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A National Systems View of University Development: Towards a Broadened Perspective on the Entrepreneurial University Based on the German and US Experience

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Abstract:

This paper postulates a life cycle model of university entrepreneurialism at the national level. Based on the analysis, this paper identifies two fundamental sources of such entrepreneurialism: 1) the institutional anchoring of the university of a public-private hybrid form in organization and finance; 2) decentralization of the system in such a way as to encourage a high level of competition and differentiation. We hypothesize that when national university systems grow and exhibit signs of demand overload, political pressures for system homogenization increase; system homogenization weakens both sources of entrepreneurialism and leads to decline. The sources of decline are thus unintended consequences of policy choices to cope with the side effects of demand overload within national university systems. Implications for the ascendant Chinese university system are derived.

Keywords: Entrepreneurial University, German University System, US University System, National Systems of Innovation, Interregional Competition, R&D Reform

JEL classification: I23, N30, N32, N33

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The modern university represents an evolutionary paradox. Observed up close, most universities appear to be paragons of inertia: bureaucratic, inefficient, and hopelessly slower-moving organizations than private sector firms. Yet from an evolutionary perspective, many of these same universities demonstrate remarkable longevity, often with histories 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 (Clark, 1998; Etzkowitz, 2002; Siegel et al., 2003; Gulbrandsen and Smelby, 2005; Lockett et al., 2005; Rothaermel et al., 2007).

What makes universities entrepreneurial? Departing from the usual focus on individual universities and inter-university differences, we adopt in this paper a national perspective on the sources of university entrepreneurialism (Casper and Kettler, 2001; Rosenberg, 2003; Gittelman, 2006). We will review 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; Nelson, 2004) to expand the frontiers of basic scientific knowledge *as well as* in the transfer of this knowledge to industrial application.

Of course, the German university system before 1914 and the US university system after 1940 bear considerable dissimilarities. This is precisely why study of the remaining parallels is an instructive exercise, for these parallels help suggest a conceptualization of university entrepreneurialism transcending specific and current developments of the phenomenon. Based both on historical experience and on theoretical grounds, we posit two

fundamental contextual factors that are indispensable to entrepreneurialism in national university systems:

1) the institutional anchoring of the university as a public-private hybrid in organization and finance;

2) decentralization of the national university system in such a way as to encourage a high level of competition and differentiation.

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 1 proposes a framework of entrepreneurialism in national university systems. Sections 2-4 provide a theory-based historical retrospective using this framework. Section 2 highlights key structural characteristics of the pre-1914 German university system, leading to ascendancy of this system. Section 3 reviews how broadly similar characteristics were enhanced in the ascendant US university system after 1940. Section 4 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 interprets the relative decline of the German university system to a life cycle effect which, as suggested in Section 5, could play itself out in broadly similar ways in the US and elsewhere. Despite the many German-US parallels, the analysis remains attentive to differences between the German "entrepreneurial" university of the 19th century and the American "entrepreneurial" university of the 20th. Thus, for example, in the concluding section, it is suggested that the ascendant Chinese "entrepreneurial university" of the 21st century will be quite different from that of the US; of this there are already signs.

1. 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 this contribution we endeavor to flesh out the macro systemic conditions that facilitate adaptive self-development in universities. In particular we will view university entrepreneurialism in the context of national innovation systems (Lundvall, 1992; Nelson, 1993; Freeman, 2004). While a full-scale demonstration of the thesis that the nation represents an important contextual variable concerning the entrepreneurialism of universities is beyond the scope of this paper, the EPO patenting statistics collected by Malik (2006) and excerpted in Table 1 are indicative of national differences in one vital scientific area (biotechnology) requiring deep capabilities both in basic research and in the commercialization of research (Rothaermel and Deeds, 2004; Gittelman, 2006).

Table 1: EPO Biotechnology Patents (K-1, K-2, K-3) Filed by Universities, 1994-2005	
US	**5626**
UK	362
China	210
Israel	112
Germany	**9**
France	5
Source: Malik (2006)	

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. The importance of truly country-level differences in technology commercialization by universities between the US and UK on the one hand and France and Germany on the other has been shown by many authors, including Gittelman (2006), Casper and Kettler (2001), and Lehrer and Asakawa (2004). Foreshadowing a point developed in our conclusion, Table 1 reflects the recent increase of patenting by Chinese universities, which evidently have become more entrepreneurial on this dimension. The question we endeavor to shed light on is: what are some of the basic drivers and characteristics of entrepreneurialism within national university *systems*?

Our proposed framework of national university system entrepreneurialism is depicted in Figure 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.

-- Insert Figure 1 About Here --

The framework encompasses two contextual factors within the national environment of academia that in combination promote the emergence of entrepreneurial universities and three behavioral traits of the entrepreneurial universities so emerging. These three behavioral traits form the basis for an enlarged definition of the entrepreneurial university; we argue that these traits are logical organizational responses to the two combined contextual factors.

The first proposed contextual factor, *the institutional anchoring of the university as a public-private hybrid in organization and finance*, has both an economic and organizational impact. From a purely economic point of view, the positive externalities of scientific knowledge, combined with the uncertainties and serendipity surrounding its discovery and application, militate for substantial public support of academic R&D (Nelson, 1959; Arrow, 1962; Dosi et al., 2006). At the same time, there is widespread evidence of the vital role that scientists even in basic research can play in the technology transfer process (Audretsch and Stephan, 1999; Murray, 2004), implying the need for private financial returns to scientific endeavor to coexist alongside academic career rewards for contributions to public science. However, the importance of the public-private "hybrid" (Owen-Smith, 2003) extends beyond just the complex economics of science and technology. There is some reason to think that "hybrid" forms of organization (Williamson, 1991; Casper and Kettler, 2001) may be particularly adaptive, hence conducive to "dynamic efficiency" as environmental conditions change. A noted constant of science is precisely that conditions do change, usually with increasing levels of overall complexity (Ben-David, 1971; Clark, 1993). One elementary advantage of a public-private form of organization, among others, lies in its capacity to enlarge either the public or the private component as changing conditions dictate.

The second proposed factor, *decentralization of the system in such a way as to encourage a high level of competition and differentiation,* is conducive to "open science" predicated on peer review as opposed to an insider system (Dasgupta and David, 1994; Nelson, 2004). Competitive markets for scientific talent notably enhance the resources obtained by the most innovative groups and individuals, ultimately improving resource

allocation among competing research projects and increasing overall public support for science (David, 2004). Beyond improving resource allocation, decentralized competition between 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). Thus, while some accounts of university excellence emphasize forces of the "visible hand" like administrative reforms (e.g. the Humboldtian reforms in Germany) or entrepreneurial groups and individuals (Clark, 1998; Etzkowitz, 2002), the present account gives more weight to forces of the "invisible hand" like competition and decentralization.

If financial-organizational hybridization and competitive decentralization 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 after 1945 provides confirmatory evidence of this hypothesis (and we present evidence that the brain drain was not a key explanation in this). The net result of the following analysis is therefore a hypothesized 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 (albeit with a certain time lag): the rise of the German national university system (section 2), the rise of the American university system (Section 3), and the relative decline of German university dynamism after 1945 (Section 4). 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). The three behavioral traits of the entrepreneurial university we consider in the following sections are: 1. Synergistic Multitasking (e.g. achieving economies of scope between basic and applied research, teaching, and cooperation with industry); 2. Strategic Selection of Research Foci; and 3) Vehicle of Economic Development.

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			

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.

2. The Ascendance of the German National University System

It is today hard to imagine to what extent the German university in the 19th century and, indeed, up until to 1960 was a public-private hybrid. While professors did receive salaries from the state, they also received auditing fees (*Hörgelder*) from students and collected fees from other activities, such as conducting doctoral examinations. More importantly, however, large segments of the teaching corps were self-financing. Many teachers had to eke a living from *Hörgelder*. In German universities even today, the still common title of *Privatdozent* is an anachronistic relic from the days when *Privatdozenten* were literally "private instructors" paid by students. The public-private hybrid character of the German university had advantages as well as disadvantages. The availability of *Privatdozenten* and *Assistenten* permitted accommodation of swelling student enrollment in the latter half of the 19th century at low cost to German states (Titze, 1990), helping German universities and polytechnic colleges to produce far more graduates and PhDs than other European nations (Fox and Guagnini, 1994; Miozzo and Walsh, 2006: ch. 3). At the same time, the increasing proportion of *Privatdozenten* and *Assistenten* led to an imbalance between the public and private components of the German university system, creating bottlenecks (e.g. administrative overload on the chaired professors) whose consequences in the 20th century will be examined in Section 4 below.

The other 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 moving costs *to* Prussia (vom Brocke and Krüger, 1994: 159). When professors changed jobs, they usually changed states as well. Lehrer (2007) tracked the career moves of renowned organic chemists in 19th-century Germany, showing that all of them changed not only universities, but states as well at least once in their career.

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)

One reason for emphasizing economic over administrative factors in accounting for 19th-century German success is precisely that German universities were not fundamentally hotbeds of organizational innovation. German universities have remained fundamentally conservative and resistant to change throughout their history (Ringer, 1983; Clark, 1993). Reform consistently had to be imposed from above (Hoffacker, 2000: 33; Morkel, 2000: 143). Most often reform impulses required the founding of new universities, such as the University of Göttingen (1736) and the University of Berlin (1810).

Yet despite undeniable organizational rigidities, the 19th-century German university inaugurated an unprecedented role for universities beyond just teaching students and providing a source of living for scholars. The following sections cover three domains in which German universities were "entrepreneurial" in the broader sense of the term developed in this paper: 1) Synergistic Multitasking; 2) Strategic Selection of Research Foci; 3) Vehicle of Economic Development.

1. Synergistic Multitasking. The modern research university is a German invention (Ben-David, 1977; Freeman, 2004). The most important kind of multitasking developed by German universities is summarized in the famous dictum of the "synthesis of teaching and research" (*Einheit von Lehre und Forschung*) which traces its roots back to Wilhelm von Humboldt and the University of Berlin (1810). The original premise for the Humboldtian synthesis was creativity more than the advancement of scientific progress; 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 isolation from external pressures.

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 of the 1820s at Giessen, with doctoral students working in a team-based environment, was a harbinger of the new era in scientific research combining systematized experimentation with theory-building that gained steam after 1850 (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 research integrating teaching and research (Lenoir, 1997). Hundreds of foreign PhD students streamed into Germany in the 19th century to receive training in scientific research methods unavailable elsewhere.[3]

2. 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).[4] 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) essentially sealed 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 since the former were in charge of professorial hiring. 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 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 liberal 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 conception of large-scale system rationality (vom Brocke, 1991) in which efficiency and effectiveness were imposed by top-down ministerial management of the entire national university system.

Table 4: Prussian University Specialization in the Althoff Era (1882-1907)

University	**Specialization**
Univ. 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 & Literature

Source: Vereeck (2001: 53)

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.[5] 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 covered in Section 4, were in part a response to perceived limits of what could be accomplished within the German university system.

3. Vehicle of Economic Development. 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. 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 -- first chemistry and later biology and medicine – had industrial applications. Starting in the 1850s several German states sought to upgrade their chemistry departments in order to aid agriculture and industry (Lenoir, 1998). Ultimately, Imperial Germany's global dominance in the vital industry of organic chemicals (synthetic dyestuffs, pharmaceuticals, synthetic fertilizers) derived largely from Germany's supremacy in the corresponding scientific areas (Murmann and Landau, 1998; Freeman, 2004).[6] Not only were German universities central in 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 in organic chemistry, 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).

Douglass 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, a major achievement of the German national system of innovation in the 19th century. 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 three-fold importance for industry based on the synthesis of teaching and research: 1) supply of large numbers of doctoral students trained to conduct scientific research; 2) allocation of funds to the research projects of top professors; 3) furnishing a model of state-of-the-art laboratory organization. Freeman (2004: 569-70) 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.

3. The Ascendance of the American National University System

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. Federalism enhances both contextual factors underlined in Figure 1, namely the public-private hybrid character of the universities and the level of decentralized competition among them. 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 indeed allows the private-public mixture to change dynamically over time. Within the state of Pennsylvania, for example, the University of Pennsylvania has transformed itself from a state university into a private, Ivy League institution, whereas Temple University did just the opposite, receiving increasing support from the Pennsylvania state legislature and becoming de facto a state university.

Nonetheless, both the public-private character of American universities and the intensity of inter-university competition were enhanced by 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 1940-45 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 postwar 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.

The United States became unique in the sheer scale of federally funded R&D that was carried out by universities. 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]

This is not to deny that entrepreneurial universities would have developed in the US even without the big bang of 1940. Deepening relations between industry and universities began after World War I (Swann, 1988). Vannevar Bush himself had been a top administrator at MIT, so that his famous 1945 vision of the "endless frontier" (Bush, 1945) of university research-driven progress stemmed from long observation of technology transfer from MIT to industry.

Nonetheless, large federal grants for R&D at universities greatly accelerated the drive by American universities to seek outside research funding, thereby enhancing competition among US universities and their respective regions. An indication of the competitive component in the allocation of university research funds is shown by Figure 2, which compares research funding at American universities with the much more uniform funding of R&D across professors and universities in Germany. In the US, the distribution of R&D funding among professors and universities is largely determined by success in securing support from competitive grants from federal agencies, of which the single largest funding source is the Department of Defense. Obtaining grant money is in scientific fields one of the primary indicators of academic productivity, imparting onto the US model of the entrepreneurial university the special characteristics outlined below.

-- Insert Figure 2 About Here --

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.

1. Synergistic Multitasking ("Research Entrepreneurship"). It has become customary to view the entrepreneurial university in the US as a "triple helix" (Etzkowitz, 2002; 2003) of teaching, research, and economic development. If we examine the day-to-day routine of a US academic scientist, however, one is more tempted to speak of a triple helix of teaching, research, and grant-writing; it is the preoccupation with grant-writing that perhaps most distinguishes a US research scientist from her German counterpart of a century ago. Beyond this, however, the vital role of competitive external funding of academic R&D encourages certain patterns of behavior that can be termed "research entrepreneurship."

Requiring more than just individual effort, success in the process of obtaining grants depends heavily on the ability of groups of researchers to organize themselves into teams and formulate a research agenda capable of garnering external support (Kenney, 1986; Gittelman, 2006). The core of the entrepreneurial university lies, as Etzkowitz (2003: 111) says, in "research groups [that] operate as firm-like entities":

> As group size increases to seven or eight members, professors who were formerly doing research are typically compelled to remove themselves from the bench to devote virtually full time to organization tasks. Often persons in this situation describe themselves as "running a small business" … Once having attained this goal it is extremely difficult to function again as an individual research, so every effort is made to sustain leadership of a group (2003: 111).

Similarly, 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).

Such "research entrepreneurship," which is arguably the core the US model of the entrepreneurial university, has never depended heavily on industry funding. 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). The prerequisite for "research entrepreneurship" is therefore a large-scale system of competitive grants. It is unlikely that such a 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).

Research entrepreneurship constitutes only one aspect of synergistic multitasking at US universities, of course, and one quick way of gaining a broader view of such multitasking is to look at their revenue mix. A comparison of US and German university funding (Figure 3) illustrates how US university funding has come to diverge from that of the German university. To make the differences meaningful, Figure 3 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) reflects the greater range of financially vital activities they engage in.

-- Insert Figure 3 About Here --

2. Strategic Selection of Research Foci ("Administrative Entrepreneurship"). At an administrative level as well, competitive R&D grants accentuates 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 top-down discretion in the allocation of resources. Among five criteria of the entrepreneurial university outlined by Clark (1998), the criterion relevant here is what Clark calls "a strong steering core." The top-down discretion of administrators at US universities allow such a strong steering core to emerge, whereas as in Europe, for example, "universities have long exhibited a notoriously weak capacity to steer themselves" (Clark, 1998: 5).

This steering core, 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."

The important result of this is that administrators at most research universities typically select a few strategic areas for systematic development, not least of all because 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 of the famous features of the US university system, less well-known and 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.[8] A key issue is critical mass. Specialization in strategically selected 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.

3. Vehicle of Economic Development ("Commercial Entrepreneurship"). 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 informal linkages with industry that were of considerable economic importance (Krücken, 2003; Miozzo and Walsh, 2006: ch. 3). In the US, a small number of universities, such as MIT and Stanford, developed these informal linkages to such an extent as to become veritable motors of regional economic development (Saxenian, 1994; Etzkowitz, 2002; Rosenberg, 2003).

Nonetheless, it is *formalized* commercialization activities (Rothaermel et al., 2007) that have received the most attention in 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 longstanding debate of which Guena and Nesta (2006) provide a useful overview.

Our argument is that commercial entrepreneurship, while an important and growing trend, is not nearly as central to the US-style entrepreneurial university as what we have called research and administrative entrepreneurship. For whereas the latter types of university entrepreneurialism are quite widespread in the US, the former types are truly significant only among a very few universities. For example, only a tiny handful of the American universities that have established technology licensing actually earn significant revenues (Owen-Smith and Powell, 2003). Similarly, a small number of eminent US universities generate a 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). Perhaps the best argument for encouraging commercial entrepreneurship on a larger scale is the complementary knowledge that it helps academic researchers to build in the process of commercializing discoveries (Lockett et al., 2005), since the existence of feedback loops from applied to basic research is undeniable (Rosenberg, 1994; Mokyr, 2002).

4. The Decline of the German National University System

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 account of German university decline emphasizes the reversal of precisely the three core traits of the entrepreneurial university derived from the preceding analysis, i.e. 1) Reversal of Synergistic Multitasking; 2) Reversal of Strategic Selection of Research Foci; 3) Reversal of Vehicle of Economic Development. In other words, the relative decline of Germany's universities was not just the result of inertia. It followed from active policy choices.

These policy choices were partially, to be sure, a response to institutional rigidities. Two key rigidities of the German university system, often associated with the Humboldtian reforms but with historically much deeper roots, are academic freedom and professorial self-governance. Academic freedom in the German context guaranteed not only freedom of expression, but autocratic control by the chaired professor over teaching and research activities within his largely autonomous organizational unit, the *Lehrstuhl* (Muller-Camen and Salzgeber, 2005). Academic "freedom" in the German sense means freedom from outside pressures and interference, a right which German professors except during 1933-45 have insisted upon with a vengeance. Academic freedom further vests control of university matters in the hands of the titled professors themselves (self-administration).

These two structural characteristics of the modern Germany university system are difficult to modify even today because they are so firmly anchored in law (Hoffacker, 2000). Article 5.3 of the German constitution (*Grundgesetz*) states that "art and science, research and teaching are to be conducted in liberty" (*Kunst und Wissenschaft, Forschung und Lehre sind frei*); anchored in longstanding tradition, this article was largely a carryover from the Weimar constitution.[9] In legal practice, article 5.3 has been interpreted to mean that professors must decide all matters relating to teaching and research. German professors have the right – and the burden -- of majority representation on all university committees, a right sanctioned by 1973 and 1993 decisions of the German Constitutional Court and condemning professors to exercise their "freedom" by serving on countless administrative bodies.

1) Reversal of Synergistic Multitasking. Given the unparalleled success obtained by the German teaching-research synthesis at its universities in the course of the 19th century, the question arises as to why this synthesis was rather visibly loosened during much of the 20th century. For loosened it undoubtedly was. Surprisingly, the two world wars had little long-term effect. Instead, there were two other historic developments that weakened the link between the teaching and research. The first, dating from the late 1800s, saw the growing reliance of Germany on specialized R&D institutes – not as a complement to university research but as a substitute for it --, ultimately expanding the German R&D system largely outside the realm of higher learning. This is reflected in Table 5, which shows that Germany's Nobel Prizes came increasingly from specialized R&D institutes like the Max Planck Institutes -- at the expense, one might say, of the universities. As seen in Table 5, such institutes are roughly on a par with comparable US research centers in the per-capita production of Nobel Prizes, casting doubt on brain drain theories of German university decline and suggesting organizational factors instead. The second major development, dating from the 1960s, coincides with democratic efforts to transform German universities into institutions of mass education, tilting the teaching-research balance more in favor of teaching as an administrative priority.

Table 5: 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

Development #1: The establishment of specialized R&D institutes. As science became more complex and state-of-the-art laboratories more costly to build in the course of the 19th century, it was Prussia that took the lead in consigning scientific research to specialized R&D institutes outside the university system. The German university became a victim of its own success. The swell of student enrollment during the 19th century far outstripped the rate of increase in university faculty, leading to increasing administrative burdens on faculty and

raising doubts about whether the university was the best place to locate research scientists. In period 1871-1910, the number of regular (*ordentliche*) 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 (*ordentliche*) professors by only 60%, considerably less than the rise in unchaired (*außerordentliche*) professors (+140%) and *Privatdozenten* (+250%) (Titze, 1990). The inability of the German university growth to keep pace with enrollment was in turn due in large part to the increasing cost of funding expensive laboratories in the natural sciences (vom Brocke, 1990: 24).

The financial bottlenecks were overlaid with the aforementioned institutional rigidities. Professorial self-governance precluded long-term planning and coordination of applied research (Klüver, 1983: 84). 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 unchaired 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 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).[10] The examples of Rockefeller and Carnegie drove home the importance of finding an organization 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 complicated 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 only with the rise of the welfare state in the 1960s, when the Max Planck institutes were homogenized into almost fully state-financed institutions (over 95% state-funded in the 1990s).[11] The same fate of increasing public-sector uniformity befell the universities after 1960, as explained next.

Development #2: The prerogative of mass education. The 1960s marked another weakening of the synthesis between teaching and research. Prior to this and extending back into the Weimar Republic, the German university had been stuck in a kind of time warp as an elite institution for the well-to-do. As in many other Western European countries in the 1960s, the reform objective was to make higher education accessible to a greater proportion of the population. 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).

The prerogative of mass education did not obliterate academic research but definitely made teaching the greater political priority (Hödl and Zegelin, 1999: 56-7; Morkel, 2000: 9). In two distinct phases, accommodating the massive influx of students became the paramount political objective of decision-makers. During the economic boom years of 1965-73, 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.[12] In this phase, the federal government's priority has been to promote greater efficiency of scarce resources while ensuring uniformity of conditions.

2) Reversal of Strategic Selection of Research Foci. 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, although 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 the Higher Education Framework Law was revised in 2002.

How has this affected the ability of the universities to select research foci? To be sure, German universities do feature a large variety of specialized research institutes. Some are simply normal chaired departments (*Lehrstühle*) designating themselves as such after finding a niche, 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.[13]

Concrete recommendations to induce greater specialization (*Schwerpunktförderung, Profilbildung*) at German universities only began to surface in the 1990s, mainly as a way to cope with overall budget constraints, and actual implementation has been slow (Oehler, 2000: 134-5). Thus, the positive rationale of greater specialization has been less pronounced than the negative motivation of reducing duplication. Several federal states have announced plans to merge universities in order to consolidate academic programs and reduce expenses.[14]

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.[15] The most notorious expression of such uniformity is the nationally centralized admissions agency ZVS (*Zentralstelle für die Vergabe von Studienplätzen*) that in crowded disciplines (e.g. medicine) rations admissions 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 … Even within Europe German universities hardly belong at the top. When the famous Jiao-Tong University in Shanghai recently published a ranking of universities based on international publications, the first German university (LMU Munich) came in 10th among European universities and 48th in the international rankings (Spiewak, 2004: 3).

3) *Reversal of Vehicle of Economic Development.* 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 and Stolpe (2002), according to which 89% of Germany's exports come from the industrial sectors whose basis lies in the excellent universities of a hundred years earlier, is sobering. Germany's high-tech industries of yesterday have matured into the medium-tech industries of today for which university research is not a critical component (Casper et al., 1999; Siebert, 2005). Many theories have been advanced to explain modern Germany's pronounced weakness in high-tech sectors (Casper et al., 1999; Lehrer and Asakawa, 2004); the systemically induced loss of dynamism in the German university system might well be a factor (Lehrer, 2007).

Arguably it is this systemically induced loss of dynamism that explains the German university lag in contemporary forms of commercial entrepreneurship. 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 in the 1990s was a serious attempt undertaken to set up start-up incubators at German universities (Lehrer, 2000), and only since the mid 1990s have technology licensing offices become a feature of German universities (Abramson et al., 1997).

5. Discussion

For all their differences, the German "entrepreneurial" university before 1914 and the American "entrepreneurial" university after 1940 flourished amid common contextual conditions of public-private hybridization and decentralized competition. In both national systems universities developed the following "entrepreneurial" characteristics: 1) a capacity for "synergistic multitasking," able to productively combine activities from variegated task

domains and multiple funding sources; 2) strategic differentiation by individual universities, selecting specific research areas in which to specialize and expand the knowledge frontier; 3) the ability to act as a vehicle of economic development. 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 signs of "demand overload" (Clark, 1998), political pressures for top-down reform of the university system increase. Ultimately, such reform entails homogenization of the university system, weakening both of the contextual sources of entrepreneurialism identified above. System homogenization can weaken the public-private hybrid either by converting the universities to an overwhelmingly public system (as in Germany today) or to an overwhelmingly private system (as has been traditionally the case in Japan); American universities, clearly, need to be concerned about the latter scenario as federal R&D funds risk being crowded out by other funding exigencies. By the same token, system homogenization can weaken decentralized competition by imposing uniform standards from above.

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, German 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 many fields US universities are increasingly subject to accreditation processes that in practice encourage uniformity by assessing quality on the basis of easily compared statistics 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).[16]

Succinctly put, the sources of decline of university entrepreneurialism can be viewed as the unintended consequences of policy choices to cope with demand overload of national university systems, leading to a vicious cycle. Demand overload, in turn, can result simply from the combination of the ever increasingly complexity of science and from the multiplicity of activities that entrepreneurial universities engage in. Clark 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). Interestingly, these overload problems facing universities were all felt by the German system at least 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 it created the precedent of coping with the growing complexity of science by simply 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 entrepreneurial self-adaptation.

6. Conclusion: Lessons for and about China

While much current research identifies the "entrepreneurial university" largely with its efforts to commercialize scientific discoveries, we have argued for a broader definition of the term emphasizing the capacity of entrepreneurial universities to respond to changes in their scientific and social environment. Such universities are entrepreneurial in responding to changing opportunity sets: changing opportunities to reap economies of scope across multiple task domains ("synergistic multitasking"), changing opportunities to differentiate themselves from other universities by specializing in particular domains of knowledge ("strategic selection of research foci"), and changing opportunities to contribute to the regional and national economy ("vehicle of economic development").

We have argued for the importance of adopting a national systems approach, for it is at this level that the dynamic aspects of university entrepreneurialism and adaptation over time can be studied. By way of conclusion, it is worth pointing out that one of the surely ascendant university systems of the 21st century – the Chinese one – will mostly likely develop a new and different model of the entrepreneurial university than either the German one of the 19th century or the American one of the 20th. This is due both to the different institutional and economic environment in which Chinese universities operate and the distinct competences and social structures that have crystallized in them over time. One very prominent idiosyncrasy of Chinese universities are university-run enterprises (Eun et al., 2006; Xue, 2006), firms founded and owned by the universities themselves. Interestingly, the universities with the highest revenues from their own enterprises are also those with the highest rankings in academic performance (Xue, 2006), a powerful vindication of the whole

concept of the entrepreneurial university. Although university-run enterprises are controversial even within China and their future evolution is highly uncertain (Eun et al., 2006), the historical examples of Germany and the US would suggest that the Chinese entrepreneurial university of the 21st century will develop its own special model and trajectory, partly as a result of such enterprises.

This is likely because in China the basic conditions for widespread experimentation and system adaptation are met. Chinese universities are public-private hybrids, in which government funding accounts for only about 30% of their revenue, with industry contracts (ca. 40%) and tuition (ca. 10%) providing for major sources of total revenue; this is in addition to the funding contribution of university-run enterprises, which is highly variable across institutions (Xue, 2006). And despite some pressures for centralization (Hawkins, 2000), decentralization largely prevails in the Chinese university system, enabling individual universities to try out their own local solutions. What is important here, as this research has tried to demonstrate, is not the snapshot of academic activities at a given point in time, but the underlying conditions enabling the overall system to experiment, develop, and adapt. Going into the 21st century, these conditions appear to be met in China. The normative advice emanating from the preceding analysis is too obvious as to require recapitulation.

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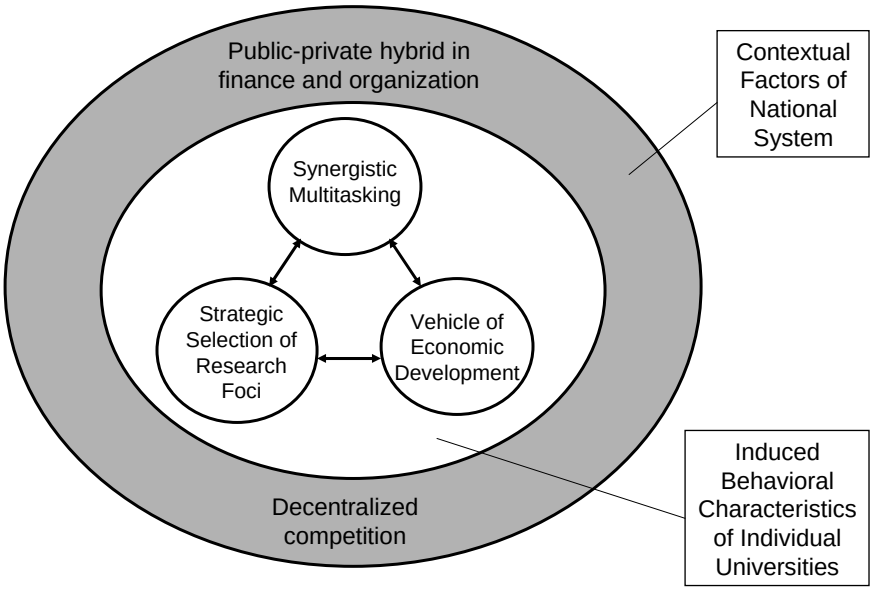
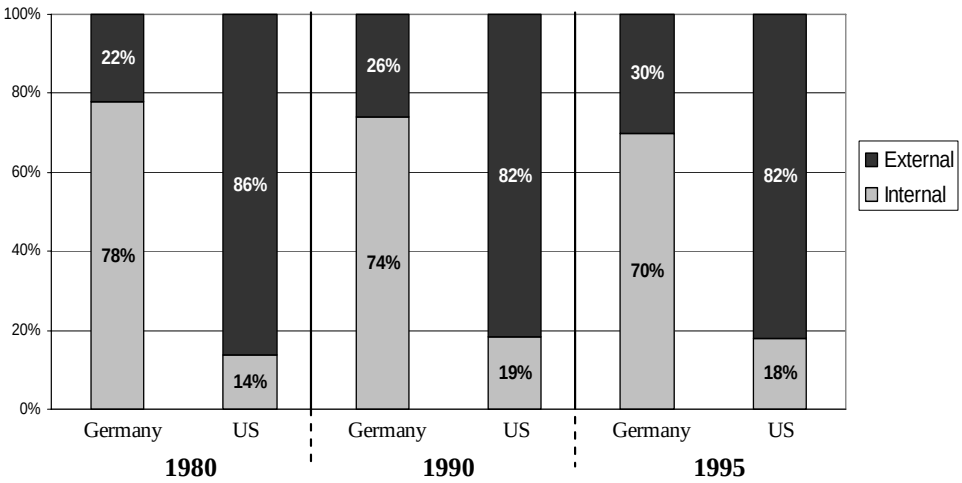


Figure 1: National University System Entrepreneurialism

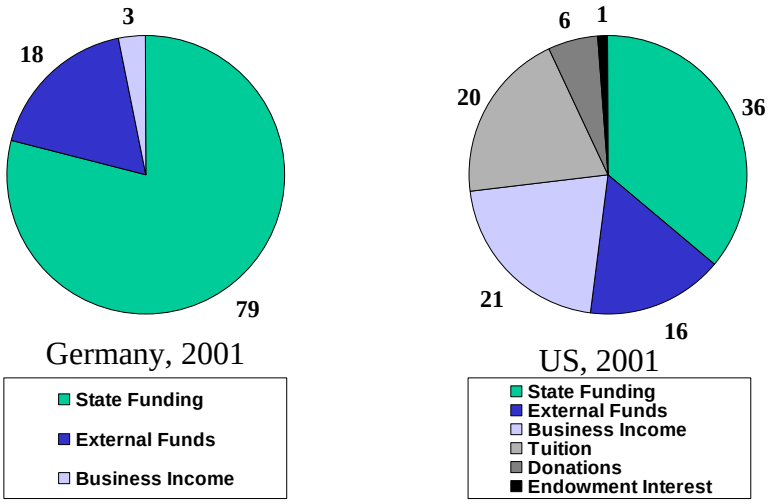
Figure 2: Proportion of Internal vs. External Funding of Academic R&D in Germany and US



Source: Calculated from Abramson et al. (1997)

Figure 3:

Income Sources of Public Universities in Germany and the US



Source: Leszczensky (2004)

NOTES

[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.

[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 & 276).

[3] The German model of laboratory-based doctoral training served as the model for implementation of doctoral research programs at US universities, beginning with Johns Hopkins in the late 19th century (Ben-David, 1977).

[4] 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.

[5] 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 15000 (Vereeck, 2001: 63); such 4:1 salary differentials became unthinkable in later more democratic eras (albeit still possible in the US today).

[6] 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).

[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).

[8] Here follows a list of non-elite public universities that offer a top-ranking academic and/or research program (usually among the top 5 nationally) in a strategically nurtured area, illustrating that private universities are not a pre-requisite for specialization and that elite status is not a pre-requisite for selective pre-eminence. Univ. of Illinois, Urbana-Champaign: College of Engineering (multiple departments); University of Minnesota: Department of Chemical Engineering; University of South Carolina: International Business Program; University of Arizona: College of Optical Sciences; Georgia Tech: School of Industrial and Systems Engineering; University of Rhode Island: School of Oceanography; University of California, Davis: Department of Viticulture and Enology; Colorado School of Mines: Department of Petroleum Engineering; Rutgers University: Department of Philosophy; University of Washington: Department of Mathematics; Univ. of Massachusetts, Amherst: Department of Linguistics.

[9] Academic freedom and corporatist self-governance by professors, well-established by the 18th century and further sanctified in laws passed in most German states after 1848, can be viewed as the heritage of a political compromise in which German professors cultivated a conservative outlook in return for freedom from state meddling in their affairs (Ringer, 1983).

[10] 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: 109-14; Szöllösi-Janze, 1996).

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

[12] 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).

[13] To be sure, competitive R&D funding is slowly advancing in Germany, as agencies like the DFG (German Research Association) and federal ministries have increased in relative importance over time (as reflected in Figure 2). Nonetheless, most German academic researchers have the option of remaining largely autonomous, if they so choose, by relying on their proportional share of basic institutional funds.

[14] 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).

[15] Recent minor reforms, such as the designation of certain “elite universities” by the state, merely reflect to what extent such uniformity had developed.

[16] 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).