system developed more or less continuously until at least 1945, it did so increasingly outside the realm of higher education. This is reflected in Table 6, which shows that Germany's Nobel Prizes came increasingly from specialized R&D institutes, most notably the Max Planck institutes – at the expense, one might say, of the universities. As seen in Table 6, Germany's specialized R&D institutes have remained thoroughly on a par with comparable US institutions in the per-capita production of Nobel Prizes – in stark contrast to Germany's universities; whatever the effect of the brain drain was or has been, Table 6 strongly suggests that organizational factors played a substantial role in university decline.

German policymakers nonetheless had their reasons for moving the locus of national R&D outside the university system. As science became more complex and state-of-the-art laboratories more costly to build in the course of the 19th century, Prussia took the lead in consigning scientific research to specialized R&D institutes. In addition, the swell of student enrollment during the 19th century far outstripped the rate of increase in university faculty, creating bottlenecks within the system itself. Whereas full professors constituted the majority of teaching faculty as late as 1860, thereafter German states relied increasingly on unsalaried adjunct faculty members to satisfy teaching needs, with the result that by 1910 chaired professors were far outnumbered by members of the irregular teaching staff (McClelland, 1980; Titze, 1990: 147). In the years 1871–1910 the number of regular professors rose only by 45%, far less than the 300% growth in the student population. In the natural sciences, student numbers rose by 640%, regular professors (*Ordinarien*) by only 60%, considerably less than the rise in non-regular professors (+140%) and private instructors (+250%); this inability of the German university to keep pace with enrollment in the natural sciences was in turn due in large part to the increasing cost of funding expensive laboratories (vom Brocke, 1990). This proliferation placed increasing administrative burdens on regular faculty, raising doubts about whether the university was the best place to locate research scientists.

The financial bottlenecks were overlaid with problems emanating from the institute- and seminar-based organization of German universities. Emerging research areas were increasingly interdisciplinary, making it difficult to incorporate them into a university system organized around autonomous professorial chairs (Ben-David, 1977; Ellwein, 1992: 134). Finally, the concentration of university control in the hands of chaired professors to the exclusion of the increasing proportions of non-chaired professors, private instructors, and assistants who were much less expensive to hire resulted in German universities becoming ever more hierarchical rather than collegial. As early as 1910, Prussian ministry officials recognized this proliferating hierarchical structure as "one of the biggest flaws of scientific organization in Germany" (vom Brocke, 1990: 23).

To be sure, the rise of independent research institutes reflected a worldwide paradigm shift in R&D and to informed observers they appeared inherently better suited to the nature of laboratory-based, application-driven projects (Vieraus and Vom Brocke, 1990). Applied research took place increasingly in privately funded research institutions like the Pasteur Institute in Paris (1888), the Rockefeller Institute in New York (1901), and the Carnegie Institution in Washington (1902), which Althoff and his main adviser Adolf Harnack monitored with nothing less than passion (vom Brocke, 1990: 127).[9] The examples of Rockefeller and Carnegie drove home the importance of finding an organizational form for scientific research that was responsive to needs of the state yet suitable also for the mobilization of private wealth.

Many years of planning and discussion within Prussian ministries led finally in 1911 to the founding of the Kaiser Wilhelm Society (renamed the Max Planck Society in 1948) with its first three institutes in Berlin. The number of institutes ballooned over time: there were 5 of them by 1914, 9 by 1918, 16 by 1923, 23 by 1948, 37 by 1955, over 60 by 1996 and about 80 today. The Society's compli-

[9] Meanwhile, on a smaller scale, many independent laboratories began spouting up throughout Germany itself, of which the Georg-Speyer-Haus, established by Ehrlich in Frankfurt in 1906 and quick to develop a cure for syphilis (1910), was just one example of proliferating partnerships between the state, philanthropists, and industrial sponsors (vom Brocke, 1990: 109–114; Szöllösi-Janze, 1996).

cated organizational structure reflected the varying mix of state, philanthropic, and industry interests involved. This was no centralized bureaucracy, but a fairly loose federation of institutes that varied substantially in structure, funding scheme and basic clientele: some institutes served mainly private industry while others reported to state ministries (this was especially true in wartime); some institutes were heavily financed by industry and expected to produce industrially useful results, while others conducted state-funded basic research (Szöllösi-Janze, 1996).

From the beginning, then, the Kaiser Wilhelm Society was conceived as an umbrella organization for heterogeneous R&D institutes that varied in their relations to industry, time horizons, financing structures, and research mandates (e.g. basic vs. applied). The supple and highly differentiated nature of the Kaiser Wilhelm Society, in contrast to the rigidities of the university system, helps explain why independent research institutes developed a special dynamism in Germany. This changed to a certain extent with the rise of the welfare state in the 1960s, when the Max Planck institutes were transformed into almost fully state-financed institutions (over 95% state-funded in the 1990s).[10] Nonetheless, the impact of increasing uniformity induced by public-sector influence after 1960 assuredly affected the universities more deeply and, as far as entrepreneurialism is concerned, more negatively.

### 5.2. Narrowing latitude in mission and revenue mix: the prerogative of mass education

As long as university education was open only to segments of the population that could afford to pay for it, German universities remained elite institutions. The democratization of German universities, dating from the 1960s, abolished student fees while creating institutions of mass education expressly designed to make university education widely available. The number of students increased more than five-fold from 291,100 in 1960 to 1,582,200 in 1993 (Hödl and Zegelin, 1999: 24). Inevitably, the rise of mass education tilted the teaching-research balance in favor of teaching as an administrative priority (Hödl and Zegelin, 1999: 56–57; Morkel, 2000: 9). The success of universities was increasingly measured by the number of degrees produced; while state ministries continued to provide professors with research budgets, research productivity was a matter of little scrutiny.

In two distinct phases, accommodating the massive influx of students became the paramount political objective of decision-makers. During the economic boom years of 1965–1973, the federal government co-financed the construction of new universities and became increasingly involved in regulating the overall system. After the economic miracle subsided in 1973, student enrollments continued to rise but overall expenditures for higher education stagnated.[11] In this phase, the federal government's priority was to promote greater efficiency of scarce resources while ensuring uniformity of conditions.

### 5.3. Increasing homogenization and declining national competition

In both phases, federal influence meant increasing national harmonization; the hidden cost arguably lay in the erosion of interregional competition and thus in concomitant failures to experiment, reward local initiatives, and develop special local competences (Frey and Eichenberger, 1999; Dohse, 2003). National harmonization was abetted by article 75 of the constitution, added in 1969, in which the federal government gained the right to lay down national guidelines in higher education. Beginning with the first Higher Education Framework Law of 1976 (revised several times thereafter), German universities submit to largely centralized rules and regulations, even though expenditures are made at the state (*Land*) level. Federal harmonization made decentralized experimentation nearly impossible, since reforms of any scope require modification of the Higher Education Framework Law and thus ratification by both federal and state levels. For example, the rights of the *Länder* to introduce performance-based pay for professors had to wait until a revised Higher Education Framework Law went into effect at the national level in 2002.

How has this affected the ability of the universities to select research foci? To be sure, German universities still feature a large variety of specialized research institutes. Some are simply regular professorial chairs (*Lehrstühle*) designating themselves as "institutes," others are larger-scale institutes set up and financed by the state ministries. Nonetheless, German universities find it much more difficult than their US counterparts to concentrate resources strategically. University administrators have little power to steer R&D funding into preferred areas, as the German system of professorial self-governance limits their authority quite dramatically (Muller-Camen and Salzgeber, 2005). With academic research funded primarily from internal university sources, it is hard to prevent research funds from being distributed in a fairly equal fashion among professors and projects according to the "watering can principle" (*Gießkannenprinzip*) legendary within contemporary German university practice.

To sum up, German universities have evolved into paragons of institutional uniformity, with talent distributed fairly equally among universities offering more or less the same salaries and working conditions to professors and similar degree programs to students.[12] As Peisert and Framheim (Peisert and Framhein, 1997: 7) explain in their history of German higher education:

> In further efforts to strengthen federal competence, the constitutionally derived maxim of maintaining unity of living conditions in all areas of the Federal Republic played an important role. This perspective obeys a centralist evaluation standard in contrast to the original standpoint of cultural federalism with an interest in maintaining pluralism. In the wake of a national financial reform this obligation led to the idea of having the federal government taking on tasks that are important for the common good ...

A telling expression of such uniformity is the nationally centralized admissions agency *Zentralstelle für die Vergabe von Studienplätzen* (ZVS) that in crowded disciplines (e.g. medicine) rations admission slots across applicants nationwide under the tacit assumption that all degree programs are largely equivalent. This has advantages and disadvantages:

> Uniformity has advantages. A degree in Flensburg is officially worth as much as one in Konstanz. Every German university professor can feel like a top researcher ... In international comparisons, however, the prescribed equality paved the way to mediocrity ... When the famous Jiao-Tong University in Shanghai recently published a ranking of universities based on international publications, the first German university (LMU

[10] The institutes have been funded jointly on a 50:50 basis by the *Länder* and federal government since 1964 (Meusel, 1996).

[11] For example, the student–teacher ratio more than doubled from 9 to 19 between 1970 and 1994; while real expenditures on higher education were level in the period 1975–85, enrollments increased by 65% (Keck, 1993).

[12] Recent reforms, such as the designation of certain "elite universities" by the state, merely betray to what extent such uniformity had developed.

Munich) came in 10th among European universities and 48th in the international rankings (Spiewak, 2004: 3).

It was only in the 1990s that efforts to induce greater specialization (*Schwerpunktförderung, Profilbildung*) at German universities began to surface, in part as a way to cope with overall budget constraints (Oehler, 2000: 134-5). Often the positive rationale of greater specialization was less pronounced than the negative motivation of reducing duplication. Even in recent instances some federal states have announced plans to merge universities in order to consolidate academic programs and reduce expenses.[13] Nonetheless, a set of initiatives since the year 2000 has sought to enhance competition and excellence among universities. German regions do increasingly compete, with especially the southern states of Baden-Württemberg and Bavaria establishing a disproportionate share of Germany's prominent research universities. Meanwhile, the proportion of competitive research funding has steadily increased since the 1990s (Abramson et al., 1997).

While explanations for modern Germany's pronounced weakness in high-tech sectors usually revolve around capital and labor markets (Casper et al., 1999; Hall and Soskice, 2001), the diminished relevance of German universities to emerging industries cannot be excluded as another key factor (Siebert and Stolpe, 2002; Whitley, 2003; Lehrer, 2007). Röpke (1998) emphasizes how the entrepreneurial university can become a "competence block" for further development of the economy. In this respect, the calculations of Siebert (2005), according to which 89% of Germany's exports come from the industrial sectors whose basis lies in the excellent universities of a century earlier, is sobering. Germany's high-tech industries of yesterday have matured into the medium-tech industries of today in which university research is not a critical component.

The systemically induced loss of dynamism undoubtedly explains the German university lag in commercializing research results. Although many German universities established technology transfer offices in the 1970s, they were mainly a political gesture that generated little interest among industry partners and were poorly embedded in the local reality (Krücken, 2003). Only since the mid 1990s have technology licensing offices become a feature of German universities (Abramson et al., 1997), followed in the late 1990s by start-up incubators (Lehrer, 2000).

## 6. Discussion and conclusion

For all their differences, the German "entrepreneurial" university before 1914 and the American "entrepreneurial" university after 1940 flourished on the basis of a historically unique interface between the invisible hand of decentralized competition and the visible hand of publicly funded R&D. We have characterized this interface as composed of three factors, of which the lynchpin is a nationwide, diversified bidding system for the funding of large-scale university-based research. In 19th-century Germany, the interface consisted essentially of competing activist state education ministries sponsoring highly autonomous chaired professorships. In the 20th-century United States, the interface consisted of a large-scale competitive grant system and dedicated graduate schools for doctoral training. Universities in both national systems developed the following "entrepreneurial" characteristics: (1) organizational innovations for achieving economies of scope; (2) an institutionalized capacity for strategic selection of research foci; and (3) a capacity to contribute to the development of new industries. All of these characteristics are entrepreneurial to the extent they distinguish universities from a narrowly defined or bureaucratic role as purveyors of a single task like providing higher education.

The preceding account suggests a basic mechanism of decline in university system entrepreneurialism as well. The mechanism works as follows. When national university systems grow and begin to exhibit cost containment problems, political pressures for top-down reform of the university system increase. Ultimately, top-down reform entails homogenization of the university system, weakening the contextual sources of entrepreneurialism identified in Fig. 1. The danger of system homogenization lies not only in the erosion of decentralized competition and of the associated benefits in allocative efficiency, but also in the longer-term disincentives to experimentation and adaptation.

This is to say that while certain details of the decline of German universities may seem idiosyncratic, the broad outlines of the process are arguably rather generic. For one thing, Germany was by no means alone in pursuing "big science" outside university walls or in opting for mass education policies in the 1960s. For another, the political pressures for institutional homogenization are quite visible even in university systems like that of the US. In response to rising tuition costs, US universities are increasingly subject to external scrutiny. Such scrutiny increasingly takes the form of accreditation processes that in practice encourage uniformity by assessing quality not on an ex post outcomes basis, but on the basis of ex ante characteristics like the percentage of student credit hours taught by PhD-holders. Recently, the federal government's National Commission on the Future of Higher Education recommended nationalized testing of college students, which, if enacted, could easily result in cookie-cutter standardization of higher education (Commission on the Future of Higher Education, 2006).[14]

Succinctly put, the sources of decline of university entrepreneurialism can be viewed as the partly unintended consequences of policy choices to cope with cost problems and, more broadly perhaps, the general problem of "demand overload" (Clark, 1998). Demand overload can result from growth, from the ever increasingly complexity of science, and from the multiplicity of activities that entrepreneurial universities engage in.[15] Interestingly, these overload problems facing universities were all felt by the German system over a century ago. The solution devised then was to create specialized R&D institutes. In and of itself, this was not an ominous development or one unique to Germany, but in retrospect it created the unfortunate precedent of coping with the growing complexity of science by alleviating universities of the opportunity to experiment with their own ways of mastering this complexity. The German university experience serves as a warning that reforms aiming to alleviate symptoms of complex choices by reducing the choices that universities are allowed to make may set into motion a path-dependent trajectory of system homogenization, eroding the system's capacity for self-adaptation.

[13] For example, the government of Schleswig-Holstein recently announced plans to merge the three universities at Lübeck, Kiel and Flensburg, although the geographical distance between them is substantial. The reaction to such plans in the mainstream press speaks volumes: "Mergers among colleges are no different than in large firms. Management hopes to realize savings, known as 'synergy effects' in merger jargon. Employees worry about losing their job or working under tough conditions" ("Nord-Unis wollen keine Fusion," www.spiegel.de, 12 November, 2005).

[14] As one US college president so succinctly put it: "National standards and testing in higher education will only strengthen a bureaucracy that already plagues an otherwise competitive system" (Arnn, 2007).

[15] Clark himself refers to the "demand overload" along four dimensions: more students, labor force segmentation, rising public expectations, and above all, "knowledge outruns resources" (Clark, 1998: 130).

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