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The Politics of Innovation: Institutional Change in Organizational Fields

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THE POLITICS OF INNOVATION:
INSTITUTIONAL CHANGE IN ORGANIZATIONAL FIELDS

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ABSTRACT

THE POLITICS OF INNOVATION: INSTITUTIONAL CHANGE IN ORGANIZATIONAL FIELDS

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This dissertation draws on organizational theory and the sociology of knowledge to explore of the politics surrounding innovations. I examine three cases of innovation within organizational fields: laboratory biology in nineteenth-century Germany, alternative medicine in the antebellum United States, and the contemporary global market for asset-backed securities. Institutionalist theories suggest that change is set in motion by exogenous shocks, whereas relational theories treat change as the product of endogenous shifts in patterns of interaction. For each case, I bring together archival sources and quantitative analysis to investigate how organizations' environment and networks predict the emergence of new field positions. I find that exogenous shocks can disrupt existing field positions, but new positions only coalesce when innovators are linked together through shared networks. The results carry implications for organizational theory, economic sociology, and the sociology of science.

For my parents

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INTRODUCTION

Scientific and technological innovation are central features of modernity. According to one school of thought, innovation necessarily takes the form of great upheavals. Schumpeter (1934) believed that innovation can release "gales of creative destruction" that sweep away old, outdated economic arrangements and leave behind new ones in their place. Much research on innovation follows in these footsteps. From this perspective, the adoption of an innovation cannot occur without a revolution the instruments of productive activity. Once loosed upon the world, organization built around successful innovations prosper, while those that cling to tradition are gradually driven out of business (Hannan and Freeman, 1977; Padgett and Powell, 2012, esp. Ch. 3 and 4).

Another approach sees the spread of innovations as primarily a matter of communication. This school of thought asserts that the adoption of new technologies is primarily a function whether individuals are aware of the innovation and their willingness to make the necessary changes (Rogers, 1983). Useful innovations are quickly taken up by early adopters, who set an instructive example for others. Successful innovations diffuse through networks of communication, spreading in a predictable way until they saturate the population.

These perspectives appear to present rather different views, but they share certain assumptions. Both treat innovations and their adopters as relatively fixed: new technologies are treated as uniform in their advantages, adopters have stable preferences, and organizational contexts are sufficiently immutable that change entails either minor adjustments or wholesale destruction. Together, they paint a Darwinian picture where adopters select useful innovations and are then selected upon by market forces. The best innovations ultimately win out, while less fit innovations and organizations wither away. There is little room in this picture for human agency or contingency in the implementation of new technologies.

The goal of this dissertation is to develop an alternate perspective that begins from the premise that scientific and technological change involves many actors working together in concert, and is often the product of long-run historical projects. The adoption of new technologies is rarely immediate or seamless, but instead requires the construction of new conventions governing the uses of innovations and their place in the broader social world. Technologies must be integrated into larger social and technological systems (Lounsbury, Ventresca, and Hirsch, 2003). Such systems often create their own politics: beneficiaries of the status quo tend to resist all but the most incremental changes, and moments of crisis can give rise to new coalitions that attempt to change the existing social and technological order.

Technological change is therefore also institutional change. In the context of formal organizations, institutional change is embedded within organizational fields, groups of organizations that share common goals and orient their actions towards one another. The three essays that follow provide analyses of social and technological change within three very different organizational fields: laboratory biology in nineteenth-century Germany, alternative medicine in the antebellum United States, and the contemporary global market for asset-backed securities. For each case, I bring together archival sources and quantitative analysis to investigate how changes in organizations' environments and network of relations predict the adoption of new sciences, therapies, and financial instruments. I show that innovations took root when actors coalesced in

response to challenges around new field positions, distinctive "bundles" of organizational features and activities. Legal and economic challenges to the status of universities, medical boards, and banks precipitated a crisis in each field, and new markets, medical groups, and scientific disciplines emerged as patterns of organization shifted in response to new conditions.

The remainder of the introduction develops a theoretical framework for processes of institutional change within organizational fields, and concludes with a brief overview of each of the three cases.

INSTITUTIONS AND ORGANIZATIONAL FIELDS

Institutional change is unavoidably a broad, rather diffuse concept. Social scientists use designate many things as institutions, and in part this reflects the very nature of social life. Institutionalization, as Berger and Luckmann (1966: 55-6) observe, is "incipient in every social situation continuing in time." For the sake of clarity, it is useful to briefly consider the concepts of institution, field, and organization in greater detail before applying them to processes of social and technological change.

We may say an institution exists when individuals have a sense of what actions are appropriate to a particular type of actor (Berger and Luckmann, 1966: 53ff.). Although institutions are often defined as any regular pattern of activity, what is distinctive about an institution is not so much its regularity as the fact that individuals know more or less what to do in a particular situation. The basis of any institution is a shared stock of knowledge about actors, activities, and situations. That knowledge becomes an institution when individuals engage in what Berger and Luckman (1966: 54) call "reciprocal typification" and generalize it to groups or categories of actors, including oneself and others. Institutions become internalized as both interpretive tools for assigning meaning to the actions of others and commitments to performing the actions appropriate to us in certain situations (cf. Mead, [1934] 1962). We also externalize them by encouraging others to uphold institutions and censoring them when they fail to do so, and by constructing our environment in such a way as to reinforce and naturalize the institutional rules we ourselves have made (Sewell, 2005: 356-69).

It is this latter form of externalization that lends an institution much of its durability and appearance of objective reality. The creation of consistent sets of environmental affordances sustain the regularities of social life that emerge from habit: good fences may not always make good neighbors, nor working stoplights better drivers, but they certainly make it easier for us to be fulfill these commitments (Martin, 2003: 40-42; 2010). Environmental affordances can also give overlapping institutions a degree of subjective coherence, even when the demands of each institution are different or contradictory. For example, the phrase "professor with grants" makes more sense in contemporary society than "professor with holy orders" because the infrastructure of university teaching closely coincide with that of scientific research. Of course, in an earlier era when universities were primarily church organizations this would not be the case. In a given time and place, some affordances may be highly consequential, like the publication record of a university teacher, while others, such as church membership, may be treated as largely irrelevant. The overlapping of multiple institutions nevertheless gives rise to what may be called a social

position. Having a sense of occupying a social position joins together an individual's conception of self with the wider flow of human experience.

Social positions are the building blocks of the larger social structures implicated in processes of social and technological change. Many social configurations are possible, but two overlapping but distinct concepts of social structure are especially relevant here: that of a field, and that of a formal organization.

Whenever a sense of social position leads to local inducements for actors to align their actions vis-à-vis one another, a field can be said to exist. For example, a simple rule embedded in geographic space like "neighbors ought to talk to one another" can give rise to predictable patterns in the spread of rumors, fashions, and the like (Butts, forthcoming). More sociologically consequential examples of field processes emerge when relationships between actors are agonistically oriented towards shared prizes or values (Turner, 1974: 135, cf. Bourdieu and Wacquant, 1992; Martin, 2003; DiMaggio and Powell, 1983; Fligstein and McAdam, 2012). In such a field, individuals' commitment to shared goals and sense of the opportunities available are determined in part by their position relative to other participants. The means to pursue a career as, say, a university professor is intertwined with the characteristics of others in the field, including both the pool of other candidates and the composition of the professoriate. Which qualities matter depends on present state of the field: in the case university professors, thousands of individual recruitment decisions collectively produce a hierarchy of criteria regarding what makes for a successful candidate (Bourdieu, [1984] 1988: 128-151). For all their dynamism, fields of organized striving are stable to the extent that dominant actors possess the authority to reproduce the principles underlying their own advantages. Field processes of this type have been well documented across a number of social environments, ranging from the professions (Delazay and Garth, 1996) to the arts and sciences (Bourdieu, [1984] 1988; [1992] 1996), to various markets of economic production (Fligstein, 2001).

A formal organization is likewise an institutional structure made up of a system of positions. At a minimum, it consists of nothing more than a set of rules that coordinate the activity of individual participants around a collective task (March and Simon, 1958; Weber, 1958). Typically, formal organizations have explicit membership criteria and some degree of functional differentiation between positions, although in the principles governing the division of labor may vary considerably. Under this minimum conception, an organization is nothing more than "a nexus of contracts," as agency theorists argue (Jensen and Meckling, 1976). But in practice, organizations frequently give rise to a variety of non-contractual forms of social order, including collective identities, networks of informal relationships, and struggles over the distribution of control and rewards within the organization. Because these activities can supplement, displace, or subvert the official goals of the organization, organizations may themselves also constitute fields (Fligstein, 2001; cf. Meyer and Rowan, 1977). Organizational fields may also emerge between different organizations if share common goals and are made up of a similar structure of positions. Organizational fields of this latter type can structure overall firm strategy, as well as the activities of individual members or subunits, which may be oriented towards their own field of rivals.

So far, this vision of social and organizational life appears quite static. It is easy to see how organizational fields can produce a dense tangle of institutionalized relationships, locking in

one set of structures within and across organizations, even when others may be possible and desirable. What is more, field processes also create powerful interests with an incentive to defend the status quo to the extent that they concentrate authority behind a group of dominant actors within the field. Yet nothing in this framework implies that change is impossible. Indeed, because in any field both the goals and the rules are at stake in any moment, a field also provides the basis for both dominant actors and their rivals to try out new strategies, technologies, and institutional arrangements in their ongoing struggle with one another. As a result, institutional change within an organizational field implies a kind of political process wherein actors attempt to change the field structure to their advantage.

PROCESSES OF INSTITUTIONAL CHANGE

Whether an innovation originates within or outside of the field, transforming it into an advantage within the specific institutional politics of a field often requires gaining the cooperation of other actors. The agonistic nature of relationships within a field is not necessarily a barrier to cooperation. Indeed, it may create powerful incentives to cooperate where different actors can perceive a mutual advantage. But securing cooperation often entails the enrollment of very different groups of actors into coalitions. Because organizational fields are structured around competing firms as well as their suppliers, consumers, regulatory agencies, and so on, the internal and external environment of an organizational field may be highly complex (DiMaggio and Powell, 1983, Scott et al. 2000).

Within an organizational field, innovations present challenges for dominant actors. Dominant actors can attempt to subvert potential challenges by absorbing the new technology into existing institutional structures. Task areas associated with new technologies may be subordinated into the existing hierarchy or partitioned off through functional differentiation. Tasks requiring the use of information technologies, for example, are often handed over to specialists who nevertheless fall under the supervision of incumbent authorities. This strategy has the advantage that it incorporates technological changes into existing institutional structures with an absolute minimum of disruption, but it also has risks: dominant actors my yield control of part of the organization to outsiders who may have only weak commitments to the current values that structure the field, and may bring with them alternative cultural frameworks. Should the new technology prove intractable, it may offer a basis for new criteria of value with the field. Within any field there may coexist many possible criteria of worth, not all of which are equally consequential. Subalterns can mobilize around new technologies to make claims on resources or to alter the principles of governance within a field. The challenges presented by innovations may work themselves out in a field in many ways, ranging from the preservation of the field structure, to it fragmentation or the transformation of existing hierarchies.

Organizational fields are embedded in a social environment consisting of diverse audiences, many of which are also structured as organizational fields. These include states, professions, and partner organizations (Abbott, 2005; DiMaggio and Powell 1983; Scott and Meyer, 1991). Shared linkages to external audiences may also facilitate the adoption of new technologies, or act as a bulwark preserving the current structure of the field (DiMaggio and Powell, 1991; Scott et al. 2000).

Perhaps the most important of these audiences are states. States are themselves dense latticeworks of organizational fields consisting of many levels and branches Abbott, 2005; Fligstein and McAdam, 2012). Under different circumstances the same issue can be elevated to national level or delegated to municipalities, and pass from legislators, to executive agencies, to the courts. States therefore possess many tools for enforcing different settlements upon organizational fields. They command considerable resources in the form of public funds, they can set down legal mandates that confer privileges on different actors or models of institutional structure within the field, and can promote certain models of organization through informal expectations regarding partner organizations (DiMaggio and Powell, 1983; Pfeffer and Salancik, 1974; Meyer and Rowan, 1977). Some linkages to the state may be quite tenuous, taking the form of passing opportunities created by the temporary ascendance of a particular coalition of political forces, while others by quite durable, as when agencies of government step in to sponsor "internal governance units" that setting down the rules of a particular field (Abbott, 2005; Fligstein and McAdam, 2012). Either kind of linkage can have long-lasting consequences for the institutional structure and balance of power within an organizational field.

The broader environment of economic life also constitutes an important environment for organizational fields. Clients, suppliers, and the professions all have direct and ongoing interactions with the organizations making up a field. Although they are not as well positioned to dictate decisive changes in field structures as states are, their ongoing relationships with actors in the field make it possible for institutional changes to diffuse into the organizational field and back. Distinctions based on relationships with these audiences are often the basis for distinctions among the organizations making up a field: customers and clients may be partitioned according to geography, social status, or any other category. Professions spread new organizational practices through training and accreditation programs that redefine the nature and aims of work within organizations (DiMaggio, 1991; DiMaggio and Powell 1983; Larson, 1977). Here too, shifting alignments due to social and technological changes can serve to degrade one set of institutional arrangements within a field or provide an organizational base for another.

In practice, none of these processes need operate independently. The internal dynamics of a field may feed into constraints or opportunities presented by external audiences, and the demands of external audiences may be refracted through different internal constituencies. It is necessarily therefore to examine the role of all of these factors simultaneously as institutional change unfolds over time in a given organizational field.

THREE CASE STUDIES OF INSTITUTIONAL CHANGE

The dissertation examines three cases of institutional change within organizational fields. The first paper examines the emergence of new life sciences disciplines at German universities over the course of the nineteenth-century Germany, drawing attention the role of relationships between states, the learned professions, and within the scientific field in this process. The second paper examines the causes and consequences of the erosion of the medical profession's institutional collapse in the early United States, focusing on how different groups of medical practitioners understood their relationship to one another and attempted make common cause with

state authorities for or against the profession's mainstream. In the final, I use a quasi-spatial method to model the structure of the mortgage finance market following the repeal of the Glass-Steagall Act, showing how U.S. and international banking firms converged on a strategy of vertical integration in subprime mortgage lending pioneered by nonbank lenders. In each case, I examine how the interplay between forces internal and external to the field gave rise to new institutional structures incorporating new technologies.

The emergence of the life sciences in Germany constitutes an early and extensive case of institutional change in an organizational field. The structure of the field in the eighteenth century guaranteed the privileges of individual universities while separating the study of life into the distinctive milieus of medical theory, natural history, and agricultural improvement. Over the course of the nineteenth century, new disciplines such as physiology, biochemistry, and comparative anatomy proliferated in the German universities, and by the end of the century dominant life science disciplines commanded considerable cultural and organizational power across the universities. The incorporation of isolated university faculties into disciplinary hierarchies required that new relationships be forged between states, professions, and universities. The university reforms of Prussia and other German states were instrumental to the invention of the modern research university, as was the development of the medical professions in the case of the life sciences, but the successful establishment of new life science disciplines also entailed the reconfiguration of relationships among scholars across universities and disciplines.

The rapid and complete collapse of the professional monopoly of physicians in the United States during the first half of the nineteenth century demonstrates how changes within an organizational field can also lead to its fragmentation. The structure of the eighteenth-century medical profession placed physicians at the top of the social and professional hierarchy. Pharmacists, dentists, and practitioners of alternative therapies like botanical doctors and homeopaths all stood under the jurisdiction of licensing boards composed of physicians. But between 1833 and 1844, all states but one repealed or nullified medical licensing laws, even as national credentialing systems granting new powers to physicians were established in France (1803), Britain (1858), and Germany (1869). In the United States, however, broader campaigns to eliminate traditional privileges and place trust in the judgement of common man and the workings of free markets took hold during the Jacksonian era. Citizens, legislators, and alternative medical practitioners found common ground in overturning the institutions governing the medical profession.

In the case of subprime mortgage lending, questions about how fields evolve also have considerable substantive importance. In 1996, subprime lending was a marginal financial activity, largely separate from the rest of the U.S. banking industry. The three largest lenders were a diverse cast of non-bank firms with ties to consumer finance, including an automobile loan company (Associates First Capital), a mobile home contractor owned by a Belgian conglomerate (Conti), and a non-bank lending company (The Money Store). By 2007 however, the origination and securitization of subprime mortgages had become a core activity of some of the largest banks and financial services companies in the world. The old model of subprime lending as a side business for check-cashing companies and mobile-home builders was replaced by an "industrial conception" of subprime mortgage finance, in which vertically-integrated firms sought to capture as much subprime lending activity as possible and used those loans as assets to back an array of

novel financial products (Fligstein and Goldstein 2010; Goldstein and Fligstein n.d). The rise of this new model brought down the barriers between subprime mortgage lending and securities trading. It also led worldwide to huge losses for investors, laid low some of largest financial institutions, and prepared the grounds for a prolonged recession.

CHAPTER 1: THE EMERGENCE OF THE LIFE SCIENCES FIELD

States, professions, and the institutionalization of disciplines in Germany, 1770-1890

The emergence of scientific disciplines is intertwined with the development of the bureaucratic state and the learned professions. Scientific disciplines first appeared in their contemporary form around the start of the nineteenth century (Cahan, 2003; Heilbron, 2004; Stichweh, 1984). Since that time, governments have been among the most generous patrons of disciplines and the largest employers of scientists, mainly through research centers and public universities (Ben-David, 1971: 173-6; Price, 1963: 82-102; Gerbod, 2004). Professions, for their part, have come to depend upon disciplinary specialists both to authorize their claims of expertise and to train aspiring professionals (Abbott, 1988: 195-211; Larson, 1977: 51, 149-54). And perhaps most importantly, scientific disciplines are themselves often organized along professional lines (Ben-David, 1971: 169-71; Gieryn et al., 1985; Gieryn, 1999; Kuhn, [1974] 1977: 294-8). In these ways, states, professions, and disciplines have constructed and defined themselves partly in relation to one other.

Studies of these interconnections tend to focus on the role of disciplines as guarantors of scientific autonomy. Much of the scholarly literature treats scientific disciplines as independent communities, each organized as an exclusive profession pursuing its own unique model of inquiry (Abbott, 2001: 121-31; Bourdieu, [2001] 2004: 45-50; Gieryn, 1999). This arrangement is thought to protect and delimit the internal activities of disciplines, thus preserving the autonomy of the scientific community and rendering outside authorities dependent on disciplinary experts for guidance in scientific matters (Polanyi, 1962; cf. Ben-David, 1971, esp. 160-2; Bourdieu, [2001] 2004: 47-51, 54-5; Stichweh, 1984: 90-1). Of course, in recent years disciplines have come under increasing strain from an "unprecedented perfect storm" of declining state support for universities, rising demands for social and commercial relevance, and new models of higher education (Smelser, 2013: 78-115). In this climate, there have been renewed calls for a reexamination of disciplinary authority and its social underpinnings, but most of this work attends exclusively to the contemporary moment (Frickel and Moore, 2006; Jacobs, 2013; Panofsky, 2010; Stevens et al., 2008).

The present article takes a longer historical perspective in order to show how states and professions have played a powerful but largely indirect role in the development of scientific disciplines. I begin from the premise that disciplines are not isolated social worlds, but are instead akin to intellectual coalitions that depend on the cooperation of both external authorities and other scientists to further their research agendas (Collins, 1998; Knorr-Cetina, 1981: 68-90; Latour, 1984; Whitley, 1984). Relations with other scientists are often of the most immediate importance: scientists find employment, inspiration, and recognition through colleagues within their home disciplines and elsewhere. But I shall argue that states and professions establish the very conditions of existence for these kinds of relations (Abbott, 1988: 169-75; Bourdieu, 1996: 127-8, 198-200; Collins, 1998: 380-381,791-793). States construct markets for scientific labor by funding research and channeling it into higher education systems. The cultural affinities between professions and disciplines reinforce the authority of established disciplines, but can also help foster the development of new disciplines. Even if the initial formation of a new

discipline is largely unconnected to external conditions, its development is not: the activities of states and professions feed into the relative circumstances of both disciplines and universities, lifting some upwards and casting others down into obscurity.

To establish this argument, I analyze the founding of research institutes in 22 life science disciplines at eighteen German universities over the course of the nineteenth century. The development of the life sciences in Germany constitutes an early and extensive case of discipline building. The case is exemplary because life science institutes were among the first organizations to unify research and teaching under the aegis of specialized disciplines (Heilbron, 2004; Zloczower, [1960] 1981). In the eighteenth century, medical theory, natural history, and agricultural improvement were all part of an Enlightenment scientific milieu that was largely separate from higher education. Physiology, biochemistry, and comparative anatomy, and other new life sciences organized around the phenomena of life itself arose in the early nineteenth century and were incorporated into the universities in the form of specialized institutes. New relationships between states, professions, and rising life science disciplines were forged in the early nineteenth century German universities. The university reforms of Prussia and other German states have long been acknowledge to have been instrumental to the invention of the modern research university, and the development of the life sciences was prototypical of successful discipline-building (Ben-David, 1971; McClelland, 1980; Turner, 1987). By the end of the nineteenth century, the life sciences were held up as an exemplar of disciplinary professionalism in other fields, most especially in the social sciences (Ben-David and Collins, 1966; Lepenies, 1985).

I focus on university research institutes because the activities of these organizations were decisive to the triumph of specialized disciplines over the gentlemanly milieu of eighteenth-century science. Within the natural sciences, university institutes were foundational to the creation of new research practices and the constitution of disciplines as recognized groups. As forerunners to academic departments, they were among the first establishments to bear explicit disciplinary identities. Institutes brought together access to materials and equipment, the dissemination of research findings, and the training of new scientists (Kremer, 1992; Turner, 1987). By the middle of the nineteenth century, the burgeoning scholarly output of university life science institutes claimed a large share of scholarly attention in Germany, making the directors of institutes influential scientific gatekeepers and marginalizing independent scientists (Collins, 1998; Turner, 1987). Of course, scientific societies and even disciplinary institutes existed as far back as the sixteenth century. Yet it was only in the nineteenth century that university institutes brought higher education and original research into sustained conversation. University institute personnel would go on to found disciplinary journals, lead disciplinary societies, and establish disciplinary credentials. This was especially true in the case of the life sciences in Germany.

STATES, PROFESSIONS, AND DISCIPLINARY INSTITUTIONALIZATION

Like contemporary departments, nineteenth-century life science institutes had a dual mandate as both research and teaching organizations. The staff of a life science institute therefore had to justify claims to state and university resources in terms of both the scientific

value of their research and the pedagogical contributions of the institute. It is therefore useful to think of research institutes as embedded within two different fields of activity: first, the field of universities and other institutions of higher education, and second, the field of scholarship scientific disciplines. States and professions sit largely outside of both of these spheres of activity, but have the potential to shape their organization in consequential ways.

Sociological neoinstitutionalism assigns a central role to states and professions in the diffusion of new organizational forms (DiMaggio and Powell 1983; Scott and Meyer, 1991). For Dimaggio and Powell (1983: 147) states and professions are an "engine of rationalization and bureaucratization." Legislators, executive agencies, and the courts restructure organizations through the use of legal mandates and other less formal stipulations on the conditions for access to public funds and recognition (Pfeffer and Salancik, 1974; Meyer and Rowan, 1977). Professions spread new organizational practices through training and accreditation programs that redefine the nature and aims of work within organizations (Larson, 1977; DiMaggio, 1991). Shared linkages to either may therefore facilitate the adoption of common structures, procedures, and beliefs across a field of organizations (DiMaggio and Powell, 1991; Scott et al. 2000).

Because university science is dependent on each of these clienteles, it is likely to be especially susceptible to these kinds of isomorphic pressures (DiMaggio and Powell 1983: 155-156). Nation states subsidize higher education in order to train useful citizens and to foster a shared high culture, often at the expense of local and particular loyalties (Gellner, 1983; Jarausch, 1982). From the nineteenth century onwards, higher education policymakers have concerned themselves with expanding science education at colleges and universities in order to prepare students for technical and professional occupations (Drori, et al. 2003; Schofer and Meyer, 2005). The steady expansion of university enrollments since the late nineteenth century has encouraged the further rationalization and differentiation of instruction into an expansive array disciplines and interdisciplinary subjects (Frank and Gabler, 2006; Jencks and Riesmann, 1968). It easy to see how the seemingly ever increasing supply of students and resources directed towards university science could give rise to opportunities to develop new specialty areas.

The rise of the professions has also supported the growth of scientific disciplines. Not only are professions consumers of disciplinary knowledge, but the very process of discipline formation is often seen as akin to professionalization in the sociology of science (Ben-David, 1971: 169-71; Gieryn, et al., 1985; Gieryn 1999). Building on Kuhn, this work proceeds from the idea that science makes progress when a research community possesses a strong commitment to a "paradigm" or "disciplinary matrix" of shared theoretical beliefs, values, and techniques (Kuhn, 1962; 1977: 294ff.). Professional organization provides the social foundations of disciplinary consensus: standardized training, disciplinary credentials, specialized publishing outlets, annual meetings, and a dense communication network among scientists all help academic departments maintain a clearly bounded disciplinary identity and a high degree of control over the market for scientists (Burris, 2004; Gieryn, 1999; Mullins, 1972; White, 1992: 118-24). Taken together, there is good reason to expect that both the bureaucratic rationalization of universities and the professionalization of disciplines have contributed to the widespread institutionalization of scientific disciplines.

But it is also clear that these influences will not be experienced in the same way by all universities and all disciplines. Research institutes are structurally equivalent to one another in the sense that they draw upon common audiences for material support, students, and recognition (DiMaggio and Powell, 1983: 148). But like many organizations, research institutes are also in competition with one another for the attention of those audiences. Any difference between institutes may offer an advantage, and therefore institute directors make every effort to stay abreast of the activities of their rivals (Latour, [1984] 1988; Knorr-Cetina, 1998). Competition of this sort contains the seeds of inequality within the field, and dependence on states or professions may accentuate these inequalities by further empowering some institutes and disempowering others. As Bourdieu (1996: 127-8) puts it, the principles at stake in struggles within the most autonomous of fields may quite be independent of the concerns of outside audiences, but they are nevertheless dependent in their outcome on the correspondence they maintain to external conditions. New institutes succeed in part based on the degree to which they are able to convert potentially favorable external circumstances into specifically scientific and educational advantages (Abbott, 1988: 169-75; Collins, 1998: 380-381,791-793).

It is perhaps immediately apparent to any academic that not all universities are created equal. The actions of states or other external authorities may strengthen or weaken universities, as well as alter the relationships between universities. In continental countries, this often takes the form of direct involvement of the ministry of education in university affairs, but even in the United States state and federal governments help maintain stark differences among universities. Although scientists generally face fewer challenges in traversing national boundaries for employment than other professionals, states can use their considerable resources to either cultivate networks of external recruitments or protect national higher education markets from the predominance of outsiders. State programs may also concentrate resources behind a certain subset of universities, hardening distinctions between universities. Funding from the National Science Foundation, for example, has been dominated by a small subset of universities throughout the postwar era (O'Mara, 2005). And state mandates and regulatory regimes help give rise to steep distinctions between higher education institutes. The segmentation of the higher education market tends to concentrate scholarly attention around a few elite centers of learning, which educate the majority share of future university teachers. (Collins, 1998: 379-383; Burris, 2004).

The relationship between disciplines and professions is more complex, due in part to the apparent overlaps between the two concepts (on the conflation of disciplines and professions, see Forman, 2012). On the one hand, professionalization often seen as model outcome for successful discipline, and other hand successful professions seek to establish "disciplinary avatars" within the university to train future professionals and ensure the cultural authority of the profession (Abbott, 2005; Mullins, 1972; Gieryn, 1998). But because the production and dissemination of scientific knowledge is a different task from competition among professions, the professionalization of disciplinary work is never complete. Disciplinary boundaries a much hazier than professional boundaries within universities, interdisciplinary collaboration appears to be as old as the disciplines themselves (Abbott, 2001; Jacobs, 2013). Common research interests lead scientists to collaborate across disciplines, and many administrative tasks such as budgeting and collegial governance are inherently interdisciplinary (Friedkin, 1998; Pfeffer and Salancik 1974; Rawlings, 2015). Nevertheless, the field of scientific disciplines is no more inherently

equal than the field of universities. Disciplines compete for attention and scientific authority with one another, and the legitimacy of a new discipline depends in part on its ability to intercalate itself into this implicit pecking order (Bourdieu, 2004: 62-68).

THE EMERGENCE OF THE LIFE SCIENCES AT THE GERMAN UNIVERSITIES

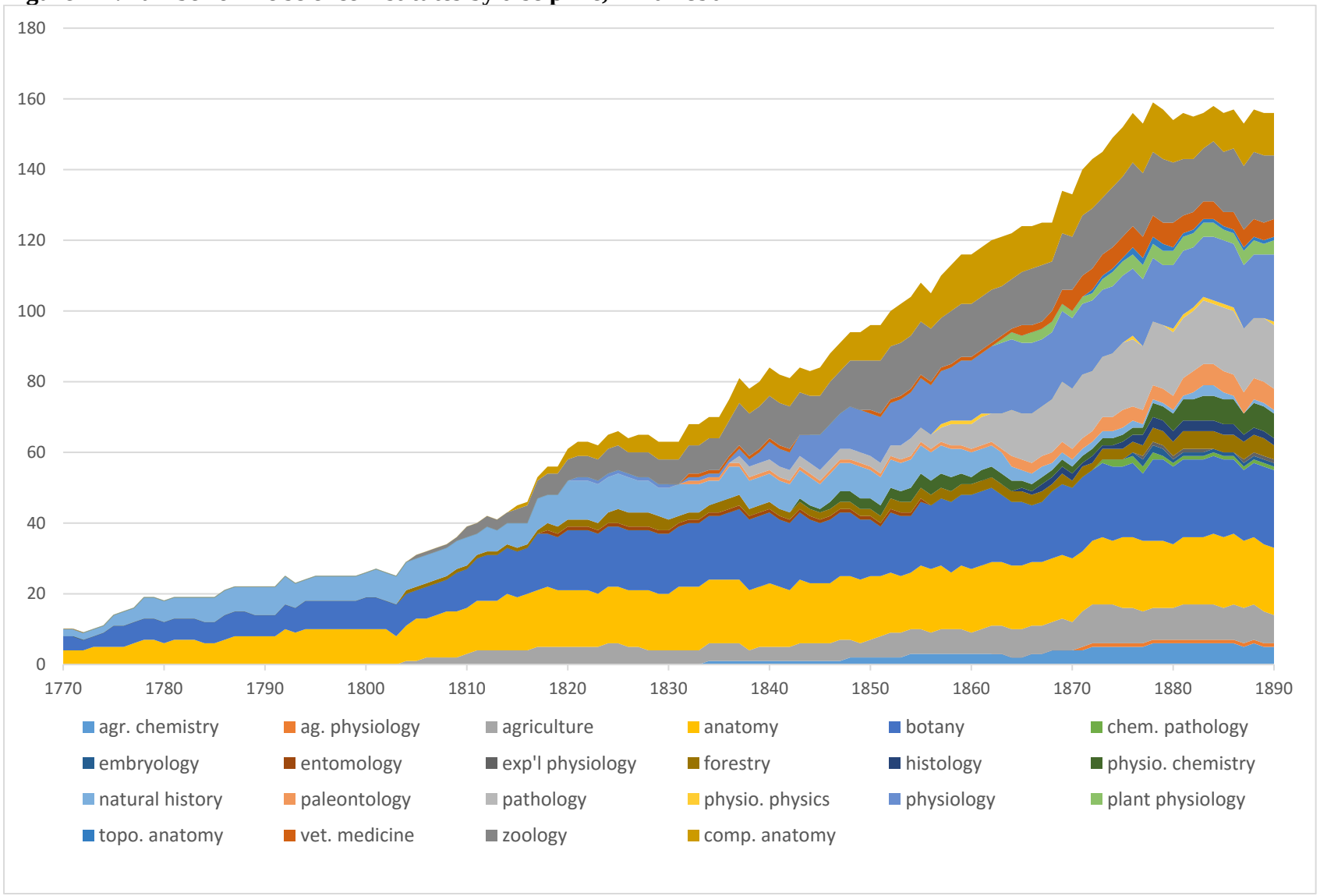
The life sciences took root at the German universities as part of a wide-ranging transformation of the relationship between science and higher education. The incorporation of new sciences into the academic division of labor wove together research and teaching. Once a class of teachers defined largely by corporate privileges, the German professoriate gradually developed into an exclusive profession closely identified with specialized knowledge and commanding wide cultural authority.

Prior to the nineteenth century, research and teaching were largely separate activities. Science was cultivated primarily at royal academies and learned societies. Here scholars, professionals, and wealthy amateurs met on equal footing as men of learning (*Gelehrtern*) to witness and validate knowledge claims (Biagioli, 1993; Shapin, 1994). Disciplines, in contrast, were compilations of doctrines taught to students at the universities (the Latin *disciplina* simply meant a course of study; Brockliss, 1996; Heilbron, 2004). Of course, eighteenth-century scholars sought to advance disciplinary knowledge, but they understood disciplines as "intellectual genres," rather than distinct specialties in the contemporary sense (Heilbron, [1990] 1995: 3). Characteristically, disciplinary journals, associations, and specialized degrees did not exist prior to the very end of the eighteenth century.

Permanent institutional support *did* exist for certain disciplines at eighteenth-century universities, but it depended almost entirely on relevance to professional education. Early modern universities were organized around three higher faculties of theology, law, and medicine, which prepared students for careers in the professions, and one lower faculty of philosophy or arts, which served a propaedeutic role and taught the liberal arts (Brockliss, 1996; Frijhoff, 1996). Because the study of living beings was of great significance to the medical faculty, anatomical theaters and botanical gardens were common at eighteenth-century universities (Broman, 1996). These institutes served to familiarize students with the structures of the human body and the medicinal plants, respectively. Topics of less relevance to the practice of medicine, such as natural history and agriculture, enjoyed occasional support through faculties of medicine or philosophy, but remained exceptional at the universities.

Over the course of the nineteenth century, many new sciences found a place at the German universities, often with substantial institutional support. In no area was this growth as expansive as in the life sciences. Figure 1-1 shows the cumulative number of life science institutes by discipline across eighteen German universities from 1770 until 1890. Anatomical theaters and botanical gardens predominated until 1800, alongside a few natural history museums. After 1800, there was a sustained increase and diversification of life science institutes. Not all disciplines benefitted: institutes for agriculture and forestry remained rare, and natural history went into a long decline after 1840. Nevertheless, the number of institutes in

Figure 1-1:Number of life science institutes by discipline, 1770-1890



other life science disciplines, particularly physiology, pathology, and zoology, continued to increase until nearly every university had institutes for the full complement of these disciplines. Many institutes had extensive support staff, lecture halls, and research space (Lenoir, 1997; Tuchman, 1993; Zloczower, [1960] 1981). To Max Weber ([1919] 1946: 131) they were essentially large "state-capitalist enterprises." They were at the very least one of the most visible symbols of the great difference between the modern research university and its traditional predecessor.

The creation of these great many new institutes was no small undertaking. I now turn to consider how the growth of two powerful constituencies – German states and disciplinary professions – shaped the demand for life science institutes, attending both to their direct claims on university resources, and to how each may have reshaped into the dynamics of the field universities and the field disciplines.

States and the field of universities

In Germany the emergence of the research university was closely intertwined with the development of the modern state. In the decades preceding unification, most of the various German states restructured their universities as part of broader efforts to create centralized, bureaucratic polities. Ministers of education had a direct hand in the creation or modernization of research universities, but nevertheless, there is surprisingly little agreement among historians and sociologists on the precise role of state policy in the growth of new disciplines.

Part of the reason is that eighteenth-century territorial states already had considerable power over universities in Germany. But they competed for influence with Imperial and church officials as well as with universities' own corporate solidarities (Clark, 2007; McClelland, 1980). Bornhak (1900: 164) describes the administration of eighteenth-century Prussian universities as caught between the medieval feudal order and the modern money economy. As privileged corporations, universities generally governed their own affairs and received income from a variety of special rights, including landholdings, trade monopolies, and excise taxes. Universities also received funds from states, religious orders, and other patrons (Frijhoff, 1996). State support made up an especially large share of university revenues at more recent foundations, such as Göttingen, Erlangen, and Halle, but with the exception of Göttingen even these universities retained much of their legal autonomy and traditional privileges (Clark, 2007; McClelland, 1980).

Nevertheless, it is clear that the role of the state in higher education expanded greatly in the nineteenth century. Most famously, the Prussian university reforms initiated by Wilhelm von Humboldt promoted a humanistic ideal of education through original scholarship (*Bildung durch Wissenschaft*), which placed the natural sciences and humanities on an equal footing with the higher faculties, and also granted students and teachers freedom to choose their own courses (Anderson, 2004). Significantly, the Prussian reforms also made universities attributes of the state: university finances were consolidated onto the public budget, professors were made part of the civil service, and new universities embodying the Humboldtian ideal were set up in Berlin (1810), Breslau (1811), and Bonn (1818; Ben-David, 1971; Lenoir, 1998; McClelland, 1980).

Although the officials of other states were often more utilitarian in their aims than von Humboldt, they too embraced state funding of university science as a means to improve higher education, sometimes even before von Humboldt (Tuchman, 1993; Lenoir, 1997 McClelland, 1980). It is reasonable to expect that reformed universities would have been more likely to support the construction of new life science institutes than traditional universities.

The evidence for a precise cause and effect relationship between reforms and institute founding however is not unambiguous. In particular, many historians see the university reforms as only one aspect of larger political and cultural transformations that weakened the local, corporate solidarities in favor of regional and national attachments (McNeely, 2003; Walker, 1971). Following the dissolution of the Holy Roman Empire in 1803, Prussia and several other states were granted control of dozens of small principalities, free cities, and ecclesiastical territories. The integration of new territories into expanding states also brought additional universities under their control, a development that had several consequences. The almost accidental creation of large university systems created new opportunities for universities to command additional patronage, but it also eroded the autonomy of individual universities and contributed to the development of a national market for academic talent (Baumgarten, 1997; Clark, 2007). Emerging university systems created pressures to conform to shared standards, and to recruit promising scholars with the promise of research support. Even for universities in independent territories, we might therefore expect that the more a university participated in emerging recruitment networks, the more likely it was to found new life science institutes.

At the same time, higher education reforms and the integration of academic labor market were tightly interlinked. I may thus be the case that reformed universities participated more extensively in university networks. Moreover, the concentration of state resources within emerging university systems should have clear consequences for the topology of university networks. Prestigious reformed universities would have been especially well placed to attract the most promising professors and students, and thus would be more likely than traditional universities to occupy an advantageous position in external recruitment networks.

Professions and the field of disciplines

The relationship between disciplines and professions also evolved over the nineteenth century. The life sciences had longstanding ties to the medical professions, and because the German universities maintained control over the education of physicians, the professoriate benefited directly from the growth of the medical professions. But while some disciplines adopted the trappings of professional organization, there is also evidence that others flourished precisely where disciplinary boundaries remained permeable.

Eighteenth-century disciplines were organized around service to the learned professions, rather than as professions for their own sake. Teaching responsibilities were assigned by university faculties. Professors generally did not cultivate a specific disciplinary competence, but instead advanced from one discipline to another in keeping with the custom of transference (*Aufrücken*). Under this system, lecturers and junior professors taught propaedeutic or elective disciplines, and awaited an opening to be transferred to a more prestigious (and remunerative)

subject (Broman, 1996; Clark, 2007). For example, an *extraordinarius* professor of medicine might teach the "institutes of medicine," which included introductory topics such as history of medicine, physiology, and pathology, and later move up to a full *ordinarius* chair in anatomy, surgery, botany, or pharmacy when it became available (Broman, 1996). Career advancement in this case depended on seniority within the medical faculty, rather than disciplinary affiliation.

Disciplinary affiliation became far more important during the nineteenth century. Much of the sociology of science equates these changes with the professionalization of scientific disciplines (Ben-David, 1971; Gieryn, et al. 1985). Certainly it was true that at the end of the nineteenth century, the largest life science disciplines were organized along increasingly professional lines. Professors of anatomy, botany, physiology, pathology, and zoology founded their own associations, scholarly periodicals, and research institutes, and defended their control over academic posts in terms of specialized disciplinary competence. Although specialized disciplinary degrees and other credentials remained absent in the life sciences, work experience within research institutes served instead as an indicator of disciplinary competence (Harwood 1993; Nyhart 1995). These developments were concomitant with what Ringer (1969) has described as the formation of a highly exclusive "mandarin" professoriate with wide cultural authority. It is reasonable therefore to expect that as individual disciplines became more professionalized, they would also be more likely to command support for the creation of new institutes.

Others have called into question the identification of discipline-building with professionalization. The boundaries between different areas of scholarly activity, they argue, remained far more permeable than professional jurisdictions would imply. There is evidence that less professionalized, "interdisciplinary" research flourished in the gaps. Looking back on the nineteenth century, the biologist and philosopher E. S. Russell (1916) argued that the connections between anatomical, physiological, and natural historical phenomena preoccupied biologists far more than pure specialization. Kohler (1983) and Nyhart (1995) have more recently characterized the boundary-spanning disciplines of biochemistry and comparative anatomy as "institutional failures but intellectual successes" within the nineteenth-century German universities. Although they lacked strong professional organs, these disciplines nevertheless succeeded at influencing research agendas across the life sciences, colonizing niches in other disciplines, and attracting significant institutional support. (In these respects, they bear a great deal of similarity to many contemporary areas of interdisciplinary research.) Disciplinary avatars new vocations like agronomy and forestry also found some support within the universities, but these too depended on connections to canonical scientific disciplines (Harwood, 2005). Taken together, these observations suggest that participation in the networks between disciplines may also have been a factor in the founding of new life science institutes.

Less clear is the relationship between professionalization and interdisciplinary networks. According to Stichweh (1984) and Weisz (2006), the growth of new disciplines at the start of the nineteenth century in part represented a rejection of earlier professional identities in favor of scientific identities. Certainly a professional monopoly is antithetical to permeable disciplinary boundaries. But it is also possible that professionalization might advantage a discipline in placing its own representatives in *other*, less influential disciplines. Disciplinary

professionalization might therefore be associated with greater participation and a stronger position within networks between disciplines.

THE DATA SET

The analyses presented below are based on a unique data set of university life science institutes and their recruitment networks. The data set covers every institute in twenty-two life science disciplines at eighteen German universities active between 1770, when there were relatively few such institutes, and 1890, by which time life science disciplines had become thoroughly institutionalized at the German universities. In all, the data includes information on 205 institutes and 552 distinct hiring events, which makes it far more comprehensive than similar lists of life science institutes available in the secondary literature (e.g. Eulner, 1970; Nyhart, 1995; Zloczower, [1960] 1981).

My primary source of information on university life science institutes are official university directories (*amtliche Verzeichnisse*). The directories, which were printed at nearly every German university starting in the early decades of the nineteenth century, contain detailed information on each university's organization and personnel, including administrators, teachers, students, and institute staff. Because the directories were printed once every semester, it is possible to identify changes within each university from one year to the next. For years in which official directories were not available, I turned to university histories, lecture catalogs, biographies of professors, and local almanacs. (A full list of these sources appears in the appendix.) Different sources nearly always corroborated each other, and the discrepancies that did appear were generally small, such as a difference of a year or two in the first appearance of an institute. In such cases, I favored the official directories, unless another source explicitly accounted for its discrepancy with the university record.

Two further matters are important to clarify in order to frame the scope of this study: the definition of "German university" and the definition "life science discipline." Because both the population of German universities and the population of life sciences changed considerably over the course of the eighteenth and nineteenth centuries, special consideration must be given to each of these terms.

The eighteen universities included in the data set are listed in Table 1-1.The data cover the population of all eighteen German-language higher education institutions that met certain criteria. To ensure comparability between institutions, I limited data collection to only those schools that were organized as university corporations, empowered to issue doctoral degrees, and composed of the four traditional faculties of theology, law, medicine, and philosophy (or arts). These criteria exclude both the Swiss and Austrian universities, which were not always organized as full, four-faculty universities during the nineteenth century, as well as non-university technical schools (*technische Hochschulen*), which were neither organized as universities nor empowered to grant doctoral degrees in the nineteenth century. Data collection was also limited to those universities that remained in operation from 1820 to 1890. Unfortunately, gaps in the historical record make it impossible to identify directors at the dozen or so eighteenth-century German universities that closed before 1820. My conclusions will not

Table 1-1: University attributes

University	Founded	Reformed	Reforming State
Berlin	1810	1810	Prussia
Bonn	1818	1818	Prussia
Breslau	1811	1811	Prussia
Erlangen	1743	1810	Bavaria
Freiburg	1457	1803	Baden
Gießen	1607	1831	Hesse-Darmstadt
Göttingen	1734	1734	Hannover; Prussia [b]
Greifswald	1456	1815	Prussia
Halle	1694	1814	Prussia
Heidelberg	1386	1803	Baden
Jena	1558		
Königsberg	1544	1810	Prussia
Leipzig	1409	1831	Saxony
Marburg	1527	1866	Prussia [b]
Munich [a]	1472	1802	Bavaria
Rostock	1419	1827	Mecklenburg
Tübingen	1477	1806	Württemberg
Würzburg	1583	1805	Würzburg; Bavaria

Notes: (a) The Ludwig-Maximilian University of Munich was located at Landshut from 1800 to 1826. (b) Marburg and Göttingen fell under Prussian sovereignty following the Austro-Prussian War (1866). Würzburg was under the sovereignty of the short-lived Grand Duchy of Würzburg from 1805 to 1814.

be robust to this larger population of higher education institutions. It is worth noting, however, that the resulting sample is quite similar to that examined in other histories of the German universities (e.g. Baumgarten, 1997; Eulenburg, 1908; Jarausch, 1982; McClelland, 1980; Nyhart, 1995).[1]

Table 1-2 provides a complete list of life science disciplines appearing in the data set. The existing historiography provides little guidance as to how to delimit the life science disciplines. For the purposes of data collection, I defined the life sciences as all disciplines that take nonhuman living beings as part of their object of study. This definition is very expansive: it embraces a wide swathe of disciplines that comprise elements of medical theory, natural history, and agriculture, as well as others that span the boundaries of these fields, such as biology, biochemistry, and comparative anatomy. But it is not all-encompassing: the definition excludes medical, historical, religious, and social scientific disciplines that concern themselves exclusively with human beings, along with disciplines in the natural sciences that pertain only to nonliving objects, such as mineralogy and physics. Using the university directories, I was able to identify 22 life science disciplines with active institutes between 1770 and 1890 that fit these criteria. In a few cases, coding was complicated by the fact that alternate names were occasionally used for what was clearly the same discipline (usually based on different German, Latin, and Greek derivations); these cases were coded together as one discipline.

[1] I exclude the universities of Kiel and Strassbourg because they would enter the data set only after 1867 and 1871, respectively. The Russian-administered German-language University of Dorpat also does not appear in the data.

Table 1-2: Discipline attributes

Discipline	First institute	Association
Agricultural chemistry	1834	
Agricultural physics	1871	
Agriculture	1804	1837-1876
Anatomy	1555	1885-
Botany	1586	1882-
Chemical pathology	1872	
Comparative anatomy	1815	
Embryology	1872	
Entomology	1818	1886-
Experimental physiology	1877	
Forestry	1804	1837-1876
Histology	1865	
Natural history	1775	
Paleontology	1832	1912-
Pathology	1822	1896-
Physiological chemistry	1843	
Physiological physics	1857	
Physiology	1821	1903-
Plant physiology	1863	
Topographic anatomy	1872	
Veterinary medicine	1850	1841-1851
Zoology	1805	1890-

MEASURES

The hypotheses elaborated above pertain to two different types of variables: the characteristics of university life science institutes, and their positions within networks of recruitment. For the sake of simplicity, I discuss the variables referring to institute, university, and discipline attributes first, and then turn to the construction of the network variables.

Institute, university, and discipline attributes

Institute founding: the main dependent variable concerns whether an institute for a particular life science discipline was present or absent at a university in a given year. An institute was coded as present if there existed an organizational subunit of the university that had (a) an explicit disciplinary identity, (b) a dedicated physical location where research equipment could be stored or used, and (c) an official director with the status of professor and authority over the institute's equipment and premises.[2] Finding institutes using the university directories was

[2] This definition excludes university professors' personal research collections, research institutes without university affiliation, and university institutes without permanent directors. Although examples of such institutes existed in

straightforward: for each organizational unit of the university, the directories listed the name and address, along with the title, name, and role of every employee from the director and academic staff down to the technicians and custodians. The same information was also available from the supplementary sources, but not always in such a convenient format. University institutes occasionally contained several separate laboratories or departments that met the above definition. When this was the case, I treated each subunit as an institute in its own right.

Rationalization: To measure rationalization at each university, I drew on administrative histories of the German states, as well as histories of each university. For information on state bureaucracies, I relied primarily on Bornhak (1900), Knemeyer (1970), and Schwabe (1983); the full list of university histories consulted is available in the references. I operationalized rationalization in Weberian terms as the existence of a clearly defined hierarchy of offices linking the state to the university, each with salaried employees and a specific sphere of competence (cf. Weber, 1978: 217-223). To identify the offices linking together the civil service and university administration, I first determined which state had sovereignty over each university and every year in the data using the university histories. I then turned to the administrative histories to determine when and whether higher education was assigned to a permanent ministry or standing committee. Using the university histories, I also checked whether university protocols gave authority over university finances and professorial appointments to the state, usually mediated through the appointment of a *Curator* or *Prokanzler* to the university governing board. Based on these materials, I constructed a dichotomous variable coding for the replacement of traditional modes of university governance with more rationalized bureaucratic structures. If a university met both of these conditions in a given year, the rationalization variable was coded to one; otherwise, it was coded to zero.

The dates of rationalization are available in Table 1-1. Of course, struggles over the control of the university neither began nor ended in these years. Administrators took many approaches to making universities more *zweckrational* during the eighteenth and nineteenth centuries. In some cases, they took control budgeting and faculty appointments away from the university corporation. In others, they sought only to curtail the power of religious authorities. In still other cases, they appointed temporary committees to inspect a university, introduced new curricula, and established entirely new academies and schools (Broman, 1996; Clark, 2007; McClelland, 1980; Tuchman, 1993; Turner, 1971). The classificatory scheme employed here excludes some well-known university reform programs, most notably several early efforts, such as at universities of Halle (1694) and Erlangen (1743). Nineteenth-century reforms are more fully represented here because the creation of formal channels through which governments supported new institutes was often intertwined with broader state-building efforts (Clark, 2007; McClelland, 1980; Turner, 1971).

Professionalization: To measure the degree of professionalization of each discipline, I focused on the creation of disciplinary associations. I constructed a dichotomous variable coded to one if a national German association existed for a discipline in a given year, and zero otherwise. Finding disciplinary associations required that I draw on several sources of information. My primary source was associations' own published records of their proceedings.

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nineteenth-century Germany, they fail to capture the close and continuing association between research and teaching that characterizes contemporary scientific disciplines.

These I found through keyword searches in the Online Computer Library Center's *WorldCat* database. I also sought out information on life science associations within the official reports of the Congress of German Naturalists and Physicians (VDNAe), an annual meeting of scientists that first occurred in 1822. The dates of activity for these associations are listed by discipline in Table 1-2. Although Germany was not politically unified until 1871, the earliest national life science association, the Congress of German Agriculturalists and Foresters, was founded in 1834. Most disciplinary associations, however, did not take shape until the last decades of the nineteenth century.[3]

University and discipline networks

As I have argued above, university rationalization and disciplinary professionalization may also influence disciplinary institutionalization by altering the relationships between universities and between disciplines. Measuring these relationships requires additional information on both the extent to which the universities and disciplines participate in these networks, and the positions which they come to occupy. To do so, I collected information on the recruitment of institute directors.

Characterizing recruitment networks required addition information on institute directors' previous university and disciplinary affiliations. I first identified each spell of office-holding for every institute director in the data set. In cases where the same individual was appointed to the directorship of more than one institute, or stepped down from a directorship and later regained it, I treated these as separate spells. Next I sought out each director's doctoral degree(s) and the name and location of his occupation immediately prior to each spell. I found degrees and occupations using standard biographical dictionaries, including the *Allgemeine Deutsche Biographie*, the *Neue Deutsche Biographie*, Pagel's (1901) *Biographisches Lexikon hervorragender Aerzte des neunzehnten Jahrhunderts*, and local and regional biographical lexicons. Since the great majority of hires were made within or between universities, the official directories and university histories also provided much information, even where biographical records were incomplete.

The resulting observations can be interpreted as a set of dyadic transitions between the different disciplines and universities in the data set. It is a simple task to project these dyads into two one-mode networks: one network of universities and one network of disciplines (Breiger, 1974). These networks capture the structure of relations between universities and between disciplines embedded in the backgrounds of institute directors active in a given year. From one year to the next, the networks evolve as old directors receive new appointments, die, or retire, and as new directors are recruited. The transition processes constituting these networks are quite similar to those that define vacancy chains (White, 1970). But certain features of the mobility process between both universities and disciplines make vacancy chain models inappropriate for these data, as will become apparent below.

[3] Many cities and towns had local associations for natural history, botany, and agricultural sciences, and several state- or national-level general scholarly associations predate these associations, but to my knowledge, no other preceding state-level associations existed that was specific to any life science discipline.

In the case of the university networks, it is possible to construct a network based on either the location of prior employment, as in a vacancy chain, or the location at which the director was originally trained and received his doctoral degree. The latter option has several advantages. Empirically, the education data make for a more complete network because there are considerably fewer locations at which one could receive a degree than at which one could hold a job. But more importantly, there is good reason to expect that the education measure captures more salient features of the recruitment process than location of prior employment. Higher education is an important site of secondary socialization, and academic credentials are a crucial form of cultural capital. Prior occupation, on the other hand, is less likely to be informative precisely because academic degrees can open up a wide variety of employment opportunities, and a scientist may take a job in one locale in order to await an opening in another. The university networks thus describe which universities were able to exchange graduates, rather than the precise structure of directors' careers.

The discipline networks raise a different set of issues. Doctoral degrees are less informative in this case because before the twentieth century, graduates of the German universities almost always received their doctorates in philosophy, medicine, law, or theology, rather than in a specific academic discipline. Institute employees, however, could and did move from one life science discipline to another. For example, a director might begin as an assistant in an anatomical theater, then become director of a zoological collection, and later be recruited to direct a physiology institute. The exact paths different directors took were quite diverse: some jumped between several disciplines, others accumulated control of more than one life science institutes, and still others never made any transitions between disciplines, or even between institutes. Nevertheless, these moves offer a window into which life science discipline were perceived as offering a relevant background for other life science disciplines in a given year.

For each network, I constructed two actor-level measures, which capture different aspects of a university or discipline's network position. The first is a simple measure of the degree to which a university or disciplines actually chose to participate in external recruitment networks rather than simply hiring from among its own. I refer to this measure as "inbreeding" (c.f. Burris, 2004; Godechot and Louvet, 2008). To calculate university or discipline inbreeding in a given year, I simply took the number of directors for each university or discipline unit with a network tie to the same unit within which they currently held a position, and then divided it by the total number of institute directors in the focal unit. This measure can be interpreted substantively as the percentage of directors within a university or discipline that are inbred in a given year.

The second is describes the position of a university or discipline within external recruitment networks. This measure is based on the degree to which a university or discipline was a source of new directors for *other* universities or disciplines. In keeping with the literature on social networks, I refer to it as "prestige" (e.g. Wasserman and Faust, 1994: 202ff.) To calculate prestige, I took the number of directors with ties to a university or discipline but holding positions *outside* of that unit, and then divided by the total number of positions outside of that unit. In network parlance, prestige is simply a normalized measure of directed degree centrality for each node, not counting reflexive ties. (These, of course, are used to calculate

inbreeding). This measure can be interpreted as the percentage of all directors hired outside that have come from a particular university or discipline in a given year.[4]

Control variables

Lastly, I attempted to control for some of the more important time-varying characteristics of each university and discipline in the multivariate analyses. (Time-invariant characteristics are less of a concern, as well shall see below.) University size is perhaps to most obvious constraint on the capacity to add new institutes. Since institutes are linked to the teaching mission of the university, I measured university size using the number of students in attendance during the winter semester for each university from Eulenburg's (1908) statistical overview of the German universities. For disciplines, the general intellectual renown it enjoys may be easily confounded with its more local prestige among the life sciences. To measure intellectual renown, I determined whether each institute director had been a member of the Leopoldina, the national academy of sciences for German-language countries, using a complete list of academy members since 1642. I then calculated the percentage of institute directors who were also members of the Leopoldina for each discipline in a given year. I will return to these measures in the multivariate analyses, but first it is useful explore in greater detail how rationalization, professionalization, and network structure was associated with the prevalence on life science institutes over the course of the study period.

PATTERNS OF DISCIPLINE FORMATION AND GROWTH

I now examine the institutionalization of life sciences across three historical periods corresponding to different phases in their development. During period 1, which includes the late eighteenth and early nineteenth centuries, life science institutes were few in number. In period 2, the middle years of the century, new institutes appeared and new disciplines flourished. Finally, in period 3, the last decades of the nineteenth century, institute founding rates declined once again and a more settled configuration of disciplines took shape. For each period, I first describe the organization of university and discipline fields, and then consider how rationalization, professionalization, and network positions are related to the occurrence of life science institutes.

Period 1: the early nineteenth century

At the start of the nineteenth century, the life sciences were not a central concern at the German universities. Institutes were rare, and neither the market for scholarly talent nor the order of disciplines exerted much of an influence on recruitment into the life sciences. Instead, institute directors were likely to be recruited locally, and often spent their entire careers from

[4] An important concern is that these measures are not completely disjoint from one another. A university, for example, may choose to hire one of its own students precisely because its graduates enjoy higher prestige than those of other universities. In such a case, inbreeding and prestige can easily become confounded. Fortunately, the logic of statistical control applies nicely to these circumstances, and the prestige measure can be used to control for its own potential confounding effect on inbreeding.

student to emeritus at a single university. Disciplinary identities, far from being exclusive specialties, remained subsumed into professional education, above all medical training. Within the German universities, the life sciences simply did not exist as a distinct constellation of disciplines.

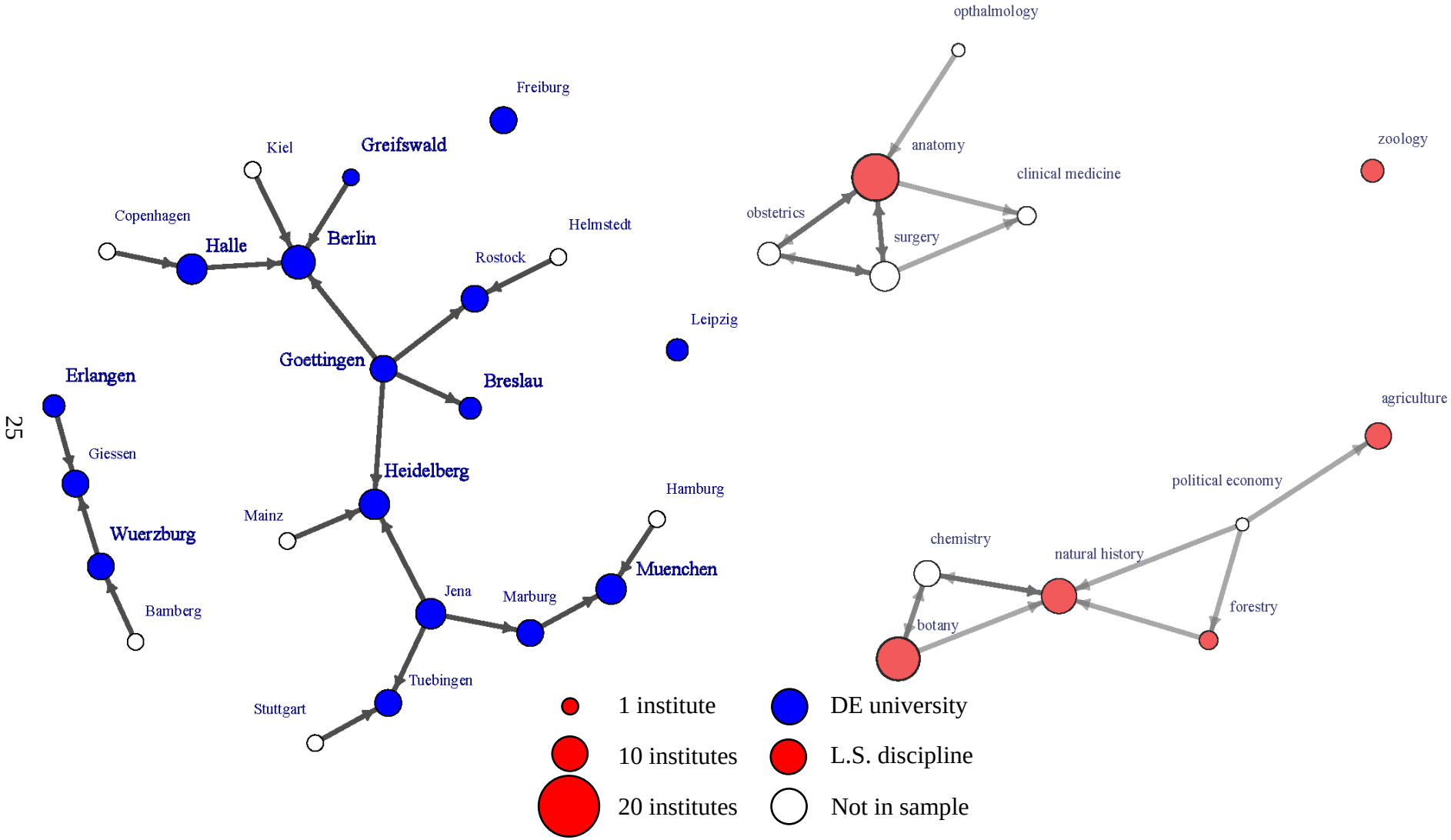
This summary is confirmed by Figure 1-2, which provides diagrams of university and discipline recruitment networks in 1810. The fragmented nature of each network is immediately apparent. The universities appear on the left. Recruitment ties were not common, nor did they possess any apparent pattern with respect to university reforms: among externally recruited directors, about one third came from reformed universities and about one quarter came from unreformed universities. (The remaining share came from schools outside of the data set, which is not surprising given that data is missing for several eighteenth-century universities.) Among the disciplines, on the right, there was a very clear split between the anatomical institutes, which were affiliated with medicine and surgery at the top, the life science institutes affiliated with the natural sciences at the bottom, and lastly those affiliated with political economy to the right. Strikingly, there were no recruitment ties between these different clusters. Life science disciplines, even more so than the universities, remained isolated from one another.

The structure of the university field appears to have played little role in the distribution of life science institutes at the start of the nineteenth century. Table 1-3a rank-orders the universities according to the number of life science institutes present in 1810, and reports their inbreeding and prestige statistics as well as reform status. The German universities were quite diverse. Only around half had undergone rationalizing reforms, and eight of fifteen universities in the data were at least half inbred in the life sciences. Five universities were completely inbred. Nevertheless, within the sparse recruitment network there is a clear prestige hierarchy. As is apparent in Figure 1-2, universities either sent or received directors, but almost never both. This variation among universities, however, tells us little about where life science institutes appeared and where they did not. Neither reforms nor low levels of inbreeding predict the appearance of life science institutes. Similarly, although the universities that sat atop the prestige hierarchy in 1810 were well-known as intellectual centers, particularly Göttingen and Jena, they were no more disposed to support life science institutes than other universities. Although several universities had already diverged from their more guild-like predecessors, none of these changes were clearly associated with changes in the life sciences.[5]

Within the field of disciplines, there does appear to be a clear distinction between more established life science disciplines and new arrivals. Institute counts along with inbreeding and prestige statistics for each discipline in 1810 appear in Table 1-3b (specialized disciplinary associations still did not exist in Germany at this time). Only institutes for anatomy and botany appeared at more than half of the universities, while other disciplines had few institutes and weakly institutionalized. In the former two disciplines, levels of inbreeding were moderate. Botany also stood at the top the prestige order, the source of seven percent of all hires in other

[5] It is worthy of note that there is also no evidence of a confessional divide. The Catholic universities at Freiburg, Landshut, and Würzburg were more isolated in the recruitment network, but no more or less inbred or equipped with life science institutes than other universities. Each of these universities, however, had recently been secularized and incorporated into the state bureaucracies of Baden, Bavaria, and the short-lived Duchy of Würzburg, respectively, as a consequence of the Peace of Pressburg in 1805.

Figure 1-2: University and discipline networks in 1810



Note: reformed universities and disciplines with associations are labeled in bold.

Table 1-3a: University attributes and network statistics in 1810

University	Institutes	Inbreeding	Prestige	Reforms
Berlin	4	0%	0%	Yes
Halle	3	67%	3%	Yes
Heidelberg	3	0%	0%	Yes
Jena	3	100%	10%	No
Landshut	3	0%	0%	Yes
Freiburg	2	0%	0%	Yes
Gießen	2	0%	0%	No
Göttingen	2	100%	13%	Yes
Marburg	2	50%	3%	No
Rostock	2	0%	0%	No
Tübingen	2	0%	0%	No
Würzburg	2	50%	3%	Yes
Erlangen	1	100%	3%	Yes
Greifswald	1	100%	3%	No
Leipzig	1	100%	0%	No
Königsberg	0	—	—	Yes

Table 1-3b: Discipline attributes and network statistics in 1810

Discipline	Institutes	Inbreeding	Prestige	Association
Anatomy	13	31%	0%	No
Botany	11	18%	7%	No
Natural history	8	0%	0%	No
Agriculture	3	33%	0%	No
Zoology	3	0%	0%	No
Forestry	1	0%	0%	No

life science disciplines. In contrast, among less established disciplines like forestry, natural history and zoology, inbreeding and prestige hires were nonexistent. But it is likely that these differences were less a factor in the success of anatomy and botany than a symptom of it. As Figure 1-2 illustrates, both disciplines had extensive ties beyond the life sciences: several anatomists also directed institutes of surgery, obstetrics, ophthalmology, and clinical medicine, and botanists were active in chemistry and mineralogy. Institute directors moved between the disciplines of medicine, the natural sciences, and political economy in keeping with the eighteenth-century custom of transference. Each of these fields hired from distinct populations of instructors. As a result, disciplines in the life sciences remained isolated from one another.[6]

Taken together, the results suggest that ten years into the nineteenth century the life sciences were of limited consequence at the German universities. Most did have an anatomical

[6] The case of agriculture is instructive. The first agriculture institutes appeared at the German universities in the late eighteenth century. In most cases, these institutes were founded as part of new faculties of political economy (*Staatswirtschaft*), separate from the traditional university faculty structure. In the absence of a clear path of transference with the faculties, directors of agriculture institutes were not recruited from more established natural sciences in the philosophical faculty, but instead from the civil service or agricultural practice.

theater and a botanical garden to train students in medicine. But other life science institutes, such as natural history museums and agricultural institutes, were rarities that supplemented curricula in the natural sciences and political economy. There is no evidence of an imperative to strengthen these disciplines. In these respects, early nineteenth-century German universities still closely resembled their eighteenth-century predecessors.

Period 2: The middle of the nineteenth century

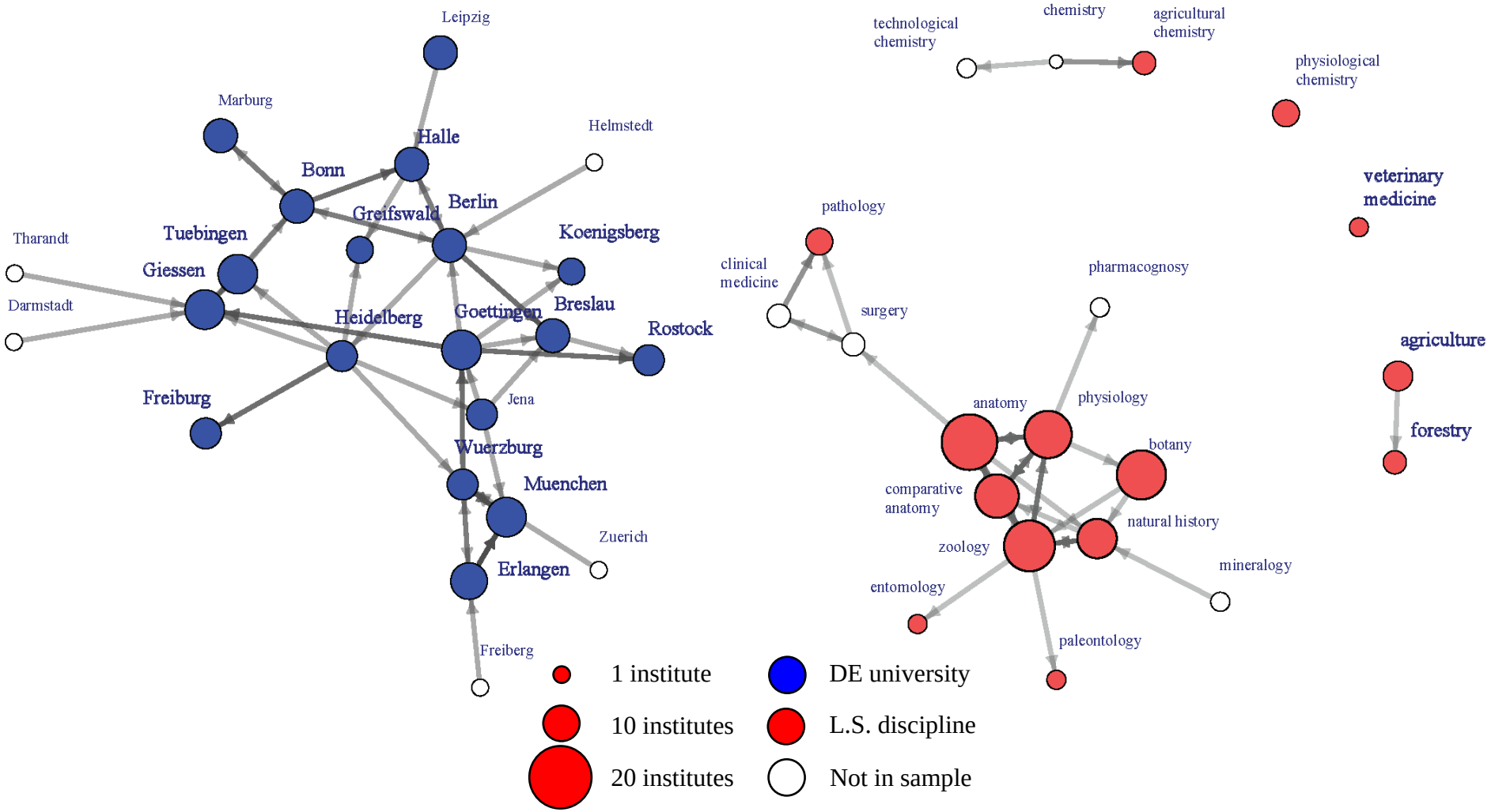
By the middle of the nineteenth century, the situation of the life sciences was very different. Life science institutes were a growing presence at the German universities. Half a dozen new disciplines had taken hold, and some of the most successful, such as physiology and comparative anatomy, addressed abstract concerns at great remove from professional practice. Rationalizing reforms also spread and resistance to outside recruiting fell during this period. These shifts undermined the old system of transference based in the faculties, and confirmed the life sciences as a distinctive realm of activity within the German universities.

Some of these changes can be seen in Figure 1-3, which displays the university and discipline networks for 1850, forty years after the preceding figure. The university recruitment network is more fulsome than before: tie density has increased, and there are no longer any isolates among the universities. The number of mutual ties is also far greater, suggesting less hierarchy between universities. Much of the increase in tie density was concentrated within the multiple-university systems established in Prussia, Baden, and Bavaria: density within these states was much higher (37%) than density between states (7%).[7] In the discipline recruitment network, a new cluster of disciplines with dense, overlapping ties has appeared between the older medical and natural science clusters. Beyond this grouping, however, life science institutes remained few and isolated from one another. From these patterned increases in external hiring decisions, new structures arose in university and discipline recruitment networks.

Higher levels of state intervention and external recruitment are apparent in the field of universities during this period, but limits to the influence of these trends are also clear. Table 1-4a reports the number of life science institutes for each university in 1850, along with its reform status and network statistics. By mid-century, nearly every German university had undergone rationalizing reforms (the exceptions are Marburg and Jena), new model universities had been founded at Bonn and Breslau, and the average number of life science institutes per university increased to exactly four, nearly doubling since 1810. The model universities established by the Prussian state at Berlin and Bonn stood high in the prestige hierarchy, displacing more traditional universities like Jena, but other aspects of network structure remained unchanged. Levels of inbreeding remained high at many universities: although fewer schools were fully inbred in1850, average inbreeding was only slightly below its 1810 level. Rationalizing reforms also did not benefit every university. Institute founding rates were stagnant at several universities in Prussia Baden, and Bavaria, such as Greifswald, Würzburg, and even Heidelberg, presumably because ministries concentrated their resources elsewhere. The university field was in a state of flux in

[7] The Prussian universities were Berlin, Bonn, Breslau, Greifswald, Halle, and Königsberg. The universities of Baden were Freiburg and Heidelberg. The Bavarian universities were Erlangen, Landshut (later Munich), and Würzburg.

Figure 1-3: University and discipline networks in 1850



Note: reformed universities and disciplines with associations are labeled in bold.

1850, but changes to the field brought uneven changes to levels of institute founding.

The field of disciplines was also in flux, but patterns of institute founding moved more decisively away from eighteenth-century models. The five leading life science disciplines immediately stand out in Table 1-4b. Each had ten or more institutes, moderate rates of inbreeding, and substantial prestige. This group included both long-established disciplines like anatomy and botany and newer disciplines like zoology, physiology, and comparative anatomy. The latter three had grown rapidly since 1810, and together accounted for around two-thirds of all new institute foundations. The disciplines of this morphological cluster were also tightly interconnected. Their high prestige scores are due primarily to recruitment from within the group: in Figure 1-3, they are clustered around what Russell (1916: v) called "the main battle-ground" of animal morphology, the relationship of living structures (e.g., anatomy) to their functions (e.g., physiology). Other life science disciplines, in contrast, grew slowly and accumulated little prestige. These disciplines included practical fields like pathology, veterinary medicine, agriculture, and forestry, as well as the "biological" branches of chemistry, which were hard to align with morphological concerns of zoologists and physiologists in an era when metabolic processes within cells were still poorly understood (Nyhart, 1995: 47-62).[8] Surprisingly, it was precisely the practical disciplines that fostered the earliest disciplinary associations. But if these organizations were the expression of a collective mobility project among agronomists, foresters, and veterinarians, then this makes sense. These sciences were only loosely bound to the universities and enjoyed little security there. Voluntary associations were doubtless a promising means of organizing their diverse and widespread supporters, and of far less relevance to those disciplines more comfortably ensconced within the university walls.

By 1850 it is possible to speak of the life sciences as a distinctive grouping of disciplines within the German universities. New institutes of physiology, zoology, and comparative anatomy sprang up at many universities, often via recruitment from existing institutes of anatomy, botany, and natural history. The connections between the founding of these institutes and the broader transformation of the university system, however, is less clear. New institutes appeared at the same time as rationalizing reforms and the territorial integration of recruitment networks, but these changes did not have any obvious association with patterns of institute founding.

Period 3: The late nineteenth century

The processes transforming the field of universities and the field of disciplines continued to advance and ramify over the rest of the nineteenth century. Within a newly unified Germany a unified university system took shape, centered on a few highly prestigious schools. The field of life science disciplines also became increasingly organized around a core set of exclusive, professionalized disciplines, which held sway over a range of minor disciplines.

[8] Kohler (1983) argues that the institutional weakness of biochemical disciplines stems in part from the fact that university chemists were attempting to distance themselves from their service role in the medical faculty in favor of a more scientific orientation. The analysis presented here is consistent with this argument, which serves to illustrate how isolated agricultural and physiological chemists were from the flourishing life science networks centered in the medical faculties.

Table 1-4a: University attributes and network statistics in 1850

University	Institutes	Inbreeding	Prestige	Reforms
Gießen	6	17%	0%	Yes
Göttingen	6	50%	11%	Yes
Munich	6	17%	2%	Yes
Tübingen	6	83%	3%	Yes
Erlangen	5	40%	6%	Yes
Berlin	4	0%	9%	Yes
Bonn*	4	0%	7%	Yes
Breslau*	4	0%	1%	Yes
Halle	4	25%	4%	Yes
Leipzig	4	75%	1%	Yes
Marburg	4	75%	1%	No
Freiburg	3	33%	0%	Yes
Heidelberg	3	33%	10%	Yes
Jena	3	100%	4%	No
Rostock	3	0%	0%	Yes
Würzburg	3	33%	7%	Yes
Greifswald	2	0%	0%	Yes
Königsberg	2	50%	0%	Yes

Table 1-4b: Discipline attributes and network statistics in 1850

Discipline	Institutes	Inbreeding	Prestige	Association
Anatomy	18	50%	13%	No
Botany	16	44%	3%	No
Zoology	14	14%	9%	No
Physiology*	12	25%	12%	No
Comparative anatomy*	10	30%	6%	No
Natural history	8	0%	5%	No
Agriculture	5	40%	1%	Yes
Pathology*	3	0%	0%	No
Physiological chemistry*	3	0%	0%	No
Agricultural chemistry*	2	0%	0%	No
Forestry	2	0%	1%	Yes
Entomology*	1	0%	0%	No
Paleontology*	1	0%	0%	No
Veterinary medicine*	1	0%	0%	Yes

Institute founding activity slowed in these years (see Figure 1-1), but the new foundations did occur tended to be associated with only the most advantaged positions in either field.

Figure 1-4 presents the university and discipline recruitment networks for 1890. Both networks are both now highly structured. The university network is tightly interconnected and all evidence of within-state clustering has disappeared (this is perhaps not surprising, given that

the figure describes conditions almost twenty years after German unification). Instead, a few prominent schools like Berlin and Göttingen now occupy the core of the network, and have recruitment ties to universities from across the population. The rest appear around the periphery of the network because they possess no more than a few ties to universities outside of the core. The discipline network, in contrast, is organized around three main clusters. Each cluster is anchored by one or more large disciplines, three of which have founded their own learned associations. A pathology cluster appears at the top of the diagram, and botanical and agricultural cluster to the left, and much of the old morphological cluster to the right. These disciplines are in turn surrounded by other, less common disciplines, which for the most part only have ties to the more dominant disciplines. In both recruitment networks, relatively few ties are reciprocated, suggesting a tendency towards asymmetry and hierarchy.

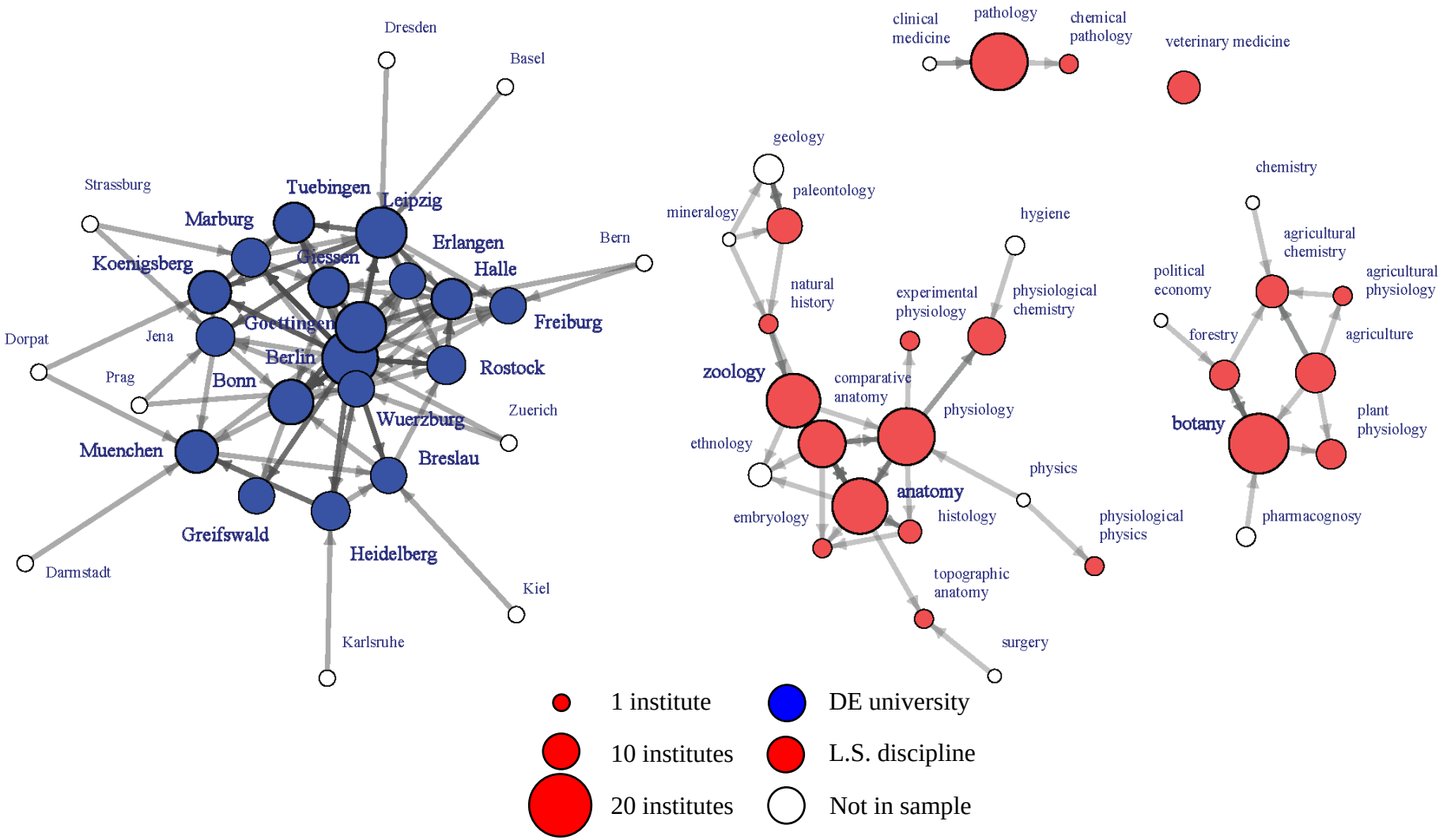
A closer examination of the field of universities bears this impression out. Based on the statistics in Table 1-5a, the universities can be divided into two different and unequal classes in 1890. The universities of Berlin, Göttingen, and Leipzig are at the top of this table. They had more life science institutes than any of the remaining universities, stood at the top of the prestige hierarchy, were moderately inbred, and appear at the core of the university network in Figure 1-4.[9] The results are consistent with the historiography, which often places Berlin, Göttingen, and Leipzig at the peak of the university hierarchy in the late nineteenth century using different measures (e.g., Baumgarten, 1997; Zloczower, [1960] 1981). Each of these schools had several large-scale life science institute buildings that were constructed in the 1860s and 1870s with capacious lecture halls and extensive laboratory space, often with room for more than one discipline (Lenoir, 1997). The remainder of the universities supported fewer life science disciplines and produced very few prestige hires. Most also had very low levels of inbreeding and thus relied on outside hires for their staffing needs. The only remaining traditional university, Jena, was part of this group, but it well worth noting that was not alone. Taken together with the network diagram, these findings provide support for the existence of an integrated but highly unequal market for academic talent at the end of the nineteenth century. Top universities with more life science institutes were also more able place their students in directorships across the field, leaving other universities to a position of relative dependence.

A similar pattern obtains in the field of disciplines. New life science disciplines continued to appear, but for the most part the same disciplines are at the top of Table 1-5b as in the previous table for 1850. This group included anatomy, physiology, zoology, and botany, along with the new addition of pathology (comparative anatomy has fallen somewhat behind). These disciplines bore the markings of power and exclusivity: all had at least one institute at every university, some were almost completely inbred, three had their own associations, and two – anatomy and physiology – stood at the top of the prestige hierarchy.[10]

[9] The top three universities provided 40% of all external hires in 1890, and the University of Berlin alone accounts for more than a fifth.

[10] This structure is also more completely reflected in annual meetings of German Naturalists and Physicians, which were divided into no less than seven different sections for life sciences by the 1870s.

F igure 1-4: University and discipline networks in 1890



Note: reformed universities and disciplines with associations are labeled in bold.

Table 1-5a: University attributes and network statistics in 1890

University	Institutes	Inbreeding	Prestige	Reforms
Berlin	15	53%	22%	Yes
Göttingen	12	50%	10%	Yes
Leipzig	12	33%	8%	Yes
Bonn	9	0%	3%	Yes
Munich	9	33%	2%	Yes
Königsberg	8	13%	1%	Yes
Gießen	7	14%	2%	Yes
Halle	7	0%	3%	Yes
Tübingen	7	0%	1%	Yes
Heidelberg	6	50%	2%	Yes
Jena	6	17%	3%	No
Marburg	6	33%	3%	Yes
Rostock	6	0%	3%	Yes
Breslau	5	0%	2%	Yes
Erlangen	5	0%	2%	Yes
Freiburg	5	0%	0%	Yes
Greifswald	5	40%	0%	Yes
Würzburg	5	20%	6%	Yes

Table 1-5b: Discipline attributes and network statistics in 1890

Discipline	Institutes	Inbreeding	Prestige	Association
Botany	22	64%	1%	Yes
Anatomy	19	84%	7%	Yes
Physiology	19	74%	6%	No
Pathology	18	72%	1%	No
Zoology	18	56%	4%	Yes
Comparative anatomy	12	17%	7%	No
Agriculture	8	63%	3%	No
Physiological chemistry	7	14%	0%	No
Paleontology	6	0%	1%	No
Agricultural chemistry	5	20%	0%	No
Veterinary medicine	5	40%	0%	No
Forestry	4	25%	3%	No
Plant physiology*	4	0%	0%	No
Histology*	2	0%	1%	No
Agricultural physics*	1	0%	1%	No
Chemical pathology*	1	0%	0%	No
Embryology*	1	0%	0%	No
Experimental physiology*	1	0%	0%	No
Natural history	1	0%	2%	No
Physiological physics*	1	0%	0%	No
Topographic anatomy*	1	0%	0%	No

The rest of the life sciences had fewer institutes, little prestige, no associations, and lower rates of inbreeding. In other respects, they were a diverse group. Some were theoretical, including fields which today we might consider to be *interdisciplinary* such as physiological physics, chemical pathology, and plant physiology. Strikingly, the venerable discipline of natural history has also been reduced to this interstitial status: the only natural history institute remaining, in Berlin, was primarily an administrative bridge between the zoology and mineralogy institutes (Nyhart, 1995). Practical disciplines like agriculture, forestry, and topographical anatomy were also marginalized.[11] Professional associations for agronomists, foresters, and veterinarians fell apart in the second half of the nineteenth century, although universities and other schools began to offer credentials for these groups (Harwood, 2005; McClelland, 1991). By 1890, a strong distinction had developed between a dominant group of exclusive and relatively professionalized life science disciplines, and a variety of other, less successful disciplines.

To summarize, by the end of the nineteenth century, a clear hierarchy had emerged within both the field of universities and the field of disciplines. Among the universities, a select group of schools with more institutes and greater autonomy controlled much of the academic labor market, and this market was largely held by a few dominant life science disciplines. A small number of dominant institutes trained not only their own staff, but also the directors of institutes in more marginal disciplines, and at more marginal universities.

MULTIVARIATE ANALYSES

It is useful to begin the discussion of the multivariate analyses by returning to the research design. Briefly, I expect that university reforms and disciplinary professionalization may explain changes in the university and discipline networks, which together may shed light on patterns of institute founding. The hypotheses pertain to three dependent variables. The main dependent variable is, of course, the founding of life science institutes. The other two concern position within university and discipline networks. I use the two prestige measures because the descriptive results above suggest that they generally carry more information about institute founding than the inbreeding measures (models of inbreeding are available upon request from the author). To avoid conflating the effects of the predictors with the outcomes, the independent variables are lagged by one year in all models.

Each dependent variable implies a different level of analysis. Because it is rare for any discipline to have more than one institute at a university, the units of analysis for institute founding are university-discipline dyads, with one observation per year over the period of study. These observations are structured as event histories that indicate when an institute is founded for a particular university-discipline pair; event history models of the "hazard" of institute founding are therefore appropriate for these data. Entry into the hazard set occurs in 1770 – or later if the university was founded after 1770 – and further requires that at least one institute existed for the discipline in that year. Each university-discipline pair exits the data set once an institute is founded. For example, all universities without an anatomical institute are at hazard of founding

[11] Topographical anatomy concerns the relative positions of structures within the body and is thus of most immediate relevance to surgery.

one in 1770, with the exception of Berlin, Bonn, and Breslau (which did not yet exist), but no university is at hazard of founding an institute of agricultural chemistry until after the first one appeared at Tübingen in 1834.

The units of analysis for the two prestige variables are the university and the discipline, respectively, again with one observation per year during the period of study. The prestige measures range between zero and one (recall that network prestige is a ratio measure of the number of external placements to the total number of possible external placements). As a result, a linear model can easily lead to predictions outside of the possible range of data values. Instead, I separate out the numerator and the denominator, and estimate Poisson regressions of the number of external placements (the numerator), using the total number of possible external placements (the denominator) as an exposure variable. These models estimate the incidence of prestige hires, given the total number of possible prestige hires for each observation. Conditions for entry into the data set are the same as for the event history data. Exits only occurs if a discipline or university falls to zero institutes.

Because the data include one observation per year for up to 120 years, several complications enter into the analyses. The first is that baseline rates of founding and network formation may vary considerably over time, introducing a correlation-of-errors problem that can confound estimates for the time-varying covariates. For the event history models of institute founding, I therefore employ Cox (1972) proportional hazard models, which use a semiparametric procedure to obtain parameter estimates that are relative to the overall observed hazard rate for the data. For the Poisson regressions, I approximate the nonlinear time trend for using natural cubic splines (Beck, Katz, and Tucker, 1998). Substantively, the splines describe nonlinear increases in outside placements for both networks during first half of the nineteenth century, followed by declines later on in the century.

A second complication comes from the fact that the observations making up the data are not independent, but instead consist of multiple observations on institute, university, and discipline units. It is possible that outcomes are linked to unobserved time-invariant characteristics of each unit, meaning that errors may also be correlated within these units. I therefore use a fixed-effects specification for each of the analyses. For the Cox regressions of institute founding, I estimate the fixed effects by allowing different baseline hazard functions for each university according the procedure described by Allison (2009: 74). (Ideally these models would use separate hazard functions for each institute, but as there is only one founding event per institute such a model would be impossible to estimate.) For the Poisson models of university and disciplinary prestige, I estimate separate baseline incidence rates by simply including a dummy variable for each university or discipline in the data (Allison, 2009: 59). In all cases, I use the Huber-White estimates of variance to obtain robust estimates of the standard errors (Woolridge, 2002).

A final complication is that, as the descriptive results above suggest, the processes linking the time-varying covariates to the outcomes may themselves vary over long periods of time in both their direction and strength. For this reason, I include time-varying effects for each of the focal covariates using interactions between these variables and a time variable (measured in years, starting at 1770). The procedure is essentially the same for both the Cox models and

the Poisson models, but the interactions must be interpreted with caution because the main effect of time is absorbed into hazard function or the spline cubic spline terms for the respective models.

Results 1: Models of institute founding

I begin with a simple model of institute founding, regressing the hazard of institute founding on the rationalization and professionalization variables. I also include as controls the number of students at the university and the percentage of Leopoldina members in the discipline. The results are reported in Model 1, Table 1-6. The coefficients for disciplinary association, number of students, and Leopoldina membership are all small and statistically insignificant. The coefficient for university reforms is larger and negative, although it is also statistically significant: the model predicts that reformed universities were only about 70 percent (=exp(-0.370)) as likely to found a new institute as traditional universities. This finding is contrary to much of the literature on the university reforms, but it makes perfect sense when we recall that in Table 1-4 many of the more peripheral reformed universities had fewer life science institutes than either reformed or unreformed universities around the middle of the nineteenth century. The results do not change when we introduce variables for university and discipline networks, as Model 2, Table 1-6 makes clear. There is little evidence that either university rationalization or disciplinary professionalization was directly associated with differences in founding rates.

But there is evidence that position within the discipline network is associated with the founding of new institutes. The importance of disciplinary prestige is quite clear: the model predicts that a one percent increase in a discipline's prestige is associated with a thirteen percent (=exp(0.121)) increase in the chances of founding a new institute. We might imagine that as a life science discipline places its own scholars within other life science disciplines, the number of advocates for that discipline would grow, and along with it the sense that a relevant institute was a necessary part of a research university. Some candidates for a directorship made it quite clear that they would only accept on the condition that they also received substantial institutional support for their preferred discipline. Such was the case for the call of Hermann Helmholtz to Heidelberg and Carl Theodor Ernst von Siebold to Munich in the 1850s. Both men sought improved facilities for their physiological research, and in Helmholtz's case, the offer was the fruit of longstanding efforts at Heidelberg to recruit an experimental physiologist (Tuchman, 1993: 139-54). But institute founding does not appear to vary predictably with university prestige, and the coefficients for university and discipline inbreeding are even smaller and likewise not statistically significant. Among the network variables, only discipline prestige is strongly related to patterns of institute founding.

The models we have examined so far are based on pooled variation both between universities and within universities. It is therefore possible that these results are due primarily to unobserved differences in founding rates between universities. Such differences between high prestige and low prestige universities could, for example, be masking a relationship between changes in prestige and rates of institute founding. Model 3, Table 1-6, therefore stratifies the baseline hazard function according to university. The pattern of statistical significance remains unchanged for the network variables, indicating that the relationship of changes in network

Table 1-6: Cox regressions for institute founding

Model	1	2	3	4
University and Discipline Attributes				
Uni. Reformed	-0.370	-0.407	-32.380	-34.086
	(0.266)	(0.302)	(---)	(---)
Disc. Association	0.056	0.183	0.103	0.471
	(0.400)	(0.405)	(0.393)	(2.970)
Uni. Students (1,000s)	0.080	0.093	-3.010***	-3.273***
	(0.165)	(0.206)	(0.661)	(0.756)
Disc. Leopoldina (Pct.)	0.003+	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Network Measures				
Uni. Inbreeding (Pct.)		-0.002	-0.002	-0.019
		(0.004)	(0.005)	(0.013)
Uni. Prestige (Pct.)		0.014	-0.074	-0.413*
		(0.028)	(0.078)	(0.182)
Disc. Inbreeding (Pct.)		-0.007	-0.006	-0.011
		(0.010)	(0.009)	(0.024)
Disc. Prestige (Pct.)		0.121**	0.104**	0.139
		(0.043)	(0.039)	(0.105)
Time-Varying Effects				
Uni. Reformed				-0.016
				(---)
Disc. Association				-0.004
				(0.033)
Uni. Inbreeding (Pct.)				0.000
				(0.000)
Uni. Prestige (Pct.)				0.006*
				(0.003)
Disc. Inbreeding (Pct.)				0.000
				(0.000)
Disc. Prestige (Pct.)				-0.000
				(0.001)
University Strata?	No	No	Yes	Yes
N	15805	15084	15084	15084
Log-pseudolikelihood	-726.09	-685.73	-316.87	-313.55

Note: Robust standard errors clustering universities are in parentheses.

position to institute founding within universities is quite similar to what we observed in the random-effects model. The coefficients for university reforms and student enrollments, however, have become very large and negative. The undefined standard errors on the former parameter indicate a problem of quasi-complete separation in the data: because most reforms occurred either very early in the nineteenth century or even before the period of observation, the hazard set for traditional universities is quite small for some universities and undefined for others. The coefficient for the number of students is not a result of separation, and reflects the

fact that enrollments grew very rapidly in the 1880s, just as institute founding rates slowed to almost nothing.

In the descriptive results, we observed that the relationship between institute counts, inbreeding, university prestige, and discipline professionalization all appeared to change considerably over time. Model 4, Table 1-6, accounts for these changes by adding interactions with time for each of the focal covariates. The main effect and interaction for university prestige are both significant and show a clear pattern of change over time: in the eighteenth century increases in university prestige were associated with decreases in the hazard of founding, but by the late nineteenth century increases in university prestige were associated with *increases* in founding. The parameter for university prestige switches from negative to positive around 1838. This finding is consistent with the expectation that the growing interdependence of universities over the course of the nineteenth century tended to strengthen the position of a select group of dominant universities. Whereas prestigious universities of the eighteenth century were if anything less likely to found institutes than other universities, the dominant universities of the late nineteenth century boasted an array of institutes in both canonical disciplines and more unusual fields like chemical pathology, plant physiology, or physiological chemistry.

The interactions for the remaining variables are not statistically significant and the main effects appear to be mostly unaltered. The coefficient of disciplinary prestige loses statistical significance but remains similar in magnitude, indicating that the relationship between disciplinary prestige and institute founding was relatively stable over the period of observation. Interestingly, the coefficients for university inbreeding, discipline inbreeding, and presence of a disciplinary association all remain statistically insignificant, along with their interactions – even though we saw above that these qualities varied quite predictably with institute counts in 1890. The results may imply that the observed gains in each of these qualities tended to occur after the founding of institute rather than preceding it. It is also possible that gains in prestige tended to account for any interdependence between inbreeding, professionalization, and founding. In either case, the findings suggest that professionalization and inbreeding were consequences of successful discipline-building rather than causes of it.

To recapitulate, the results show strong evidence for the importance of network position to explaining patterns of institute founding, but provide little support for a direct role for states or professions. Disciplinary prestige mattered a great deal, as did university prestige, albeit less reliably over the span of the nineteenth century. Neither university rationalization nor disciplinary professionalization appear to have lent much direct support the founding of new life science institutes.

Results 2: Models of university and discipline prestige

To get a better grasp on other possible interdependencies between university rationalization, disciplinary professionalization, and network positions, the next two tables present models of university and discipline prestige. Model 1, Table 1-7 regresses university prestige on university inbreeding, reform status, and student enrollments. Both university inbreeding and number of students are strongly associated with greater chances of having placed

Table 1-7: Poisson regressions for university prestige

Model	1	2	3
Uni. Inbreeding (Pct.)	0.012**	0.008**	0.013+
	(0.004)	(0.003)	(0.007)
Uni. Reformed	0.222	0.571+	-0.858
	(0.324)	(0.327)	(0.600)
Uni. Students (1,000s)	0.492***	0.312**	0.925
	(0.078)	(0.098)	(0.566)
Time (Year – 1769)	-0.032	-0.033+	-0.022
	(0.020)	(0.019)	(0.016)
1st Cubic Spline on Time	0.094+	0.088+	0.060+
	(0.053)	(0.045)	(0.036)
2nd Cubic Spline in Time	-0.291+	-0.260*	-0.213*
	(0.162)	(0.129)	(0.101)
Inbreeding X Time			-0.000
			(0.000)
Reformed X Time			0.021***
			(0.006)
Students X Time			-0.005
			(0.005)
Constant	-3.876***		
	(0.633)		
Fixed Effects?	No	Yes	Yes
N	1813	1813	1813
Log-pseudolikelihood	-3299.58	-2511.31	-2458.31

Note: Robust standard errors clustering on universities are in parentheses.

a prestige hire at another university. Neither of these findings is surprising: it makes sense that universities that were able to hire their own were more likely to also have a strong reputation with other universities, and that larger universities also produced larger pool of qualified scientists. The coefficient for university reforms is positive, but not statistically significant.

The same concerns regarding differences between universities and within universities apply here as they did in the models of institute founding. It is quite likely that some universities had characteristics that made them more attractive to the best and brightest students and faculty, and we would expect that these characteristics would also be associated with university prestige, inbreeding, and the number of students. Model 2, Table 1-7, therefore adds fixed effects for each university. There is very little change in any of the coefficients, indicating that much of the association between inbreeding, students, and prestige operates through changes within university rather than differences between universities. And because the independent variables are lagged by one year, this cannot be due to a reverse effect of increases in prestige attracting more students and encouraging greater inbreeding.

The first two models showed that university inbreeding and reform status can predict differences in university prestige over the period of observation. Model 3, Table 1-7, adds

interactions with the linear time variable, which is equivalent to the first cubic spline term these models, and reveals an increasing association between reform status and university prestige over time. University reforms had a negative and statistically insignificant relationship with prestige in 1770, but the coefficient flips direction in 1810, the very year of the Humboldtian university reforms. By 1871, reformed universities were about three and a half times ($\exp(1.284) = 3.6$) more likely to place an outside hire than a traditional university. Indeed, the Jena-trained Munich botanist Ludwig Radlkofer was the only external placement from a traditional university at this time, and he also held a degree in medicine from Munich (a handful of additional hires from Jena more were made in the 1880s). This finding is consistent with the idea that territorial integration placed reformed universities at an increasing advantage over the course of the nineteenth century. Early in the nineteenth century, reformed universities found themselves incorporated into larger university systems, which created new and increasing opportunities to place students at other universities.

One can of course ask similar questions about the relationship between discipline characteristics and network position. Model 1, Table 1-8, reports the Poisson regression for disciplinary prestige on disciplinary inbreeding, presence of an association, and Leopoldina membership. Greater inbreeding and Leopoldina membership both predict greater chances of making a prestige placement in another discipline. Interestingly, the presence of a disciplinary association has a strong and negative relationship with prestige hiring. It is likely the case that this result is driven by the associations for agriculture, forestry, and veterinary medicine, which were active in the middle of the nineteenth century. None of these disciplines accumulated much prestige but together their associations existed for 89 discipline-years of observation. In contrast, the associations for the more prestigious disciplines of anatomy, botany, and zoology were active for only eleven discipline-years of observations (refer to Table 1-2 for details). Model 2, Table 1-8, adds fixed effects to the model, and the effects for inbreeding and association do change in any meaningful way.

If the estimates for disciplinary association are due largely to early associations founded in applied disciplines, we should expect this relationship to vary over time. Model 3, Table 1-8, adds interactions with time to the fixed effects model and we see that this is indeed the case. The coefficient for presence of a disciplinary association is large and negative for earlier years but becomes positive around 1882, in between the collapse of the earlier associations for agriculture, forestry, and veterinary medicine and the first appearance of associations for anatomy, botany, and zoology. (It is also of interest to note that the coefficient for the measure of general intellectual renown, Leopoldina membership, also shifts from positive before 1857 to negative thereafter. The changes are quite small, however: a one percent increase in membership predicts a three percent increase in the incidence of a prestige hire in 1770, or one percent decline in 1890.) Disciplinary professionalization does appear to matter for disciplinary prestige, but any positive influence came quite late in the nineteenth century.

Summary of results

In summary, the results suggest that position within university and discipline recruitment networks mattered a great deal for the founding of life science institutes, and that university

Table 1-8: Poisson regressions for discipline prestige

Model	1	2	3
Disc. Inbreeding (Pct.)	0.033***	0.017*	0.029
	(0.005)	(0.007)	(0.019)
Disc. Association	-0.571*	-0.431**	-3.269**
	(0.269)	(0.156)	(1.221)
Disc. Leopoldina (Pct.)	0.011*	-0.002	0.035***
	(0.006)	(0.003)	(0.009)
Time (Year – 1769)	-0.017	0.010	0.012
	(0.016)	(0.024)	(0.020)
1st Cubic Spline on Time	0.033	0.002	0.028
	(0.022)	(0.029)	(0.025)
2nd Cubic Spline in Time	-0.352*	-0.141	-0.206
	(0.168)	(0.171)	(0.127)
Inbreeding X Time			-0.000
			(0.000)
Association X Time			0.029*
			(0.013)
Leopoldina X Time			-0.000***
			(0.000)
Constant	-3.920***		
	(0.948)		
Fixed Effects?	No	Yes	Yes
N	1197	1197	1197
Log-pseudolikelihood	-2664.31	-1653.22	-1569.72

Note: Robust standard errors clustering on disciplines are in parentheses.

rationalization and disciplinary professionalization generally mattered to the degree that they influenced processes of network formation. To be sure, territorial integration placed reformed universities in large states at an advantage after 1810. But it is certain that not all of these universities gained in prestige. Those that did, however, were increasingly associated with broader support for an array of new life science disciplines by the middle of the nineteenth century. The center of intellectual attention in the life sciences shifted as a result from wealthy old universities like Jena to new model universities in the center of expanding university systems.

The role of professionalization in the growth of new disciplines was quite limited, but interdependencies between disciplinary prestige and institute founding were robust over the course of the nineteenth century. Prestigious disciplines were especially likely to add life science institutes across the entire period of observation. At no time did the professionalization of a discipline have a direct influence on the founding of new institutes, and professionalization was only likely to predict an increase in prestige after 1880. At the middle of the nineteenth century, professionalization was associated with lower lever levels of prestige hiring. Thus, there is evidence that early discipline formation was in some respects an antiprofessional activity, as Stichweh (1984) and Weisz (2006) have both argued. And although there is evidence

of disciplinary professionalization at the end of the nineteenth century, these appear to be a consequence of the rise of disciplinary research institutes, and not a cause.

CONCLUSIONS

To conclude, the evidence provided little support for the direct dependence of institute founding on university rationalization or disciplinary professionalization. If anything, reformed universities had lower chances of adding new institutes then their traditional equivalents. The direct links between rationalization, professionalization, and the institutionalization of disciplines are tenuous. One the other hand, network position mattered a great deal: a discipline's position in the prestige hierarchy is extremely weighty in determining whether it adds new institutes or not, and a university's position in the prestige hierarchy was an increasingly clear predictor of the founding of new institutes in the late nineteenth century.

This brings us to a more general point: states and professions mattered primarily through their evolving relationship to the structures of the field of universities and the field of disciplines. Far from compromising the *Einsamkeit und Freiheit* of the scholarly vocation, the state-led construction of a national market for institute directors conferred the greatest benefit on the most prestigious universities. Even traditionally prestigious universities that undertook reforms at a relatively late moment saw the full benefit. Professionalization only became a viable strategy once the most successful disciplines adopted it. Early professionalization efforts were associated with applied, vocation subjects, and many disciplines remained both successful and largely not professionalized in the nineteenth century.

CHAPTER 2: PROFESSIONS AS POLITICS (with Heather A. Haveman)

The deregulation of medicine in the United States, 1790-1860

Sociologists define professions as occupational groups that claim exclusive authority over the market for their work. Legal statutes granting members of the profession monopoly control over a market are therefore a central goal of would-be professions (Abbott, 1988; Freidson, 1970; Larson, 1977; Wilensky, 1964: 145). This perspective casts light on how professions attained the power and prestige they enjoy today, but it provides little guidance as to how that power, once gained, might also be lost. Studies have shown that professions can stagnate even with robust legal protections from market competition, they can lose their work to the encroachment of rival occupational groups, and they can even fade out of existence completely (Abbott, 1988: 29-30, Halpern, 1992; Timmermans, 2008). Yet we know little about the conditions under which professional sovereignty comes to be challenged, and even less about the effects losing monopoly power may have on professional groups.

In order to explain how professionalization projects sometimes fall apart, we draw on insights from political sociology. This article contributes to a growing literature that reframes professional projects as a kind of social movement (Larson, 1977; Popp Berman, 2006; Whooley, 2013). Professions, like other kinds of interest groups, face the twin challenges of uniting diverse constituencies of practitioners around shared goals, while at the same time overcoming resistance from competing interests (McAdam, 1999 [1982]; see also Fligstein and McAdam, 2012: 86-96). Struggles over regulation break out when the members of a profession fail to secure complete control over their work, and rival practitioners come forward to press alternative claims. To do so, these rivals must possess their own organizational base through which to mobilize their supporters and must find allies in the broader political environment. They must also frame their interests in a way that clearly opposes them to the *status quo* of the professional establishment (cf. McAdam, 1999 [1982]: 40-51). Under these conditions, the institutionalized politics of professional regulation can break down, and the normally staid world of professionals may take on the character of a contentious social movement.

This article examines an important case of professional collapse: the deregulation of medicine in the United States during the first half of the nineteenth century. Although the development of the medical profession is often treated as an archetype of the professionalization process, its early years in the United States hardly foreshadowed its later successes. Even as reformers passed new laws in France (1803), Britain (1858), and Germany (1869) that established national credentialing systems and granted new powers to physicians, in the United States citizens, legislatures, and medical practitioners rose up to oppose the professionalization of medicine (McClelland, 1991; Newman, 1957; Rothstein, 1972; Steffens, 1989). "Medicine, like every useful science, should be thrown open to the observation and study of all," declared a writer for the *New York Evening Star* in 1833. "We should at once explode the whole machinery of mystification and concealment… which serves but as a cloak to ignorance and legalized murder!" (quoted in Starr, 1982: 56). Between 1833 and 1844, all states but one did just that, and repealed or nullified medical licensing laws (Rothstein, 1972).

The findings of this article add to sociological knowledge of the professions in two important ways. First, we show that professional sovereignty can be challenged if rival practitioners are organized, find support among the laity, and define their grievances in a way that places them in opposition to dominant professional groups. In the case of the U.S. medical profession, historians and sociologists have argued that the confluence of Jacksonian populism and the emergence of a sectarian "medical counterculture" among practitioners led to the deregulation of the medical profession (Abbott, 2005; Larson, 1977; Rothstein, 1972; Starr, 1982). Our results are largely in accord with this view. But we add to it by showing that Jacksonian democracy and the founding of new medical schools and societies were not in themselves sufficient causes for the deregulation of medicine. Instead, medical practitioners' grievances only turned toward advocacy for deregulation when they came to see their work in explicitly sectarian terms, standing in opposition to the "aristocracy" of regular medicine.

Second, we show that when a profession does lose its legal monopoly, it does not simply fade out of existence. Instead, if orthodox practitioners are also organized, they too may mobilize to defend their authority, recruit supporters among the population at large, and discredit their opponents. Even as rival practitioners rush to seize new opportunities, members of the old guard may deepen their organizing efforts and ready themselves to defend what remains of their privileges. While deregulation was a setback for regular physicians, it did not significantly weaken the organizational base of regular medicine. Instead, the early successes of medical sectarians were met by counter-mobilization among regular physicians. The repeal of licensing laws was followed by the birth of new medical schools, national associations, and a continued expansion of medical publishing as regular and sectarian physicians jockeyed with one another for popular influence.

We proceed as follows. First, we survey the sociological and historical literature on the professions to develop intuitions about what factors may predict professional deregulation and its effects on professional organization. Second, we describe the rise and fall of medical regulation in the antebellum United States, the state of the regular medical profession in those years, and the sectarian medical groups that opposed it. Then, we introduce our data sources and methods of analysis. And finally, we reveal our results and discuss their implications for theories of professionalization and research on the professions.

THE DYNAMICS OF PROFESSIONS

One of the challenges of research on the professions is that the concept of profession is itself ambiguous. We can loosely define professions as occupational groups that claim exclusive authority over their work based on the application of a body of knowledge. But the means by which professionals assert this claim are manifold. Markers of professional status may include state recognition, a national association, a code of ethics, professional journals, or specialized training schools at universities or elsewhere (Abbott, 1988: 9-19; Caplow, 1954; Wilensky, 1964). Different approaches to the professionalization process conceive of the relationships between these elements in different ways.

In the traditional professions literature, professional organization and state regulation are seen as mutually supportive elements of professional power. According to Wilensky (1964), the professionalization process typically follows an ordered sequence, beginning with the founding of a training school, then a university-affiliated school, and then local and national associations, culminating in the passage of licensing laws and the drafting of a code of ethics. Some traditional theorists dispute the sequence of events while nevertheless accepting the basic premise. For example, Caplow (1954) asserts that schooling and regulation develop concurrently, and studies of continental profession show that state recognition usually occurs first in the sequence (e.g., Steffen, 1988; McClelland, 1991). Other traditional theorists reject the possibility of identifying a single modal sequence (e.g., Millerson, 1964). But their conclusions remain the same: the organizational strength of a profession is associated with greater chances of achieving strong regulation, and vice versa.

This literature has less to say about the deregulation of professions. When it is discussed, deprofessionalization is usually seen as stemming from the weakening of professional authority in the face of the rationalization or bureaucratization of professional work (e.g., Haug, 1972; Ritzer and Walczak, 1988; Toren 1975). We might expect, therefore, that if the growing clout of a professional group should lead to the founding of schools, the founding of professional societies, and the passage of monopoly protections, so then should a weak profession be associated with the opposite. Deregulation, therefore, ought to occur where professional organization is lacking. Moreover, in places where deregulation has already occurred, we should expect it to further impede the organizing efforts of professionals. This leads to the following predictions:

H1a: The greater a profession's organizational strength, the less likely deregulation.

H1b: If a profession becomes deregulated; then professional mobilization will decrease.

Other authors argue that professionalization should not be understood in such strictly linear terms. Larson (1977) suggests that the precise constellation of professions' features is not fixed. Drawing on perspectives from political sociology, Larson describes professions as "collective mobility projects," undertaken by practitioners in order to secure power and prestige for their occupation (Larson, 1977: xii-xiii). The precise means by which professionalizing groups lay claim to collective privileges, however, depends on the social and cultural circumstances of the time. At the start of the nineteenth century, for example, some of the most determined opponents of professionalization in England and the United States were in fact elite practitioners (Larson, 1977: 104-135; see also Popp Berman, 2006). They held to a traditional, aristocratic conception of their professions, which restricted the privilege of full membership to a tiny minority. In order to dislodge the elites who controlled the traditional means of professional recognition, many advocates of professionalization sought to do away with licensing regulations altogether. Under these conditions, there is little reason to expect the unification of the profession and the safeguarding of its legal privileges should be mutually supportive elements of the professionalization process.

Applying this model to early development medical profession in United States, Larson turns the traditional model of professionalization on its head. New professional organizations,

especially medical schools, were a source of organizational strength for the mass of medical practitioners who *opposed* the restrictive licensing boards and their members (Larson, 1977: 123-33). Medical schools offered an alternative and more accessible means of credentialing medical practitioners. New, often proprietary schools proliferated in the early nineteenth century, particularly in the South and in frontier states, where elite physicians were fewer and weaker. The men and women affiliated with these schools condemned the elitism of medical societies and licensing boards, and lent their support to the abrogation of medical boards' licensing powers. This narrative, which emphasizes the role of organizational strength and mass mobilization in professionalization, leads to two alternative predictions:

H2a: The greater a profession's organizational strength, the more likely deregulation.

H2b: The greater a profession's organizational strength, the greater the amount of mobilization.

This account has much to recommend it: it is historically grounded, and begins to disentangle the processes linking together professional regulation, schooling, and other professional activities. But there is reason to doubt that organizational strength is alone sufficient for the realization of policy goals. One problem, long noted by students of social movements, is that state officials and other powerful actors often perceive collective mobility project as potential threats (McAdam, 1999: 40-43; McCarthy and Zald, 1973). In the absence of powerful allies who see the professional project as an opportunity to advance their own interests, it is very difficult for either the advocates or opponents of professional licensing to acquire enough political leverage to alter laws already on the books. In democratic societies, state politics and struggles among occupational groups constitute distinct and relatively independent realms of social life. Changes to professional regulations must find advocates in both realms (Abbott, 2005; Fligstein and McAdam, 2012).

Several studies have pointed to the distinctive political milieu of the Jacksonian era as an important factor behind the deregulation of the U.S. medical profession (Abbott, 2005: 258-61; Rothstein, 1972; Starr, 1982: 55-9; see also Larson, 1977: 117). According to Starr (1982: 55-9), public skepticism of exclusive professions found a strong voice in Andrew Jackson and his allies. Jacksonian politicians denounced the professions as "licensed monopolies," which obscured and confused matters that could be left to the judgment of ordinary men possessed of common sense in a democratic society (Starr, 1982: 57). Of course, popular skepticism of the medical profession and the grievances of marginal practitioners predate the emergence of the Jacksonian coalition. But as Abbott (2005: 258-61) argues, Jacksonian politicians and marginal medical practitioners quickly found that they had a common interest in pushing forward the cause of deregulation. Put in more general terms, we may expect that:

H3a: The greater the support for deregulatory politics, the more likely deregulation.

H3b: The greater the support for deregulatory politics, the greater the amount of mobilization.

A second and perhaps more fundamental problem with the collective mobility thesis is that organizational strength alone does not explain how practitioners come to understand that their interests lie in opposition to professional licensing. Organizational strength and political opportunities are structural preconditions for any sustained lobbying campaign. But it is just as important that potential supporters can interpret their interests in the movement's terms (McAdam, 1999: 48-50 Snow et al., 1986; Snow and Benford, 2000). This is not just a question of practitioners' naked self-interest. It is also a matter of how practitioners and clients define the very work of the profession. Professional claims to authority are based on the application of a body of knowledge (Abbott, 1988; Freidson, 2001). Advocates of professional deregulation must assert that the nature of the knowledge applied in the course of professional work is incompatible with the existing system of professional regulation.

The very foundations of medical knowledge were a subject of serious debate in early nineteenth century. Regular physicians vied for clients with a variety of other healers, including botanical doctors, homeopaths, herbalist, and mesmerists. Some of these groups, especially the botanical and homeopathic doctors, saw their medical practice in explicitly oppositional terms. These medical sectarians decried the bloodletting, doses of mercury, and other therapies favored by regular physicians in favor of other treatments. They scorned physicians' claims to special and authoritative knowledge, affirming instead that patients could judge for themselves which treatment best. According to Whooley (2013), the struggles between different groups of healers were nothing less "epistemic contests" over the basis of medical knowledge, how it was to be applied to treatment, and who was qualified to determine its efficacy. The intellectual positions of regular and sectarian physicians thus led to very different approaches to medical regulation. From this dynamic we may derive two final propositions:

H4a: The greater sectarian *organizational strength, the more likely deregulation.*

H4b: If medicine is deregulated, then sectarian *mobilization will increase.*

We have reviewed the factors that may lead to the professional deregulation, and their possible effects of the activity of the profession. We now go on to describe the condition of the medical profession in the United States before the Civil War, focusing in particular on patterns of regulation and deregulation, and the forms of organizing and mobilization used by the various groups of medical practitioners.

THE DEREGULATION OF MEDICINE IN IN THE UNITED STATES, 1790-1860

The medical profession was anything but unified in in the early nineteenth century. Writing in the *New York Monthly Chronicle of Medicine and Surgery* in 1825, one physician lamented that "no body of men are less in concert or seem less influenced by the esprit du corps, than physicians… the quarrels of physicians are proverbially frequent and bitter, their hatred, intensity, and duration seem to exceed those of other men" (Quoted in Rothstein, 1972: 64). It may come as a surprise therefore that, in 1825, after decades of struggle, the medical profession had achieved official recognition and monopoly protections in some 16 states, a high point for

U.S. medicine prior to the Civil War. We now describe the rise of medical licensing regulation in the United States, and its precipitous fall.

Medical regulation and licensing

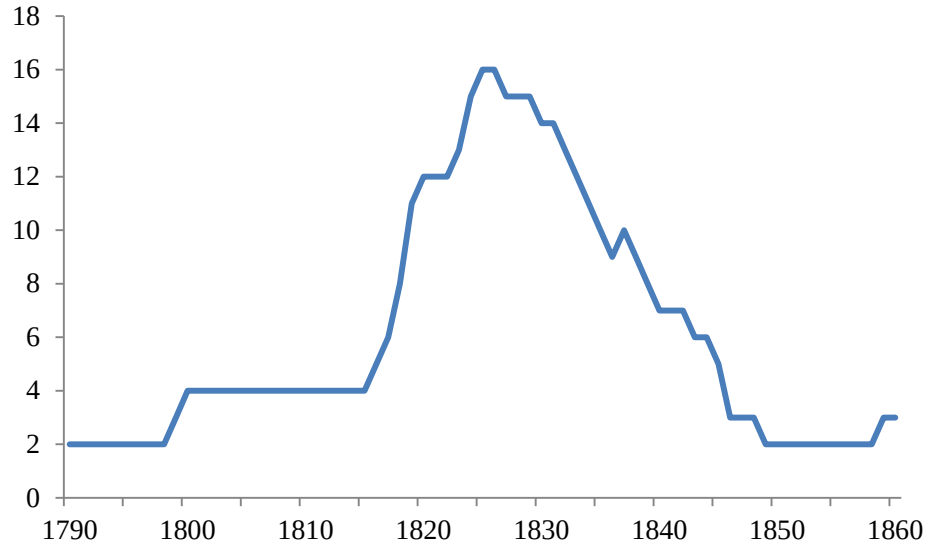
The earliest medical licenses in the United States were issued by private, exclusive medical societies. By 1790, medical societies with nominally statewide memberships existed in New York, New Jersey, Massachusetts, Pennsylvania, and South Carolina. But under the aristocratic conception of the medical profession that prevailed at the time, professional status depended on personal eminence rather than occupational qualifications (Larson, 1977; Rothstein, 1972: 64-72). Medical societies selected their members from among the wealthiest and best educated physicians, who treated the most affluent clientele. The privilege of full professional recognition was extended only to practicing physicians who met these criteria, excluding the majority of practicing physicians as well as lay healers. Nevertheless, medical societies enjoyed close ties to state governments, advising elected officials on quarantines, sanitation, public morality, and other matters.

Licensing laws strengthened these ties between states and medical societies. Colonial era laws in New York and New Jersey empowered government officials to grant medical licenses; new legislation passed in New York in 1806 and New Jersey in 1816 transferred those powers to private medical societies (Kett, 1968; Rothstein, 1972). Similar licensing laws were also enacted in Connecticut in 1792 and Maryland in 1799 (Thoms, 1942; Kett, 1968). These laws gave the licenses issued by medical societies an official imprimatur and established legal penalties for physicians practicing without a license. In all four states, only physicians bearing a medical license were permitted to sue for fees in a court of law, and in all but Connecticut, fines ranging from five to twenty-five dollars could be levied for practicing without a license. In practice, these provisions were difficult to enforce, however they did serve to attention to the distinction between society physicians and other practitioners.

During the first three decades of the nineteenth century, this model of medical licensing spread to additional states. To be sure, other, more democratic models were proposed, but they failed attract much support among physicians. In Indiana, Illinois, and Ohio, state-led efforts to establish federative associations of doctors passed the legislature in the 1810s, but in each case officials were unable to find enough willing physicians to fully staff the proposed medical boards. In contrast, elite physicians concentrated in major cities enjoyed far greater success in obtaining state recognition for their own private medical societies. New medical societies based on Northeastern models appeared in the South and along the frontier. Between 1818 and 1825, no fewer than eleven states (and the District of Columbia) passed medical licensing laws, most of which granted the power of licensing to one or more established medical societies. Figure 2-1 illustrates the swift adoption of medical licensing in more and more states prior to 1825.

Beginning around the 1830, however, the medical profession suffered a sudden change in fortune. Over the course of the next two decades, state licensing laws were repealed almost as quickly as they had first been passed. By 1849, licensing regulation had either been repealed or nullified in nearly every state. Only New Jersey and the District of Columbia kept their licensing

Figure 2-1: Number of states enacting medical licensing laws, 1790-1860



Note: Figure includes the District of Columbia
Data source: Rothstein (1972)

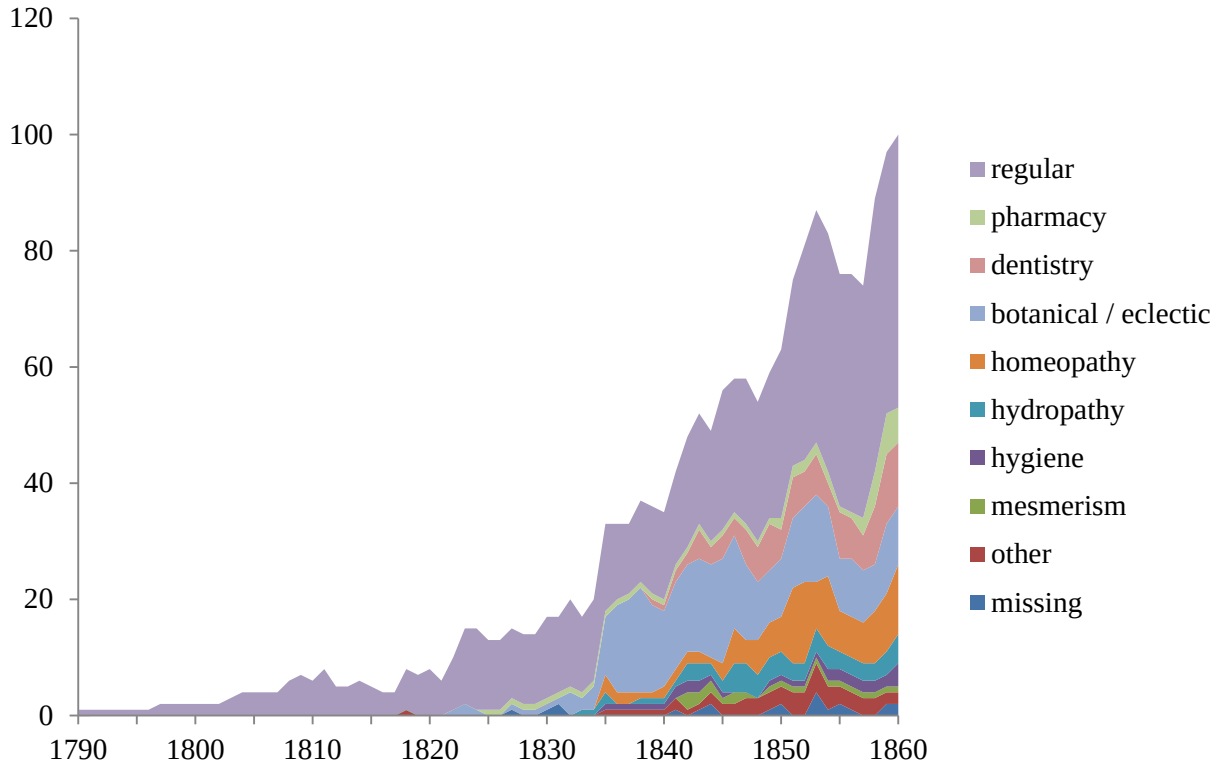
laws on the books. These years coincided with the appearance of a number of new challenges for the medical profession. These included the expansive growth of medical profession beyond educated urban circles, the proliferation of new medical schools, the surge of Jacksonian populism, and the powerlessness of the regular medical profession in the face of the horrific cholera epidemic of 1832 (Rothstein, 1972, Starr, 1982, Whooley, 2013). But it is difficult to comprehend the depth of opposition without considering the hostility of many medical practitioners to the medical societies and their physicians.

By the eighteen-thirties, medicine in the United States had also become a fiercely partisan and divided occupation. The most organized groups were the regular physicians, who were there inheritors of British and European medicine, the botanical or eclectic doctors, a homegrown opposition movement, and the homeopaths, another rival medical sect recently arrived from Europe. We describe these groups and their conflicts below. But it is important to note that these three groups did not at all exhaust the diversity of medical factions. There were specialists like pharmacists, dentists, dieticians, and psychiatrists, who were not explicitly hostile to regular medicine but who competed with general practitioners for clients to some degree. There were also sectarian groups that, like the botanical doctors and homeopaths, rejected the authority of regular physicians. These included hydropaths, mesmerists, phrenologists, electropaths, naturopaths, and iatroleptics. And, of course, much of the U.S. population relied on lay practitioners such as barbers, bonesetters, midwives, and herbalists for medical care.

Medical mobilization and publishing

Medical practitioners did not hesitate to carry out their quarrels in print. As long as medicine was broken into warring factions, medical periodicals were one of the primary means of reaching widely dispersed practitioners and mobilizing them in support of one group or

Figure 2-2: Medical magazines published by sect, 1790-1860



Data source: see the discussion of the data set below.

another. Thus medical journals included not only case studies, discussions of therapies, research reports, and news of the profession, but also blistering attacks on rival medical sects. The tone of much medical journalism, writes Cassedy (1983: 144), "alternated from condescension to sarcasm, from enthusiastic advocacy to bitter invective, all with the aim of discomfiting or defeating medical foes." The number medical magazines in print increased dramatically at around the same time as deregulation efforts gained momentum. As Figure 2-2 illustrates, in 1825 fewer than 20 medical magazines were in print, and nearly all were affiliated with regular medicine. By 1850, there were over 60, represented a wide diversity of practitioner and viewpoints. We now describe each the three largest groups, their approach to medicine, and their organizing activities.

Regular medicine: The regular physicians were the most numerous and important group of medical practitioners. This faction included not only the members of the traditional medical societies, but also the larger number of medical practitioners who learned at their schools, apprenticed in their clinics, and followed their recommendations. Regular physicians relied heavily on so-called "heroic therapies," such as surgery, bloodletting to reduce fever and inflammation, and doses of calomel (mercury) and other powerful purgatives (Rothstein, 1972; Starr, 1982; Whooley, 2013). The first medical magazine in the United States, the *Medical Papers*, was published by the Massachusetts Medical Society and appeared in 1790. But regular physicians were active in all states, and by1856 published magazines as far west as California. Much of the regulars' professional activities were therefore directed at reaching diverse local

audiences. Of the more than 150 magazines published on behalf of regular physicians before the Civil War, nearly three quarters targeted specific, geographical locales in their titles. Nevertheless, much of their contents were devoted to condemning the ignorant and deceitful practices of the quacks, pretenders, and charlatans that challenged them across the country.

Sectarian medicine: Rival medical groups likewise rejected the methods of the regular physicians and their claims to authoritative medical knowledge. The earliest of these were the Thomsonian or botanical doctors. Samuel Thomson (1769-1843) was a self-taught healer who devised a new system of medicine around the start of the nineteenth century. An ardent believer in the curative power of nature, Thomson's system relied on treatments derived from native plants. To Thomson, the knowledge of regular physicians amount to no more hand needless, even dangerous mystification. The patient, he declared, ought to be the true judge of any treatment (Haller, 1997; 2000). Thomson and his followers were quick to use periodicals to market their system to rural and frontier populations underserved by regular physicians. The first Thomsonian magazine, the *Medical Advocate; Devoted to the Cause of Advocating the Thomsonian System of the Practice of Medicine, on Botanical Principles*, was published by Thomson himself an appeared in Boston in 1827.

The Thomsonian movement splintered into several camps in the 1830s, due in part to Thomson's strict prohibitions against any deviations from his original principles. Nevertheless, the number of Thomsonian physicians continued to grow. The most important offshoot was the reformed or eclectic medical movement of Wooster Beach (1794-1868). Beach and his associates rejected Thomson's skepticism towards formal medical schooling. They founded the Reformed Medical Society of the United States in 1829 and together set up medical schools in several states. By the 1840s, there were nearly as many Thomsonian medical magazines in print as regular medical magazines, as well as number of botanical colleges and associations. In this way the Thomsonians began to accumulate the trappings of professional organization long monopolized by regular physicians.

The Thomsonians were not alone in their opposition to the regular profession. Nor was the opposition limited to self-taught men like Thomson. The homeopaths were well educated, and the medical system had ties to European science and medicine. Founded by Samuel Hahnemann (1755-1843), a German physician who became disillusioned with regular medical practice, homeopathy eschewed the heroic therapies of regular physicians as needlessly dangerous, and favored small and highly diluted doses of medicine, along with careful observation of their effects on patients. The homeopaths appeared in the United States in the 130s, and found clients among the affluent and the educated and even converts on regular physicians (Haller, 2005; Whooley 2013). They were also very active in establishing their own professional infrastructure. The first school and magazine for homeopathy both appeared in 1835. In that year Constantine Hering, a German immigrant, established as school, the Nordamerikanische Akademie der homeopathischen Heilkunst in Allentown, Pennsylvania and a periodical, the *Korrespondenzblatt der homeopathischen Aerzte* (Haller 1981: 117-18). Both lasted on a few years, but additional schools and journal in English soon appeared. By 1850, there were nearly a dozen homeopathic magazines in print, and four homeopathic medical schools in operation.

The regular medical profession thus faced significant resistance and was beset by competitors in the antebellum United States. It is thus no surprise that this was an era in which deregulation movements flourished. But to identify more clearly the precise causes of medical regulation and its consequences for both regular and sectarian groups, we now turn to our quantitative analyses.

DATA AND METHODS

We are interested in two interrelated processes: the deregulation of medical practice by states in the antebellum United States, and mobilization of different groups of medical practitioners before and after deregulation. We therefore employ a longitudinal research design that attempts to predict the occurrence of these outcomes in a given year. Each process requires a different modeling strategy. In this section we describe the data and methods we use to evaluate the predictions laid out above, including our measures for the outcome and explanatory variables, and the models used to estimate each outcome.

Dependent variables

To measure medical deregulation, we use the repeal of state medical licensing laws. Our main source is a survey of state medical licensing law that appears in the appendix of Rothstein's book, *American Physicians in the Nineteenth Century: From Sects to Science* (1972).[1] Rothstein (1972) provides detailed information on medical licensing statutes and boards for each U.S. state between 1787 and 1864. This information includes the establishment dates of official licensing boards, the composition of those boards, the benefits granted to licensed medical practitioners, and the penalties for practicing medicine without a license.

We define the medical profession as *regulated* in those states where medical licenses were issued by a state-sanctioned licensing authority and granted their holders defined legal privileges. The privileges conferred by a license varied considerably over time and from state to state, and the enforcement of licensing laws was often irregular. The most common benefit was the ability to sue to recover fees. Penalties for practicing without a license ranged from small fines to imprisonment or even possible execution. A possible disadvantage of licensing laws as an indicator is that, in some states, licensing laws remained on the books, but were "dead letter" because licensing authorities did not exist, refused their responsibilities, or were never appointed (Kett, 1968; Rothstein, 1972). For this reason, we do not classify the medical profession as regulated in those states where licensing laws existed but were not enforced, nor where medical boards existed on paper but did not meet or grant licenses.

We treat the suspension by state governments of the legal authority of licensing boards and the privileges granted to licensed practitioners occurrences of *deregulation*. The deregulation of the medical profession was accomplished through several means. In some states,

[1] We also cross-checked our measures using Joseph Kett's less compendious but more detailed history the development of licensing law in five states in *The Formation of the American Medical Profession: The Role of Institutions, 1780-1860* (1968).

courts, governors, or legislatures simply overturned medical licensing laws *in toto*. In others, they chipped away at the regulatory power of licensing authorities by eliminating the privileges held by licensed physicians, or by granting exemptions from regulation to classes of alternative medical practitioners. For example, Georgia eliminated the state licensing board in 1839, but then brought it back in 1847 but without the power to regulate alternative practitioners. New York, on other hand, limited the power of the board over alternative practitioners in 1831 and eliminated it entirely in 1844. We count both as episodes of deregulation in our analysis from the earlier date, because this it when state-sanctioned medial licenses no longer held legal force as a means to restrain rival medical groups. In models where regulation and deregulation appear as predictors, we enter them as separate dummy variables, treating instances of no regulation as the baseline category.

To measure the mobilization of different medical groups, we use the number of magazines each medical group published in a given state during any given year. We use magazines because they were the primary means by the medical profession reached far-flung members, disseminated medical knowledge, and carried on the debates between medical sects (Cassedy, 1983). Magazines were meant to carry news of the profession in a timely manner to the full range of practitioners, from students to hospital physicians to independent practitioners. But they were also partisan organs, enthusiastically advocating one school of medical opinion and directing bitter invective at its foes.

The magazine data comes from a complete data set of magazines published in the United States and its antecedent colonies between 1741, the year the first magazine was published in North America by William Bradford of Boston, to 1860, the eve of the Civil War. These data were assembled from nine primary and 88 secondary sources. A complete list of these sources and further details of the data set are available in Haveman (forthcoming). The data set excludes newspaper, pamphlets, and occasional tracts, but to the best of our knowledge encompasses virtually every U.S. magazine published before the Civil War.

We attempted to identify all medical magazines contained in the data set and their group affiliations. We found 431 medical magazines, with an average time in print of 4.4 years (the median is 2 years). Of these, we were also able the group affiliation of all but 17 magazines, or less than four percent of the total. A further 13 magazines were affiliated with marginal sects that published fewer than five magazines, These sects include Grahamism (4 magazines) and naturopathy (3 magazines), as well as magazines on the deaf and dumb, psychiatry, psychology, veterinary medicine, electropathy, and iatroleptic medicine (1 magazine each).

Independent variables

To measure organizational strength, we use the number of medical schools in each state and the existence of a national association affiliated with each medical sect. No one source suffices to describe the entire population of nineteenth-century U.S. medical schools. The American Medical Association's catalog, *Medical Colleges of the United States and of Foreign Countries* (1918) has excellent coverage of regular medical schools, including many that had closed their doors prior to 1918. It comes as no surprise that the AMA catalog excludes the many

botanical, homeopathic, and other sectarian colleges. Unfortunately it also does not list schools of dentistry, pharmacy, psychiatry, or other subordinate medical specialties

We therefore turned to histories of each medical specialty and sect to identify their schools. For information on early U.S. schools of dentistry and pharmacy, we turned to the historical overviews by Brenmer (1954) and Kremers, *et al.* (1963), respectively. For Thomsonian, botanical, and eclectic medicine, we relied on the lists of colleges that appear in Haller's (1999: 19-20; 2000: 189-196) studies of this topic. The same author has also written a history of academic homeopathy in the United States, which includes an extensive list of homeopathic colleges (Haller, 2005: Appendix B). Beyond regular medicine and these major medical sects, institution-building appears to have been rare. Weiss and Kemble (1967: 35-7) found two schools for hydropathy in operation in New York City during the 1850s, but there is no evidence that advocates of hygiene, mesmerism, or any other sectarian movement attempted to establish their own schools and colleges before the Civil War. We have found no evidence of any schools of hygiene, mesmerism, or any other medical sect that were founded before the Civil War.

Studies of professionalization have also stressed the importance of national professional associations as a key organizational resource. National associations may provide unity and coherence for an emerging profession (Larson, 1977; Popp Berman, 2005; Whooley, 2011). Using the same sources as above, we identified the founded dates of national associations for regular physicians (the American Medical Association, founded1847), dentists (the American Dental Association, 1859), pharmacists (the American Pharmaceutical Association, 1852), eclectics (the American Eclectic Medical Association, 1848, but inactive after 1856), and homeopaths (the American Institute of Homeopathy, 1844). As a second measure of organizational strength, we also included dummy variables coding for whether a group had an active national association in that year.

To measure the influence of deregulatory politics, we follow the lead of our sources and focus on the ascendancy of Andrew Jackson and Jacksonian politicians. For each year, we use the percentage of support received by the Jacksonian candidate(s) in the most recent Presidential election for each state. These results are available in the *Historical Statistics of the United States* (U.S. Census Bureau, 2006). In states where Presidential Electoral College delegates were determined by popular vote, we simply use the percentage of votes that went to the Jacksonian candidates. In states where the legislature selected Electoral College delegates, we use the percentage of votes cast by the legislature for Jacksonian candidates instead.[2]

Finally, we also attempt to control for the effects of the development of individual states and the magazine industry on professional deregulation and mobilization. As controls for each state, we include measures for the population of the state in millions, and the population density of the state in persons per square mile. We identified state populations and as areas using historical demographic data (U.S. Census Bureau, 2006). As controls for the development of the magazine industry, we include measures of the postal rate for magazines in constant dollars, and

[2] In one state, South Carolina, the state legislature selected electoral representatives but did not record the vote of the assembly and threw all of its representatives behind the winning candidate. Here, we simply coded the variable to 1 if the legislature selected a Jacksonian and 0 otherwise.

for maximum printing speed technologically possible (in thousands of sheets per hour). These measures were taken from histories of the U.S. Postal Service and the printing industry (Kielbowicz, 1989; Moran, 1973; Rich, 1924). For models of medical deregulation, we include state controls, and for models of medical mobilization, we include both state controls and magazine industry controls.

Models and Methods

Each of our dependent variables implies a different level of analysis and a different modeling strategy. We discuss each in turn. For the models of medical deregulation, the level of analysis is the state and our observations consist of state-years. For the sake of parsimony, we do not estimate separate effects for the number of colleges or magazines of each medical sect in these models. Instead, we aggregate regular colleges and magazines (including regular or allopathic medicine, dentistry, and pharmacy), and sectarian colleges and magazines (including botanical and eclectic medicine, homeopathy, hydropathy, hygiene, and mesmerism).

Because we are modeling rare events – deregulation does not occur more than once in each state over the seventy-year period of observation – the methods of event history analysis are appropriate. We therefore estimate Cox proportional hazard models predicting the chance that a state repeals it medical licensing laws (Cox, 1972). This specification of the model necessitates that we exclude all those observations for which medical regulation had not yet been passed or implemented, and that we treat states where medical regulation was never repealed as cases of right-censoring. It should also be noted that because no states repealed licensing legislation more than once, it is not possible to disentangle changes within each state from the effects of unobserved time-invariant qualities of each state. We therefore employ a random effects specification of the model.

For the models of medical magazine publishing, our dependent variable is a count variable that pertains to both a particular state and a particular medical group. The level of analysis is the state and the sect, and our observations take the form of state-group-years. We estimate models predicting the number of magazines published by a given medical group in a given state. It is therefore not necessary to aggregate our measures of colleges or magazines as in the models of medical deregulation. But an issue arises in that our dependent variable may include state-sect-years where no magazines were published. In order to place reasonable scope conditions on our analysis, we exclude purely notional observations of magazines published before the first magazine was ever published by that particular group in the United States, as well as observations of magazines published in non-state colonies or territories.

We attempt to correct for two important potential sources of bias in these models. The first is overdispersion of the dependent variable. Model selection tests revel that the observed values of the data are highly overdispersed relative to the model estimated using Poisson regression, and therefore we use negative binomial regression to fit our models (Long, 1997). The second is confounding due to the time-invariant characteristics of both states and medical sects. To eliminate these effects, we estimated a fixed-effects specification of model (Allison and Waterman, 2002). We include fixed effects for each and every group-state pairing. These

models therefore yield estimates of within-case change for each group-state rather than population-level changes. It should be noted that we therefore must exclude from the analysis all group-state cases where the dependent variable does not change over time.

RESULTS

Models of Deregulation

What predicts when states repealed their medical licensing laws? Table 2-1 presents the descriptive statistics for all variables used in the models of deregulation. All of the independent variables except state population density are positively correlated with deregulation. This is the case even though the proportional hazard model requires that we ignore all observations on a case that occur both before the onset of regulation, or after the first year of deregulation. The model specification also restricts the range of the independent variables. The maximum number of sectarian colleges is only one in these data, even though in fact as many as five sectarian colleges operated in Ohio in the 1850s. All but one of these colleges, however, were founded after the onset of deregulation and so do not appear in these analyses. It is for the same reason that these models do not include a variable for national medical associations: they too were founded after the onset of deregulation in the majority of states.

We begin with a model of the hazard of deregulation that includes only time-varying variables for the number of regular medical schools and regular medical magazines published in each state. The results are reported in Model 1, Table 2-2. The coefficients are positive, but not significant. We find no evidence to support traditional professionalization theories (H1a). But neither is there clear support for the collective mobility thesis (H2a), although the coefficients are in the correct direction. Model 2 adds a measure for support for Jacksonian politicians. These results are clear and very strong: for every one percent increase in support for Jacksonians, there's a 2.6 percent increase in the hazard of deregulation. Deregulatory politics appears to strongly predict medical deregulation (H3a).

Turning to the role of medical sectarianism, Model 3 adds variables for sectarian medical schools and sectarian magazines. The predicted effect is extremely large: the appearance of sectarian college increases the predicted hazard by approximately 2,000 percent. A closer look at the data reveals that these models include only ten observations of sectarian colleges, three of occur in the very year of deregulation. Nine of these observations are from two states: New York and Ohio. It is noteworthy that the founding of these colleges were among the most important and contentious moments in the history of medical sectarianism. Thomsonian doctors Wooster Beach and John Steele founded these medical schools without the protection of the law (Felter, 1902; Haller, 2000). Beech founded the New York Reformed Medical College in 1826, four years before medical deregulation, and Steele established the Reformed Medical College of Ohio in Worthington in 1830, three years before deregulation. These men also served as president and vice president of the Reformed Medical Society of the United States at its inaugural meeting. In contrast, support for Jackson's candidacy was very low in New York and Ohio in 1824, although he won narrow majorities in 1828. These two cases illustrate the

Table 2-1: Descriptive statistics for models of deregulation

	Variable	1	2	3	4	5	6	7	8
1	Medicine deregulated	1							
2	No. of colleges (regular)	0.095	1						
3	No. of magazines (regular)	0.123	0.484	1					
4	Jacksonian support (%)	0.160	-0.054	-0.059	1				
5	No. of colleges (sectarian)	0.258	0.167	0.283	0.088	1			
6	No. of magazines (sectarian)	0.208	0.213	0.189	0.162	0.157	1		
7	State population (millions)	0.125	0.482	0.672	0.133	0.483	0.139	1	
8	State pop. density (per mile^2)	-0.035	0.237	-0.057	-0.206	-0.035	-0.037	-0.237	1
	Statistics								
	Observations	523	523	523	523	523	523	514	514
	Mean	0.023	0.688	0.337	0.220	0.019	0.096	0.357	63.622
	Standard Deviation	0.150	0.758	0.820	0.304	0.137	0.359	0.302	135.562
	Minimum	0	0	0	0	0	0	0.008	0.148
	Maximum	1	3	5	1	1	3	1.9	834.222

Note: This table excludes 254 observations that occur after the first year of deregulation. The correlation table is based on 514 observations.

Table 2-2: Cox regressions for medical deregulation

Model	1	2	3	4
No. of colleges (regular)	0.176	0.030	-0.089	0.236
	(0.352)	(0.401)	(0.450)	(0.573)
No. of magazines (regular)	0.223	0.275	-0.075	0.194
	(0.328)	(0.357)	(0.452)	(0.488)
Jacksonian support (%)		2.554*	2.620*	3.303**
		(1.004)	(1.130)	(1.044)
No. of colleges (sectarian)			3.007*	3.791***
			(1.432)	(1.151)
No. of magazines (sectarian)			-0.044	-0.097
			(0.439)	(0.478)
State population (millions)				-2.142
				(1.480)
State population density (persons / mile^2)				0.001
				(0.002)
N cases	37	37	37	37
N observations	2317	2317	2317	2260
Log-pseudolikelihood	-39.75	-37.29	-34.40	-33.19

Notes: Regular medical groups include regular physicians, dentists, and pharmacists. Sectarian groups include botanical and eclectic doctors, homeopaths, hydropaths, hygienists, and mesmerists. Robust standard errors are in parentheses.
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

importance of the organizational efforts of sectarian doctors in two of the earliest incidences of medical deregulation in the United States.

Model 4 introduces controls for the growth of individual states. The results remain essentially unchanged, and the statistical significance of Jacksonian politics and sectarian colleges actually increases. The publishing of neither regular nor sectarian magazines predicts medical deregulation. Early sectarian agitation in places like Massachusetts and South Carolina appears to have had little effect, although sectarian college founding in New York and Ohio had a very strong effect. Thus we find no support for traditional professionalization theory (H1a) or the collective mobility thesis in its simplest form (H2a). We do find, however, strong support for the contributions of deregulatory politics (H3a) and sectarian organization (H4a).

Models of magazine publishing

We now turn to the models of medical magazine publishing. Table 2-3 provides the descriptive statistics for the variables used in these models. Note that in these models, we disaggregate the variables for the number of magazines, the number of colleges, and the presence of a national association for each group in each state into separate cases. Regular medical groups

Table 2-3: Descriptive statistics for models of magazines published

	Variable	1	2	3	4	5	6	7	8	9	10
1	No. of magazines	1									
2	Medicine deregulated	0.263	1								
3	Medicine regulated	-0.099	-0.109	1							
4	No. of colleges	0.678	0.154	-0.054	1						
5	National association	0.314	0.197	-0.153	0.370	1					
6	Jacksonian support (%)	0.107	0.260	0.011	0.117	0.123	1				
7	State population (millions)	0.435	0.482	-0.080	0.296	0.186	0.212	1			
8	State population density (per mile^2)	0.078	0.110	0.104	0.082	0.063	-0.109	0.003	1		
9	Maximum printing speed	0.320	0.526	-0.206	0.278	0.641	0.261	0.443	0.178	1	
10	Magazine postal rate	-0.083	-0.129	-0.047	-0.074	-0.109	-0.173	-0.145	-0.054	-0.208	1
	Statistics										
	Observations	5868	5868	5868	5868	5868	5868	5868	5868	5868	5758
	Mean	0.325	0.220	0.318	0.285	0.125	0.230	0.766	41.723	6.354	18.362
	Standard Deviation	0.911	0.414	0.466	0.749	0.331	0.277	0.718	68.877	7.485	52.685
	Minimum	0	0	0	0	0	0	0.012	0.594	0.2	1.905
	Maximum	11	1	1	7	1	1	3.9	834.222	20	272.73

Note: The correlation table is based on 5758 observations.

include regular physicians, dentists, and pharmacists. Sectarian groups include botanical and eclectic doctors, homeopaths, hydropaths, hygienists, and mesmerists. In order to evaluate the effects of sectarianism, we estimate separate models for the regular and sectarian medical groups. In contrast to the models of deregulation presented above, these observations cover the full the whole historical period from 1790 to 1860.

We begin with models that include time-varying indicator variables for regulation and deregulation, as well as for the number of medical schools in a state and the existence of national association. The results are reported Model 1 and Model 2, Table 2-4. Under the condition of deregulation, we expect to see about twice as many magazines published by regular medical groups and ten times as many published by sectarian groups, relative to the same state when medicine is unregulated. The increase is even larger for sectarian groups when we compare the deregulated to years when medicine is actively regulated because the coefficient for regulation is negative in this model. This is entirely in contrast with the expectations of traditional professionalization theories (H1b) but it is consistent with a process of sectarian mobilization (H4b). The presence of colleges and national association has positive and significant effects on the number of magazines published. For every additional medical school, we expect 34% more magazines for regular groups, and 54% percent more magazines for sectarian groups. If a group has a national association, we predict that group to publish 80% more magazines in each state in that group is regular and 40% more if it is sectarian. These results are consistent with the collective mobility thesis (H2b).

Models 3 and 4 add measures for support of Jacksonian politicians. The effect is positive in both models, but it reaches significance at the $p=0.05$ level only for sectarian groups. It makes sense that the effects of deregulatory politics are weaker in the models of deregulation because deregulation, once accomplished, is difficult to reverse even if political opinions shift at a later date. Moreover, it is no surprise that Jacksonian politics has a strong effect on sectarian groups because Jacksonian politics provided more opportunities for sectarian doctors than for regular doctors. Thus there appears to be strong evidence for the effects of deregulatory politics (H3b).
Finally, Models 5 and 6 add controls for both the growth of states and the growth of magazine industry. The effects of deregulation and Jacksonian politics are attenuated somewhat but our conclusions remain largely the same as in the previous models. The effects of professional organization, however, change very significantly in two ways. First, the significant effect of number of colleges disappears from both models. Why? Given that magazine publishing and college founding are rather strongly correlated ($=0.678$), it would appear that the control variables together capture much of the same variation in the number of magazines as does the number of colleges. This suggests that magazine publishing and college founding, rather than being independent activities, are both products of the same mobilization process, which in turn is conditioned on the expansion of state populations and the publishing industry. Second, when we include the control variables, our model predicts the publication of fewer magazines after the founding of a national association. But this too makes perfect sense: once a national association exists, it may be the case that practitioners devote their professionalization efforts towards building that organization, rather than founding new ones. Every national association also had its own periodical, which may have competed for medical practitioners' time and interest with more local organs of publication.

Table 2-4: Fixed-effect negative binomial regression for magazines published

Model	**1**	**2**	**3**	**4**	**5**	**6**
Sample	Regular	Sectarian	Regular	Sectarian	Regular	Sectarian
Medicine deregulated	0.653*	2.387***	0.507	2.001***	0.075	1.366*
	(0.289)	(0.425)	(0.311)	(0.512)	(0.354)	(0.540)
Medicine regulated	0.083	-0.476	0.028	-0.626+	0.125	0.197
	(0.267)	(0.326)	(0.287)	(0.355)	(0.284)	(0.222)
No. of colleges	0.291**	0.422*	0.278*	0.538**	0.032	0.066
	(0.108)	(0.180)	(0.113)	(0.199)	(0.136)	(0.176)
National association	0.616*	0.339+	0.677*	0.269	-0.442*	-0.363
	(0.296)	(0.183)	(0.282)	(0.208)	(0.182)	(0.270)
Jacksonian support (%)			0.432+	1.115*	0.238	1.840***
			(0.227)	(0.493)	(0.217)	(0.417)
State population (millions)					0.438+	1.697***
					(0.242)	(0.374)
State population density					-0.007	-0.005
(persons / mile^2)					(0.006)	(0.009)
Maximum printing speed					0.095***	0.017
(sheets per hour / 1,000)					(0.018)	(0.025)
Magazine postal rate					-0.005*	-0.004***
(constant 1860 $)					(0.002)	(0.001)
Ln(alpha)	-15.590***	-14.163***	-15.660***	-13.571	-16.093***	-14.992***
	(1.668)	(3.689)	(1.476)	(14.638)	(0.644)	(1.032)
Fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
N cases	39	43	39	43	39	43
N observations	2377	2668	2377	2668	2334	2618
Log-pseudolikelihood	-1339.2	-1058.6	-1383.2	-1042.2	-1282.2	-944.4

Notes: Regular medical groups include regular physicians, dentists, and pharmacists. Sectarian groups include botanical and eclectic doctors, homeopaths, hydropaths, hygienists, and mesmerists. Robust standard errors are in parentheses.
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

To summarize, we find no support for traditional professionalization theories (H1b). The evidence for the effects of organizational strength (H2b) appeared at first very strong, but when we control for features of individual states and the magazine industry, that evidence disappears. Instead, we find clear evidence for the importance of deregulatory politics (H3b) and sectarian organization (H4b) to the level of magazine publishing, as we did in the models of deregulation.

CONCLUSIONS

Having considered the results from both sets of models, let us now return to the broader theoretical context. First, we find that the organizational strength of the nineteenth-century medical profession did nothing to stymie the deregulation of medicine, and that deregulation in turn did little to stop the mobilizing activities of medical professionals. This evidence contradicts traditional professionalization theories. But the support for Larson's (1977) collective mobility thesis is also quite mixed. Professional organizational strength alone did not lead to regulatory change, nor does it predict patterns of professional mobilization. Popular support for deregulatory politics is extremely weighty in explaining medical deregulation, but it only predicts much greater mobilization among sectarians than regular medical professionals.

These theories must be tempered with an understanding of how both the grievances of medical practitioners became transformed into political projects. Medical practitioners' grievances only turned toward advocacy for deregulation with the emergence a sectarian "medical counterculture that stood in opposition to the "aristocracy" of regular medicine. The regular medical profession was also organized, and mobilized to defend their authority, recruit supporters among the population at large, and discredit their opponents.

CHAPTER 3: HOW ORGANIZATIONAL FIELDS EVOLVE

The industrialization of subprime mortgage finance, 1998-2008

A major current of thought in sociological and organizational research seeks to recast social action across diverse contexts as occurring within fields (Bourdieu and Wacquant 1992; DiMaggio and Powell 1983; Fligstein 2001; Martin 2003). The language of field theory is now widely used in sociology, particularly Bourdieu's influential formulation (Bourdieu and Wacquant 1992:94–115; c.f. Emirbayer and Johnson 2008; Go 2008; Ray 1999; Steinmetz 2007). Yet the implications of field concepts for empirical research remain only partly explored. Fields are often invoked in studies as a heuristic device in which the positions that make up the field are defined *a priori* by the analyst, and then represented either as bounded study populations or in the form of an arbitrary diagram (e.g. Bourdieu 1996:122–4; Lewin 1952:70–3, 136, 138). Only rarely are attempts made to measure the structure of a field empirically using observed patterns of individuals' actions (e.g. Bourdieu 1984, 1988; Slez and Martin 2007).

One reason for this omission is that there is considerable divergence between the basic assumptions of field theories and those of multivariate statistics. Field theories attempt to explain individuals' actions in terms of their positions with respect to others (cf. Bourdieu and Wacquant 1992: 94-115, Fligstein and McAdam 2012: 9-13; Martin 2003: 3-8). In contrast, methods such as correlation and regression explain individual outcomes in terms of linear associations between variables. Martin (1999: 113-116) and McPherson (2004: 269) have both shown that aggregating relations among individuals into covariance among variables discards information and may yield results that contradict the observed patters of individual behavior they mean to explain. Nevertheless, outside of social network analysis, little consideration has been given to the ways in which measures of linear associations between variables may fail to adequately capture the effects of relations between positions, and even less have been directed to the development of new methodological tools that meet the challenge of modeling field structures.

This paper advocates a spatial approach to visualizing and modeling the structure of organizational fields. It is already commonplace to represent a field in terms of a two- or three-dimensional space (e.g. Bourdieu 1996: 122-4; Lewin 1952: 136-8; Slez and Martin 2007: 51; Steinmetz 2007: 601). Following Martin (1999) and McPherson (2004), I use simple bivariate plots to show how predictions based on position in a field may differ from those expressed in terms of aggregate associations between variables. I then build on these insights by developing statistical models that predict the positions of actors in a space defined by a set of outcome variables, using the evolution of the U.S. subprime mortgage finance industry as an example. Because the unit of analysis in these models is distance between pairs of actors, our approach can easily accommodate a space of outcomes with multiple dimensions, as well as predictor variables at both the individual level and the dyad level, such as network ties.

Proper models of field structure are important because understanding how fields emerge, become stable, and change is a central concern for proponents of the field theories within the sociology of organizations (DiMaggio and Powell 1983; Fligstein 2001:75–86; Fligstein and

McAdam 2011). Studies of a variety of industries have revealed the importance of relationships between different types of actors to the construction of a field (e.g. Gulati and Gargiulo 1999; Podolny 1993; Powell et al. 2005; Stark and Vedres 2006; Uzzi 1996, 1999). A key finding is that as organizations form and alter relationships, they may sustain, undermine, or transform markets. However few of these studies examine how the actions of firms may create or undermine the meaning of the very categories that define the identities of firms within the field (although for two approaches to this problem using network ties, see Powell et al., 2005, and Stark and Vedres, 2006). Instead, the precise configuration of different market positions is often taken for granted, and assumed to be identical to either regulatory categories or organizational form.

In the case of subprime mortgage lending, questions about how fields evolve also have considerable substantive importance. In 1996, subprime lending was a marginal financial activity, largely separate from the rest of the U.S. banking industry. The three largest lenders were a diverse cast of non-bank firms with ties to consumer finance, including an automobile loan company (Associates First Capital), a mobile home contractor owned by a Belgian conglomerate (Conti), and a non-bank lending company (The Money Store).[1] By 2007 however, the origination and securitization of subprime mortgages had become a core activity of some of the largest banks and financial services companies in the world. The old model of subprime lending as a side business for check-cashing companies and mobile-home builders was replaced by an "industrial conception" of subprime mortgage finance, in which vertically-integrated firms sought to capture as much subprime lending activity as possible and used those loans as assets to back an array of novel financial products (Fligstein and Goldstein 2010; Goldstein and Fligstein n.d). The rise of this new model brought down the barriers between subprime mortgage lending and securities trading. It also led worldwide to huge losses for investors, laid low some of largest financial institutions, and prepared the grounds for a prolonged recession.

In order to understand the processes behind the restructuring of the subprime mortgage finance industry, I begin by discussing the implications of treating markets as fields for understanding the relationship between firms' activities and market structures, using simple scatterplots to identify some of the methodological challenges associated with the field approach. Then I go on to describe the transformation of the subprime mortgage lending industry and the rise of the industrial conception of subprime mortgage finance during the 2000s, focusing on the changing relationship between the mortgage origination market and the market for mortgage-backed securities. Using data on firms in each sector of the subprime mortgage finance industry, I show how changes in firm strategy across different market segments altered the overall structure of the industry between 1998 and 2007. I find that the tactics of some firms, particular non-bank lenders, lending remained consistent during this period, but that the movement of foreign and domestic investment and commercial banks into subprime mortgage lending disrupted the original division of labor within the market and led firms to converge on a strategy of vertical integration. Many major investment banks aligned their tactics other vertically

[1] Today, The Money Store is perhaps the most widely remembered of these firms because of its television advertisements featuring former Yankees shortstop and Hall of Famer Phil Rizzuto. For examples, see http://www.youtube.com/watch?v=oo_stdamO_c, http://www.youtube.com/watch?v=nDQHQkuv9l0.

integrated firms, expanding their subprime mortgage origination activities even as the market began to unravel.

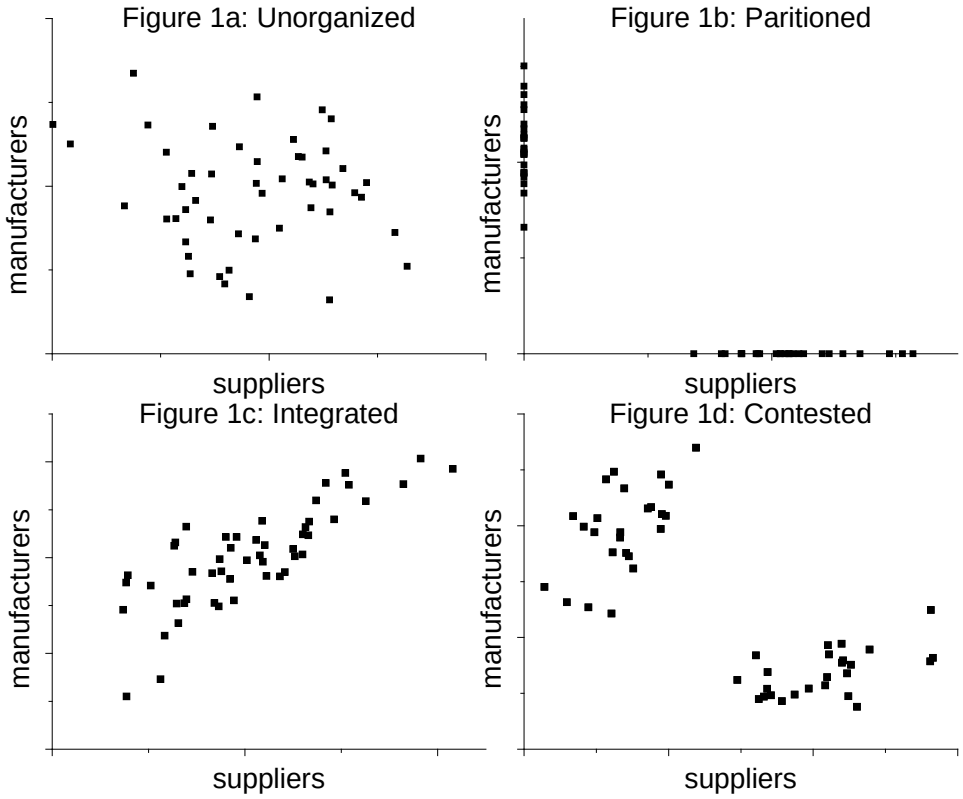
FIELD STRUCTURES AND INDUSTRIAL ORGANIZATION

Among organizational sociologists, the field concept has enjoyed widespread use in recent years as a tool for understanding the behavior of firms in a variety of different markets (DiMaggio and Powell 1991; Emirbayer and Johnson 2008). I define a field as local social orders in which actors share goals and expectations based on their position in that order (c.f. Bourdieu and Wacquant 1992; Fligstein 2001; Martin 2003). Organizational fields are socially constructed arenas within which actors vie for advantage with one another and wherein strategies are determined at least in part by relations among the positions constituting the field. Field theory is thus a cultural approach to social action in the sense that the nature of the field is the product of some degree of shared understanding among actors of both what is at stake in the field and how to interpret the actions of others. Fields are specifically local orders because they are differentiated from one another based on the extent to which different actors are invested in the stakes of different fields and attuned to the actors in some fields and not others.

But fields are not necessarily homogenous social orders in which all actors share the same collective identity. Even in a relatively settled, stable field, actors may differ considerably in their expectations and strategies based on their relative positions within the field. Dominant actors, for example, may seek to preserve the conditions responsible for their own advantage, while actors occupying marginal positions may choose either to challenge the status quo or to accept a subordinate role that avoids direct competition with more powerful actors. In contrast, in unsettled or rapidly changing circumstances, there may be little agreement on the affordances of different positions or expectations of other actors; in such a field, the positions that do or do not make up the field may be the subject of contestation or simply up for grabs. What determines a field's structure is not that everyone agrees to act the same way, but that actors are able to sustain and defend a particular understanding of their actions that continues to reproduce the present structure of the field.

Thus a difficulty in establishing the structure of an organizational field is identifying the positions that make up the field. A field may constitute a self-reproducing structure of defined roles, but be made up of actors that do not all share the same organizational form or identity (c.f. White 2002). Examples abound in the literature: firms may attempt to avoid direct competition and divide a market up into separate and distinctive niches (Carroll 1985; Carroll and Swaminathan 2000), they may shift market boundaries by acquiring suppliers and distributors in order to remove unmanageable uncertainties from the production chain (Coase 1993 [1937]; Knight 1964 [1921]), or they may move into new and unrelated markets in order to reduce its dependence on any one product (Kay 1997). In each case changes in firm tactics may shift the nature of competition across multiple markets. But, so long there is some degree of convergence among firms, those strategies may yield a clear set of positions with goals and expectations that are well understood to actors.

Figure 3-1: Four hypothetical industry structures



Visualizing field structure

We may speak of a field as having a structure to the extent that actors' behavior aligns around a set of one or more distinct positions. In order to develop the implications of this approach to market structure, it is useful to consider some hypothetical cases. In the examples that follow, a firm can act as either a supplier or a manufacturer, or both. To represent the structure of this industry visually, one can assign each firm a position in a two-dimensional Cartesian space based on its volume of production in each activity. Figure 3-1 presents four possible distributions of firms in this hypothetical industry. [2]

[2] The informational understanding of a field presented here also further implies that the inverse of structure is entropy, the amount of arbitrariness in the distribution of firms across markets. Given that the distribution both social actors and particles can also be represented in terms of Cartesian coordinates, there may be useful analogies to the statistical theromodynamics developed by Boltzmann and Maxwell, which also attempt to quantify the amount of non-arbitrary movement within an N-dimensional space. If it is possible to develop this analogy further, then it may be the case that statistical thermodynamics provides a better model for quantifying the structure of social fields than the classical field theories of Newton or Faraday.

An unstructured industry. Figure 3-1a presents an extreme case: the complete absence of apparent structure. In this figure, there is absolutely no alignment among firms around a shared approach to relationship between the suppliers' market and the manufacturers' market. In terms of firm strategy, the relationship between manufacturing and supply appears to be completely up for grabs. In terms of information, the position of any given firm in the manufacturing market implies nothing about its position among suppliers. Statistically speaking, the distribution of firms is consistent with independence: there is no association between a firms' activity as a supplier and as a manufacturer. But it is not the case that these two markets are structurally separate. Each market partly overlaps because any given firm may participate in one market, the other market, or both. The absence of structure also implies the absence of clear boundaries between manufacturing and supply.

A partitioned industry. We do not typically expect markets to resemble Figure 3-1a, particularly if the two markers are linked to each other as suppliers and manufacturers. Instead, we usually imagine that any given market is associated with a distinct set of firms. Organizational ecologists, for example, have long noted that high barriers to entry, the costs of acquiring information, and legitimacy constraints on firm strategy tend to create relatively stable, homogenous populations of firms within different markets (Hannan and Freeman 1977, 1989). Figure 3-1b presents just such a case. In contrast to the first case, we can now speak of two markets with clear boundaries, each defined by a unique strategy and a clear group of firms. Here, the relationship between the two markets is strong and mutually exclusive: participation in one market implies not participating in the other. The distribution is not at all linear, but a measure of linear association such as correlation would lead us to the correct conclusion that the relationship between the two markets is strongly negative. If a supplier were to enter the manufacturing market, that firm would appear very much out of alignment with other firms, and its actions would run contrary to the overall structure of the industry.

An integrated industry. However if all firms were to make this decision, then the industry might align around a strategy of vertical integration, in which manufacturing and supply are both done by the same firms, as in Figure 3-1c. This strategy is a common in industrial organization wherever firms seek a reliable supply of inputs in a competitive marketplace (Knight 1964 [1921]). It implies the dissolution of the boundary between manufacturing and supply markets. In terms of information, the position of a firm in one market still tells us a great deal about its position in the other because being a large manufacturer now also implies being a large supplier. Firms differ from one another based on size, but not based on the markets in which they participate because nearly all of the variation within the industry falls along the diagonal of the plot. The association between each market is thus strong, linear, and positive. There are no boundaries between manufacturing and supply in this case, but the joint field nevertheless has a clear structure.

A contested industry. At the same time, there is no reason to expect that the organization of firm strategies in fields will relate to the activities under study in such direct ways. Figure 3-1d presents a more problematic, but entirely plausible case. Here, firms are active in both manufacturing and supply, but strongly organized into two distinct groups. As in Figure 3-1a, no single understanding of the relationship between supply and manufacturing predominates, but here the position of a firm in one market nevertheless tells us quite a bit about its position in the

other. Although these two markets are not well partitioned, two clusters of firms exist, and within each cluster of firms there is a clear positive relationship between supply and manufacturing. Yet unless one can identify another variable that cleanly divides the observations into two classes, measures of association like correlation or linear regression will lead us to the conclusion that the relationship between manufacturing and supply is negative. Despite this methodological difficulty, the structural pattern here is intuitively accessible to the eye.

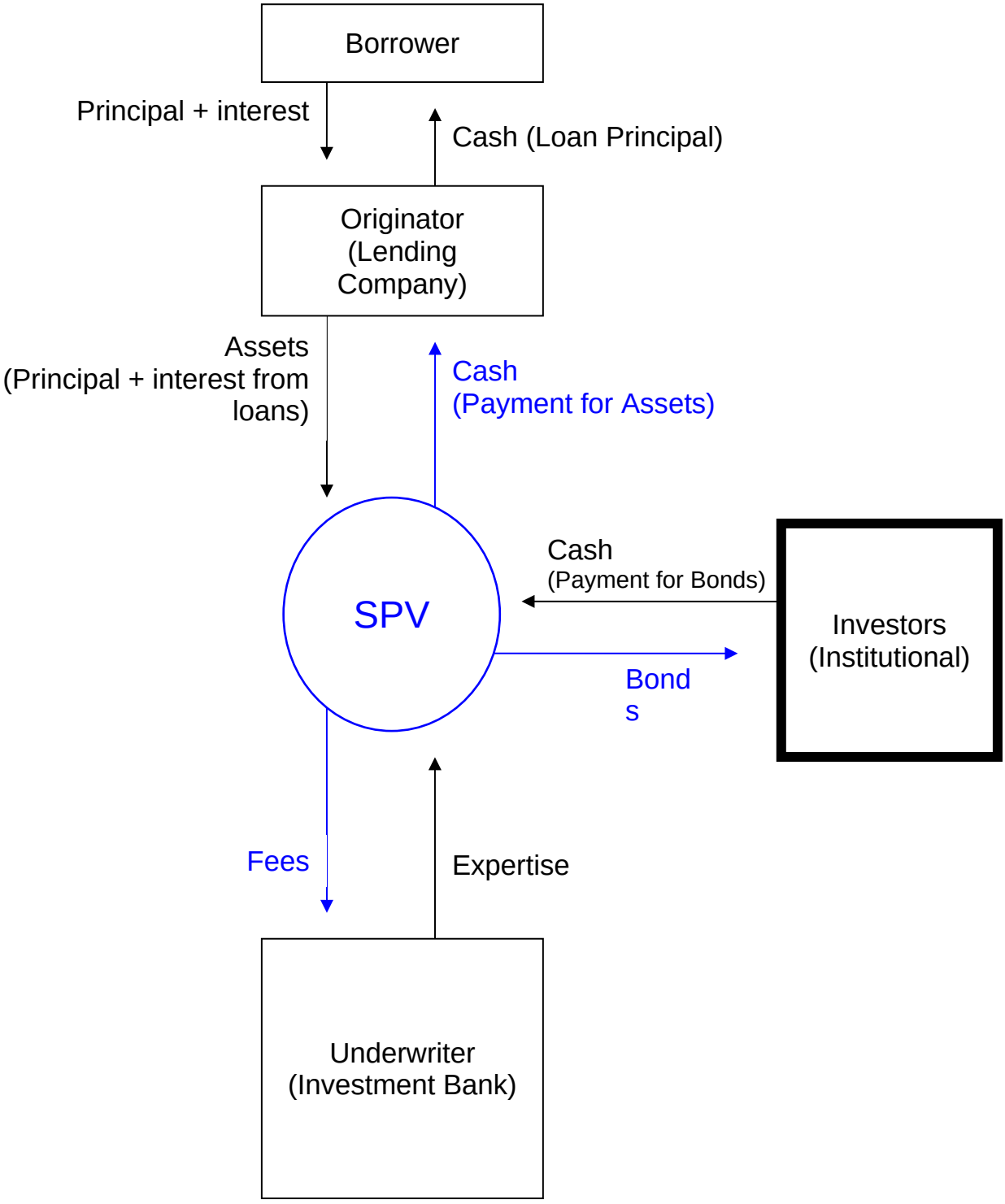
THE TRANSFORMATION OF SUBPRIME MORTGAGE FINANCE

The development of the U.S. subprime mortgage lending industry illustrates how market structures may change over time. Beginning around 1999, changes in regulatory and economic conditions undermined the boundaries between mortgage lending and securities trading. The relationship between these two markets became increasingly open to contestation as non-bank lenders, commercial banks, and investment banks all moved into one another's markets. In the years leading up to the 2007-9 financial crisis, these struggles led firms to converge on what Goldstein and Fligstein (n.d.) have called an "industrial conception" of subprime mortgage finance as the mortgage lending industry became vertically integrated around the production of subprime mortgages and mortgage-backed securities.

Mortgage securitization is a relatively recent activity. The first mortgage-backed securities (hereafter MBS) were issued in the 1970s by Fannie Mae and Freddie Mac, quasi-private government-sponsored enterprises (GSEs) created during the Johnson Administration to expand access to mortgage financing by purchasing mortgages from lenders (Quinn 2008; Sellon and VanNahmen 1988). Before the invention of MBS, most people got their mortgages from local banks and thrifts that would lend the funds and would also hold the mortgage until it was paid off. Today the borrower goes to a bank or non-bank lending company called an "originator" because they are responsible for making the initial loan. Unlike traditional savings and loan banks, these companies do not hold on to the mortgages they create. Instead, they sell their mortgages in order to recapture their capital and move back into the primary market to make more loans (Kendall 1996; Sellon and VanNahmen 1988). If the borrower and the mortgage meet certain criteria, the mortgage may be sold to Fannie Mae or Freddie Mac. Otherwise, the mortgage is packaged along with hundreds of similar mortgages into pools to back privately-issued MBS.

A number of further steps must be taken to produce MBS from mortgages. These are illustrated in Figure 3-2 (see Kendall, 1996, for further details). The mortgages are transferred to trust called a special purpose vehicle by the sponsoring company or "issuer," which may be the originator, a wholesale purchaser like Fannie Mae or Freddie Mac, a private financial company, or an investment trust. The special purpose vehicle combines the mortgages into a pooled asset that pays out an aggregate return based on the interest payments of the original home buyers. An "underwriter" (sometimes the issuer, but often an investment bank) then helps to divide the pool's returns into investment tranches, arranges to have the tranches evaluated by ratings agencies, and brokers the sale of MBS from each investment-grade tranche to investors. The tranches structure the returns so that investors can buy riskier MBS if they want a higher rate of return, or less risky MBS that pay a lower rate of return, from different tranches of the same

Figure 3-2: A mortgage securitization package (adapted from L.T. Kendall 1996: 3)



underlying pool. The production chain for MBS resembles that of many other large industries, with originators in the lending market acting as suppliers, issuers as manufacturers, and underwriters as dealers and distributors.

Until very recently, the markets for the origination of conventional mortgages, the origination of subprime mortgages, and the production of MBS remained fairly separate from one another. Chartered commercial banks and thrifts originated conventional mortgages. The GSEs bought these mortgages and packaged them into agency-backed MBS. Non-bank lending companies originated subprime mortgages. Investment banks underwrote and brokered the sale of subprime MBS to investors. In the first years of the twenty-first century, however, many of these firms went on to dramatically alter their strategies, erasing the distinctions that had once separated these markets and transforming the structure of subprime mortgage finance.

One reason for this shift is that policymakers and bankers worked over the past two decades to erode the regulatory barriers between mortgage origination and securities trading. The Glass-Steagall Act of 1933 separated commercial banking and investment banking. It forbade firms active in securities trading from operating as chartered banks and receiving deposit insurance through the newly created Federal Deposit Insurance Corporation. But in the 1990s, the Securities and Exchange Commission and the Department of the Treasury began to grant exemptions from the Glass-Steagall rules to a few commercial and investment banks. The Gramm-Leach-Bliley Act of 1999 removed the remaining restrictions on securities trading for chartered commercial banks. Whereas investment banks and commercial banks once were bound to different markets, after 1999 both were permitted to move freely into mortgage origination, MBS issuance, and MBS underwriting (Campbell 2010; Fligstein and Goldstein 2010). It is therefore plausible to expect that the field of subprime mortgage finance was divided up according to organizational type until around 1998, and afterwards these differences of form became gave less structure to the field as firms diversified their activities.

It is clear that some firms did more than simply diversify their holdings across these markets. A number of banks pursued a strategy of vertically integrating subprime mortgage origination and subprime MBS production in order to capture returns at each stage in the process of subprime mortgage financing (Goldstein and Fligstein n.d.). Table 3-1 shows that in 1998, the largest originators of subprime mortgages were nearly all either specialist lenders like The Money Store, IMC, FirstPlus, Household Finance, and Advanta – only the latter two of which were chartered as banks – or the finance arms of industrial conglomerates like Ford Motor Company, General Motors, and Conti. The underwriting of subprime MBS, in contrast, was dominated by major investment banks, such as Lehman Brothers, Bear Stearns, and Morgan Stanley. By 2007, however, the majority of top originators of subprime mortgages were also among the top underwriters of subprime MBS. Investment banks had become deeply involved in both subprime underwriting and in subprime origination. Large commercial banks like Citibank and Chase had also moved into both of these markets, and a few subprime lending specialists like Countrywide also survived and become top subprime MBS underwriters and mortgage originators. Many of the largest firms in subprime finance appear to have not only moved into new markets, but also converged on a shared strategy.

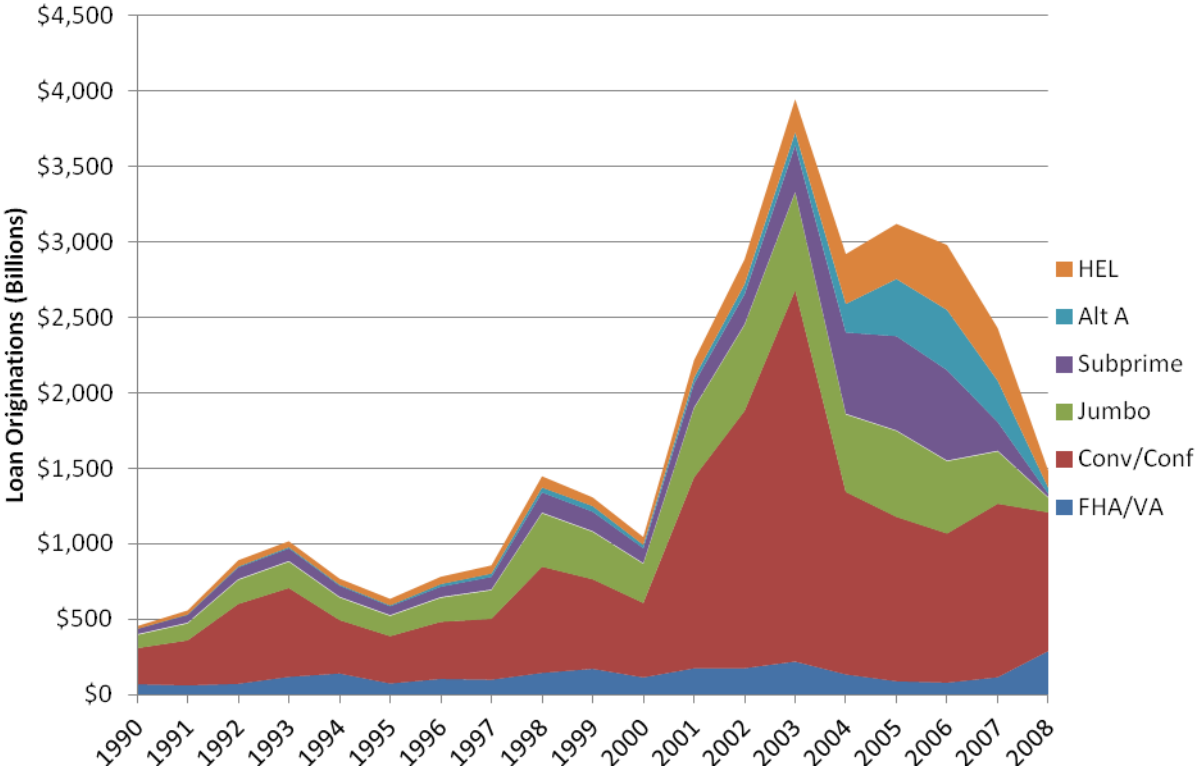
Table 3-1: Top 10 subprime originators and underwriters in 1998 and 2007

1998	Market Share	2007	Market Share
Top Subprime Mortgage Originators			
Household Finance	11.1	Citibank	10.2
Associates First Capital (Ford)	10.5	Household Finance (HSBC)	9.3
ContiMortgage	7.7	Countrywide	8.8
IMC Mortgage Co.	6.5	Wells Fargo	8
The Money Store	6.3	First Franklin (Merrill Lynch)	7
Green Tree Financial	5.2	Chase	6
Advanta Mortgage	5	Option One	5.8
GMAC (General Motors)	4.9	EMC Mortgage (Bear Stearns)	4.1
Commercial Credit Co.	4.8	Ameriquest	3.3
Firstplus	4.6	BNC Mortgage (Lehman)	3.2
Top Subprime MBS Underwriters			
Lehman Brothers	76.6	Morgan Stanley	26.7
Prudential Securities	10.4	Merrill Lynch	24.2
Morgan Stanley	9.5	RBS Greenwich	20.6
Bear Stearns	7.3	Lehman Brothers	18.4
Merrill Lynch	7.1	Countrywide Securities	16.2
Salomon Smith Barney	6.7	Bear Stearns	14.2
CS First Boston	5.5	Citigroup	13.4
PaineWebber	4.2	Deutsche Bank	12.3
Nations Bank	4	JPMorgan Chase	11.5
First Union	2.9	Bank of America	9.1

Data Source: 2009 Mortgage Market Statistical Annual published by Inside Mortgage Finance Publications, Inc. Copyright 2009.

Pressures to expand into subprime also came from beyond the boundaries of subprime mortgage finance industry. Mortgage originations increased during the early 2000s, but after 2003 the majority of those originations were subprime and nonconventional mortgages. Figure 3-3 presents data on total mortgage origination from 1990 to 2008, breaking mortgages according to their type. The expansion of mortgage origination is nothing less than astonishing: between 1990 and 2003, mortgage originations increased eightfold in value from $500 billion to almost $4 trillion; around three quarters of that increase occurred from 2000 to 2003 alone. But in 2004, the MBS market experienced a supply shock: convention originations fell from $2.6 trillion to $1.4 trillion in a single year. The expansion had been driven by refinancing existing conventional mortgages, and when the supply of outstanding conventional mortgages dried up originators shifted production to less conventional mortgage types including subprime, home

Figure 3-3: Residential mortgage origination by type, 1990-2008



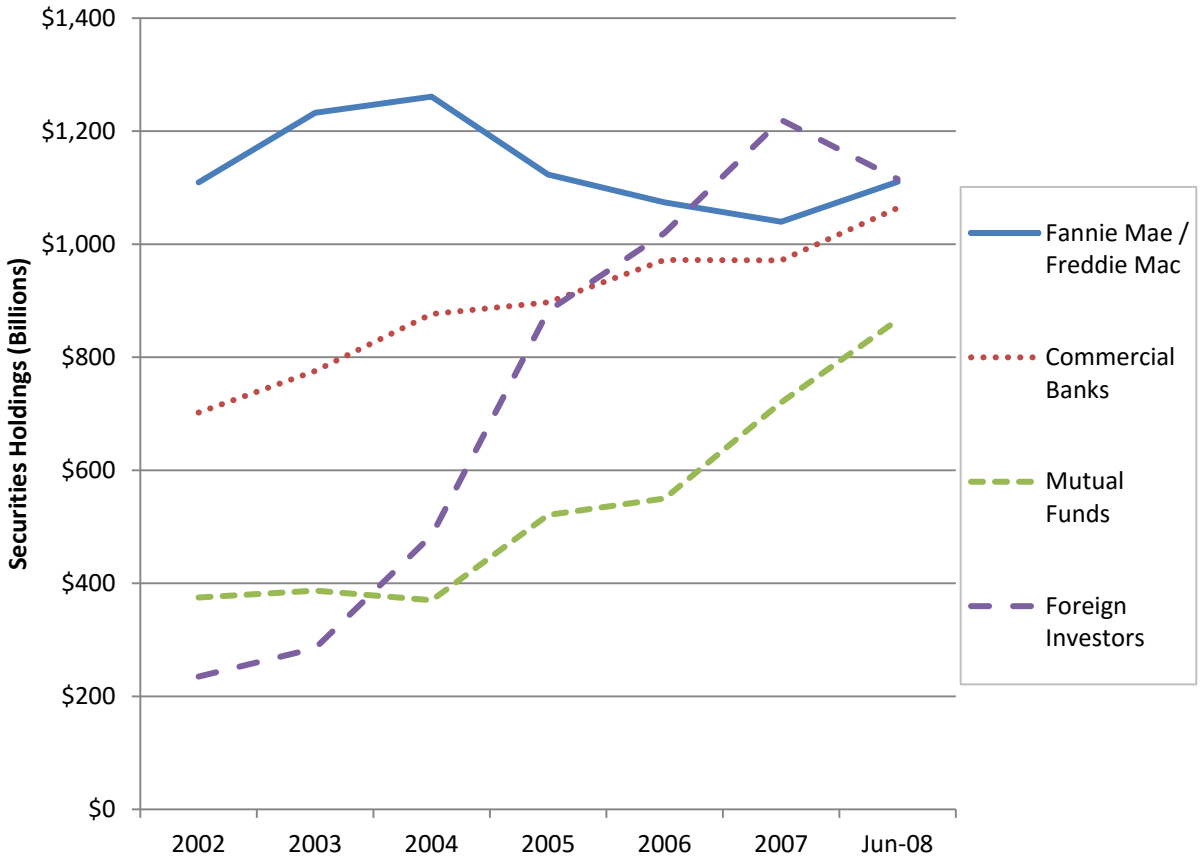
Data Source: 2009 Mortgage Market Statistical Annual published by Inside Mortgage Finance Publications, Inc. Copyright 2009.

equity loans, Alt-A, and Jumbo.[3] By 2006, unconventional mortgages accounted for fully 70 percent of all origination. Because these mortgages could not be sold to the GSEs, lenders had strong incentives not only to increase the scale of their activities in subprime lending, but also to undertake additional securitization in order to finance these mortgages.

Pressure to integrate also came from the securities markets. Strong demand from investors for relatively safe, high-yield investment increased the appeal of producing MBS. Mortgage lenders could borrow money at approximately one to two percent and uses it to finance the production of MBS that could yield six to seven percent. Figure 3-4 shows holdings of MBS by firm type from 2002 to 2008. Commercial banks increased their holdings from $650 billion in 2002 to $1.1 trillion in 2007. Mutual fund operators began to buy MBS as well and went from approximately $400 billion to nearly $850 billion. Other private investors including hedge funds (not shown) also increased their holdings from $25 billion to nearly $700 billion. Most spectacularly, foreign investors increased their holdings of MBS from $200 billion in 2002 to over $1.2 trillion by 2006. The demand for "safe," high yield MBS attracted capital from around

[3] Home equity loans (HEL) refer to loans made against the value of the equity in a house rather than the refinancing of an existing loan. These were frequently used as a line of credit or second mortgage. Alt-A and subprime mortgages (sometimes called "B" and "C" mortgages to denote their lower bond ratings) were made to people with poor credit history or who lacked the ability to make a large down payment. Jumbo loans have higher interest rates because the loan amount exceeds a value set by the FHA each year.

Figure 3-4: Mortgage-related security holdings by investor type, 2002-2008



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the world. Accordingly, securitization rates for subprime mortgages increased from 25% in 1995 to almost 90% by 2007. Companies also developed new technologies, such as collateralized debt obligations (CDO) and asset-backed commercial paper (ABCP) to facilitate investment in MBS (Acharya, Schnabl, and Suarez, 2013).

At the start of the twenty-first century, the boundaries between subprime mortgage lending and subprime MBS trading became open to new forms of contestation. Commercial banks, non-bank lenders, and investment banks all extended their activities into new territories within the subprime mortgage finance industry. To understand this transformation, it is important to get a better grasp on whether the struggles that resulted led to the construction of new positions in the subprime finance field. The influx of new entrants into each market may have dissolved the prior structure of the field, divided up existing positions among firms from other markets, or spurred a convergence around a new model of subprime finance based on vertical integration. How did the structure of the field of subprime mortgage evolve in the years leading up to the financial crisis?

MODELS OF FIELD STRUCTURE

We can get a better grasp on how the integration of these markets proceeded over time by taking a closer look at the positions of firms across each segment of the subprime mortgage lending industry in the years leading up to the financial crisis. To do so I constructed a dataset from lists of the top firms – equivalent to those presented in Table 3-1 – from the *Mortgage Market Statistical Annual* published by Inside Mortgage Finance Publications, Inc. For every year between 1998 and 2007, I collected the names of the top 25 firms in subprime mortgage origination, the top 25 firms in subprime MBS issuance, and the top 15 firms in subprime MBS underwriting. I have no data on smaller firms, but both the subprime lending market and the subprime MBS market were highly concentrated during these years: from 1998 to 2007 the combined market share of the listed firms remained between 70 and 95 percent across all three market segments (authors' calculations based on Inside Mortgage Finance data).[4] This is a striking degree of concentration in a market with annual sales of hundreds of billions of dollars and which sold its products to investors worldwide.

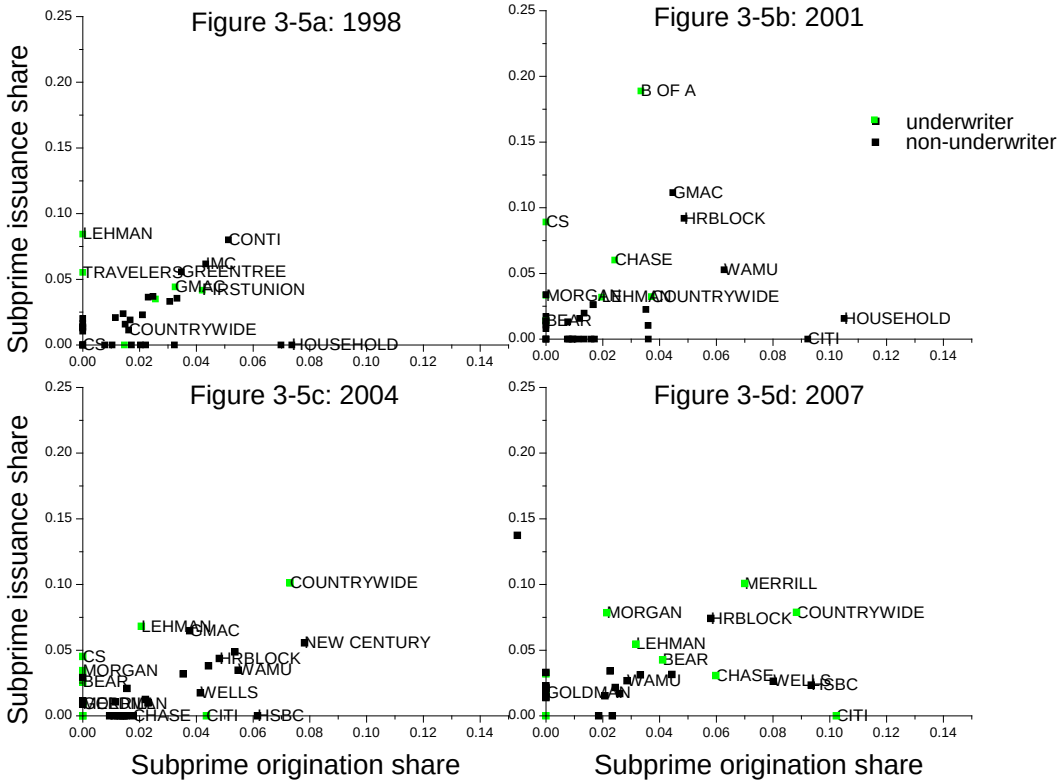
To explore how firms' positions changed over time, I first plot each firms' market share in subprime mortgage origination against its market share in subprime MBS issuance and subprime MBS underwriting. To simplify the presentation of our data I treat subprime MBS underwriting as a categorical variable. As a result, these plots unavoidably exclude a number of firms active in subprime MBS underwriting but not involved in subprime mortgage origination or subprime MBS issuance (we do, however, include these firms in the multivariate analyses below). In these scatterplots, firms involved in issuance but not in origination appear along the Y-axis, firms involved origination but not issuance appear along the X-axis, and those active in both appear in the middle of the plot.

Figure 3-5 displays scatterplots for four different years that correspond to four different moments in the development of the subprime lending industry across which the goals of firms' actions may have changed: 1998, 2001, 2004, and 2007. The year 1998 provides a snapshot of the subprime lending industry as it stood immediately before the 1999 repeal of the Glass-Steagall provisions separating investment banking and commercial banking. By 2001, the initial incentives to vertically integrate were also firm in place, mortgage sales and securitizations were increasing rapidly, and new firms had begun to enter these markets. By 2004, the conventional mortgage origination market was in steep decline but subprime and alternative originations were increasing dramatically. Finally, in 2007 the market for subprime mortgages had already begun to collapse and the vertical integration of the subprime lending industry was fairly complete.

Figure 3-5a shows that in 1998 nearly all firms active in subprime origination were vertically-integrated loan originators and issuers of subprime MBS. Non-bank firms were permitted under law to underwrite their own securities, and several did so, but they were not

[4] It was not possible to determine the names of the top 25 underwriting firms but there is evidence that this market segment was even more concentrated than the other two. In some years, there may not have even been 25 different firms active in subprime MBS underwriting. In 1996, for example, only 19 out of 151 subprime mortgage investment vehicles were underwritten by firms not in the top 10, indicating the number of firms underwriting subprime MBS could not have been any more than 28.

Figure 3-5: Scatterplots of subprime issuance and origination activities, selected years



Data Source: 2009 Mortgage Market Statistical Annual published by Inside Mortgage Finance Publications, Inc. Copyright 2009.

among the largest firms in the market. Instead, two investment banks, Lehman Brothers and Travelers Group, were the largest issuers and underwriters of subprime MBS. The largest originator of subprime mortgages in this year, Household Lending, did not issue its own MBS, but Household operated under a commercial bank charter and was subject to very different regulatory requirements than other subprime originators. Most subprime mortgage lending was undertaken by non-bank firms like Conti and GMAC, which packaged nearly all of their loans into MBS investment vehicles.

By 2001 positions in the subprime mortgage finance industry had become far less structured. Figure 3-5b shows that several large commercial banks and thrifts, including Citibank, Bank of America, and Washington Mutual had entered the subprime mortgage lending business by this time. However their strategies diverged considerably from one another: Bank of America mostly issued and underwrote subprime MBS, Washington Mutual originated loans and issued MBS, and Citibank originated loans exclusively. Several investment banks and financial services companies previously involved in underwriting subprime MBS had begun to move into subprime MBS issuance, including CS First Boston, Morgan Stanley, and Bear Stearns. The

industry appears to have been divided in complex ways among both incumbent subprime specialists and a diverse group of powerful new entrants.

In contrast, by 2004 the subprime mortgage finance industry has become fairly structured once more. Figure 3-5c displays little of the divergence over firm tactics was apparent in 2001. This was not because any one or more groups of entrants had been driven from the market: Household Lending had been acquired by HSBC in 2003, but new entrants like Citibank, CS First Boston, Morgan Stanley, and Bear Stearns all appear in roughly the same positions as in 2001.[5] Instead, in every year between 2001 and 2004, Countrywide and Ameriquest, both vertically-integrated subprime specialists, had managed to double their subprime mortgage origination volume. As a result, they were among the largest subprime mortgage originators and subprime MBS issuers in 2004, and Countrywide was also the largest subprime MBS underwriter. At this time only one investment bank, Lehman Brothers, had entered the subprime mortgage origination market. Vertically-integrated firms like Countrywide thus appear to have been the primary engineers and beneficiaries of the explosion in subprime lending that began in 2003.

By 2007 a number of other major investment banks had adopted the same tactic as Lehman and Countrywide, including Merrill Lynch, Morgan Stanley, and Bear Stearns, as seen in Figure 3-5d. Two commercial banks, Wells Fargo and Chase, also took the same approach to subprime mortgage lending. Certainly, not all investment banks or commercial banks made this choice: Goldman Sachs never entered subprime origination market, and Citibank had ceased to issue subprime MBS before 2007. However the vertical integration of several large investment banks and commercial banks increased the overall degree of vertical integration in the field. Strikingly, nearly all large firms in both issuance and origination are also underwriting their own subprime MBS. As the supply of loans was beginning to dwindle, subprime underwriters, issuers, and originators all converged on the same strategy.

Measures and methods

From 1998 to 2007, the structure of the subprime mortgage finance field changed considerably. Firm strategies evolved in complex ways over these years. The relationship between subprime mortgage origination, MBS issuance, and MBS underwriting changed over time. Different kinds of firms came to play new roles, new firms entered from adjacent markets, and new firms emerged as dominant actors within the world of subprime finance. Commercial banks and conventional lenders, as well as non-bank lenders, investment banks and other financial services companies all were drawn into subprime from different markets and over time converged on the same strategy of vertical integration. Understanding how firm strategy evolved over time requires a multivariate approach to firms' positions across multiple subprime finance markets.

[5] There is evidence that many of these firms had already begun to take advantage of regulatory changes by 2004. FDIC records show that between 2001 and 2004, Morgan Stanley, Merrill Lynch, Goldman Sachs, and Lehman Brothers all acquired savings and loan banks which were granted full trust powers as commercial banks. However with the exception of Lehman Brothers they had not begun to originate subprime mortgages during these years.

Dependent variable: building on our examination of the scatterplots above, our dependent variable is a measure of the proximity of each firms' position relative to other firms in the space of possible subprime finance activities. The proximity of firms in such a space can be used to model the structure of the field: to the extent that firms with similar characteristics are closer to one another, those characteristics also work as good predictors of the structure of that space. Our unit of analysis therefore is not the firm, but the firm-firm dyad. For *N* firms in a given year, one can construct a dataset of *N(N – 1)/2* dyads for that year. Each firm's position in the space of subprime finance is a product of its activities across three markets: the volume of subprime mortgages the firm originated, volume of subprime MBS it issued, and volume of subprime MBS it underwrote in a given year.

A potential problem with any measure of distance in a space defined by multiple variables is that the scale of the variables may introduce biases. A simple measure of Euclidean distance between cases can yield biased estimates if different variables have different scales or if positions are determined in part by factors besides actor behavior. The former is not a concern here because each market is closely related: subprime origination is an input for subprime MBS production, and for each MBS issuance there must be both an issuer and an underwriter. A firm's level activity in each market, however, is a product of both the firm's *strategy* across these markets and the overall *size* of its activities. A large firm with nationwide presence like Countrywide may appear to be quite distant from much smaller firms that are just as vertically integrated.

For this reason, instead of using Euclidean distance I use a measure of firm similarity based on angular distance. If each firm (i) has a vector (v_i) of activities across each of the subprime markets, then the similarity of firms *i* and *j* is:

$$similarity_{ij} = 1 - \pi^{-1}\cos^{-1}\left(\frac{v_i \cdot v_j}{\|v_i\|\|v_j\|}\right)$$

This formula takes the angle between vectors v_i and v_j – computed as the dot product of the two vectors divided by the product of their magnitudes – and then converts that angle into a percentile measure of similarity. [6] Essentially, it takes the spaces shown in Figure 3-5 and projects then onto a space around the origin, removing information about each point's distance from the origin.

Independent variables: I constructed three groups of independent variables. To examine whether firms' proximity is in part a function of organizational from, I classified firms into four categories: financial services companies, foreign-owned banks, commercial banks and thrifts,

[6] In summation notation, for one or more markets (*n*) this formula is equivalent to:

$$similarity_{ij} = 1 - \pi^{-1}\cos^{-1}\left(\frac{\sum_{i=1}^{n} x_{ii} * x_{ji}}{\sum_{i=1}^{n} x_{ii}^2 * \sum_{i=1}^{n} x_{ji}^2}\right)$$

and non-bank lenders. Historically, financial services companies and foreign-owned banks have been primarily active in securities trading, while commercial banks have been active in mortgage lending. I determined whether firms had a commercial bank or thrift charter using the Federal Deposit Insurance Corporation's Institution Directory. Financial services companies, foreign banks, and non-bank companies were identified using Compustat and Google searches. In all cases, firm types were coded according to the company's on the ultimate parent institution. For each firm category, I constructed a dummy variable that is set equal to one if both firms belong to that category, and is set to zero otherwise.

In order to capture the degree to which firm's positions converged around the position of dominant firms in subprime mortgage finance I constructed a variable based on each dyad's joint activity across all three subprime finance activities. As with the dependent variable, I used each firm's volume of activities across all three segments of subprime finance to construct a vector describing its position in the space of subprime finance. I then calculated the magnitude of each vector ($\|v_i\|$), where magnitude is simply that firms' Euclidean distance from the origin (in units of tens of millions of dollars), and took the product of the firms' magnitudes for each dyad. (Although these terms also appear in our calculations for the dependent variable, there is no autocorrelation problem between these measures and the dependent variable because the lengths of any two vectors are by definition orthogonal to the angular distance between them.) This measure is equal to zero if one or both firms have zero activity in subprime finance, and increases as both firms' activity in subprime increases.

Lastly, to measure the influence of entrants from adjacent markets, I collected data on firms' activities in conventional mortgage origination and asset-backed commercial paper sponsorship. (We ignore conventional issuance and underwriting because the overwhelming majority of conventional mortgages were collected and packaged into securities by the GSEs rather than private companies). I obtained the volume of conventional mortgage lending undertaken by each firm using lists of the top 25 firm in conventional mortgage origination from Inside Mortgage Finance's *Mortgage Market Statistical Annual*. I found firms' outstanding quarterly volumes of ABCP using Acharya, Schnabl, and Suarez's (2013) quarterly data on firm sponsorship of ABCP conduits. (Unfortunately, this data series only begins in 2001 and continues to 2009.) Because ABCP is a short-term debt instrument that may be rolled over several times a year, I took the annual averages of Acharya and colleagues' quarterly data.

I constructed measures of each dyad's joint activity in these two markets using a procedure similar to that used to construct the joint size measure. Here it is necessary include information about one activity in each variable instead of three, and therefore, for both conventional origination and ABCP issuance, I constructed variables based on each dyad's joint activity in those markets by simply multiplying together the two firms' annual volume of activity (again, in units of tens of millions of dollars).

Methods: Because our measure of similarity is continuous, one can simply regress the independent variables onto firm similarity using ordinary least squares. Because I am interested in change over time, I do not pool our dyads across all ten years for which I have observations. Instead I fit a separate regression equation for each year in the data. Because these are OLS estimates, one can usefully compare the coefficients for each effect across years. Coefficients

based on measures of joint volumes of activity should be interpreted with caution, however, because to total volume of activity in each market changed considerably over the period of observation.

A complication enters in that our units are dyadic observations. Ordinary least squares regression provides unbiased coefficient estimates for dyadic data, but it is not the case that errors are uncorrelated across dyads that share the same firms. Indeed, some degree of autocorrelation is unavoidable, because as with any distance measure if firm *A* is one unit away from both firm *B* and firm *C*, firms *B* and *C* cannot be more than two units apart from one another (of course, the inverse holds for any proximity measure). Significance tests based on ordinary least squares standard errors are therefore inapplicable. For this reason, I employ a permutation version of the QAP test for dyadic data (Baker and Hubert 1981, Hubert and Schultz 1976; Krackhardt 1987, 1988).[7] The QAP test is most familiar as a tool for the statistical analysis of social networks, the underlying logic is appropriate for the analysis of distances (see for example Mantel, 1967).[8]

RESULTS

Table 3-2 reports the results of our models of firm similarity for each year from 1998 to 2007. Rather than discussing each model individually, I focus on how the results of the models change over time. The models for the first three years of our analysis are all similar to one another. From 1998 to 2000, firm type is highly predictive of the position of firms within the field of subprime finance. Pairs of firms that share the same type display a much greater similarity to one another in their subprime finance activities than do pairs of firms of different types. In 1998, for example, dyads consisting of two financial services firms are associated with 14 percent higher similarity than pairs of firms of different types. Pairs of commercial banks are 7 percent more similar, non-bank lenders 17 percent are more similar, and finally foreign banks 35 percent are more similar. With the exception of pairs of commercial banks, all of these coefficients are statistically significant at the p=0.01 level. Firms that are both active in the origination of conventional mortgages are also more likely to be similar to one another. On the other hand, there is no evidence that the scale of each firms' activities in subprime finance predict their position with respect to other firms. Thus there is strong evidence that the field of subprime finance was divided up between firms of different types claiming different parts of the field, with conventional originators playing a distinctive role. But there is no evidence of convergence around a single strategy among firms active in subprime.

[7] It has recently been shown that collinearity of independent variables may pose a problem for conventional QAP analyses. Dekker, Krackhardt and Snijders (2007) have proposed a modified QAP approach (Double Semi-Partialing) that uses residuals from an OLS model as a way of dealing with As the bias in the conventional QAP multiple regression seems to be conservative (a decreased power coming from an acceptance of the null hypothesis given spuriousness), I employ the conventional approach, which can be interpreted as the position of our observations on a constructable probability distribution.

[8] Indeed, Mantel (1967), originally developed the QAP test to detect clustering in data consisting of distances between pairs of cases.

Table 3-2: Regressions of dyadic firm similarity, 1998-2007

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Organizational type										
Both financial services	0.143**	0.121*	0.154*	0.063	0.014	0.031	0.056	0.076	0.073	0.035
	[0.007]	[0.031]	[0.016]	[0.337]	[0.749]	[0.636]	[0.309]	[0.176]	[0.224]	[0.513]
Both commercial banks	0.073	0.054+	0.079*	0.031	0.102*	0.093+	0.094+	0.154**	0.067	0.012
	[0.132]	[0.085]	[0.025]	[0.251]	[0.036]	[0.077]	[0.057]	[0.005]	[0.122]	[0.555]
Both non-banks	0.168***	0.126***	0.172***	0.116**	0.134**	0.154***	0.134**	0.120**	0.138**	0.121**
	[<0.001]	[<0.001]	[<0.001]	[0.004]	[0.001]	[<0.001]	[0.003]	[0.006]	[0.001]	[0.004]
Both foreign banks	0.355***	0.265	0.254*	0.088	0.101	0.043	0.071	0.074	0.058	0.015
	[<0.001]	[0.174]	[0.038]	[0.402]	[0.238]	[0.454]	[0.381]	[0.330]	[0.470]	[0.742]
Convergence										
Joint size ($10m^2)	0.044	0.109**	0.048	0.018	0.015	0.009	0.003+	0.002+	0.003+	0.013*
	[0.175]	[0.009]	[0.106]	[0.195]	[0.185]	[0.108]	[0.095]	[0.088]	[0.058]	[0.038]
Adjacent markets										
Joint conventional origination ($10m^2)	3.615*	0.878+	1.146+	0.078	0.007	0.006	0.014	-0.007	0.023	0.022
	[0.046]	[0.083]	[0.075]	[0.134]	[0.596]	[0.450]	[0.482]	[0.793]	[0.487]	[0.300]
Joint ABCP volume ($10m^2)				-0.033	0.022	0.180	-0.014	-0.053	-0.011	0.024
				[0.813]	[0.759]	[0.432]	[0.726]	[0.837]	[0.722]	[0.648]
Constant	0.640	0.646	0.659	0.676	0.682	0.668	0.671	0.681	0.674	0.698
	[1.000]	[1.000]	[1.000]	[0.995]	[0.998]	[1.000]	[1.000]	[1.000]	[0.997]	[0.993]
N	861	780	666	630	630	630	666	528	595	406
R-squared	0.178	0.112	0.148	0.064	0.113	0.142	0.109	0.112	0.103	0.091

p-values for one-tailed QAP tests are reported in brackets. *** p<0.001, ** p<0.01, * p<0.05, + p<0.10.

During the rapid expansion of conventional lending and international investment in MBS from 2001 to 2003, the field appears to have become far less structured than in previous years. Pairs of non-bank lenders in these models remain 13 to 15 percent more similar to one another than other pairs of firms, and pairs of commercial banks also remain about 9 percent more similar to one another than other. But the latter hovers at the edge of significance at the p=0.05 level in 2002 and 2003, and the coefficients for the other firm type variables are both much smaller in magnitude and not significant in these models. Nor is there any evidence that levels of either conventional mortgage origination or ABCP sponsorship predict firms' proximity to one another in the space of subprime mortgage finance. Finally, the parameter for the joint size of pairs of firms in subprime remains insignificant in these years. It appears that as conventional lending expanded, many firms diversified their holdings into subprime finance, but beyond the bank and non-bank mortgage lenders that had long made up the core of the subprime mortgage origination market, the strategies of most firms did not converge. It appears that the subprime mortgage finance industry became less structured over the course of these years.

In the years immediately preceding the financial crisis, however, there is evidence of convergence around a shared strategy in subprime mortgage finance. The parameters for firm type continue to decline in significance, with the exception pairs of non-bank lenders. In 2006 and 2007 pairs of financial services companies, commercial banks, and foreign banks were all roughly similar to each other and to pairs of firms of different types (the baseline category for firm type). Firms' activity in the adjacent markets of conventional mortgage origination and ABCP issuance are also not associated with firms' positions in subprime mortgage finance. Indeed, 2004, 2005, and 2006, one or both of these coefficients are negative. The effect of the scale of firms' activity in subprime mortgage finance on firms' position in subprime does become positive and significant during these years, at the p=0.10 level in 2004, 2005, and 2006, and at the p=0.05 level in 2007. During these years the subprime mortgage finance market expanded, replacing declines in production in the conventional lending market. To capture returns in the growing subprime market, many companies of different types vertically integrated their subprime mortgage origination and subprime MBS production activities. As one might have expected, it is also in these years that we see the strongest convergence on a shared strategy among firms, independent of both firm type and activities in other markets.

CONCLUSIONS

Subprime lenders, commercial banks, and investment banks entered the subprime mortgage finance industry from different home markets and followed different paths to into subprime finance. But by 2007, firms in each of these categories had converged on the same strategy of vertical integration. There is evidence that the elimination of regulatory barriers between securities trading and mortgage lending encouraged investment banks and commercial banks to expand their activities in the subprime lending industry. But neither the diversification of different types of firms' business holdings in subprime, nor the invasion of new entrants from adjacent markets is sufficient to explain the rise of the industrial conception of subprime mortgage finance.

Instead, the effects of changes must be understood in terms of changes in field structure. As new firms entered different segments of the subprime mortgage finance industry, they undermined the original structure of the field without producing a new structure. Non-bank subprime lenders long active in subprime mortgage finance did little to change their strategies, and new entrants failed to converge on any shared alternative conception of the field. Only as firms converged on the strategy of highly successful, vertically-integrated mortgage lenders do we see new forms of structure emerge in the field. Vertically-integrated firms like Countrywide and Ameriquest, which had been marginal to both the conventional mortgage lending sector and the securities market but very active in the provision of subprime mortgages and subprime MBS, came to set the model for the large commercial and investment banks that entered the subprime market in order to secure their supply of mortgages.

The structure of a field depends on the alignment of actors around a set of positions. In the 1990s, the subprime lending industry remained isolated not only because of Glass-Steagall regulations, but also because of commercial banks, investment banks, and non-bank lenders all restricted their activities to certain market segments even where they were permitted to do otherwise. As subprime mortgage finance grew, the field became contested by new actors attempting to take advantage of the opportunities for profit that subprime mortgage securitization offered. Large firms aligned their tactics with other large vertically integrated firms, expanding their subprime mortgage securitization activities even as the market began to unravel.

CONCLUSIONS

Taken together, these papers show clear evidence for the role of internal field dynamics in processes of institutional change. In the emergence of the life sciences, network position mattered a great deal: a discipline's position in the prestige hierarchy was extremely weighty in determining whether it adds new institutes or not, and position in the university hierarch came to matter as well by the end of the nineteenth century. In the case of deprofessionalization of medicine, medical practitioners' grievances only turned toward advocacy for deregulation with the emergence an organized and sectarian "medical counterculture that stood in opposition to the "aristocracy" of regular medicine. Where the regular medical profession was also organized, it too mobilized to defend its authority, recruit supporters, and discredit its opponents. Although subprime lenders, commercial banks, and investment banks entered the subprime mortgage finance industry from different home markets and followed different paths to into subprime finance the incredible success of vertically integrated lenders like Countrywide drew them to converge on the same strategy.

The evidence for the effects of external pressures on institutional change was more ambiguous. There was no evidence for the direct dependence of institute founding on university rationalization or disciplinary professionalization. If anything, reformed universities had lower chances of adding new institutes then their traditional equivalents. In the case of the life sciences, the links between rationalization, professionalization, and discipline growth were tenuous. In the case of the US medical profession, the evidence was more clear-cut: popular support for deregulatory politics was extremely important in explaining medical deregulation, which in turn predicted sectarian mobilization, and deregulation and support for deregulatory politics both predict greater mobilization among sectarian groups. Finally, there was also evidence that the elimination of regulatory barriers between securities trading and mortgage lending encouraged investment banks and commercial banks to expand their activities in the subprime lending industry. But neither the diversification of different types of firms' business holdings in subprime, nor the invasion of new entrants from adjacent markets explained the rise of the industrial conception of subprime mortgage finance.

Instead, external actors mattered primarily through their evolving relationship to the structures of the field. In the life sciences, the state-led construction of a national market for institute directors conferred the greatest benefit on the most prestigious disciplines and universities. Even traditional and prestigious universities that undertook reforms at a relatively late moment like Leipzig saw the full benefit of incorporation at the top of the university hierarch. And the professionalization of disciplines, when it had a benefit, served only to strengthen the hold of established disciplines over the field of disciplines. In the case of US medicine, professional sovereignty could be challenged if rival practitioners were organized, found support among the laity, and defined their grievances in a way that places them in opposition to dominant professional groups. Jacksonian populism and the founding of new medical schools and societies were not in themselves sufficient causes for the deregulation of medicine. Instead, medical practitioners' grievances only turned toward advocacy for deregulation when they came to see their work in explicitly sectarian terms, standing in opposition to the "aristocracy" of regular medicine. Finally, the effects of regulation in the case of subprime mortgage finance must be understood through in terms of changes in field structure. As new firms entered different segments of the subprime

mortgage finance industry, they undermined the original structure of the field without producing a new structure. For a time, new entrants failed to converge on any shared alternative conception of the subprime field. Only as the successes of vertically-integrated mortgage lenders became clear relative to the rest of the financial do we see other firms aligning their tactics around vertical integration, even at the moment the market began to unravel.

REFERENCES

Abbott, Andrew D. 2001. *Chaos of Disciplines*. Chicago: University of Chicago Press.

Abbott, Andrew D. 1988. *The System of Professions: An Essay on the Division of Expert Labor*. Chicago: University of Chicago Press.

Abbott, Andrew D. 2005. "Linked ecologies: states and universities as environments for professions." *Sociological Theory, 23* (3): 245-274.

Allison, Paul D. 2009. *Fixed Effects Regression Models*. Thousand Oaks, CA: Sage Publications.

Allison, Paul D., and R. Waterman. 2002. "Fixed effects negative binomial regression models." In R. Stolzenberg (ed.), *Sociological methodology, 2002:* 247-265. Oxford: Basil Blackwell.

American Medical Association. 1918 *Medical colleges of the United States and of foreign countries*. Washington: American Medical Association.

Baker, Frank B., and Lawrence J. Hubert. 1981. "The Analysis of Social Interaction Data: A Nonparametric Technique." *Sociological Methods and Research* 9:339-361.

Baumgarten, Marita. 1997. *Professoren und Universitäten im 19. Jahrhundert: zur Sozialgeschichte deutscher Geistes- und Naturwissenschaftler*. Göttingen: Vandenhoeck & Ruprecht.

Beck, Nathaniel, Jonathan N. Katz, and Richard Tucker. 1998. "Taking Time Seriously: Time-Series-Cross-Section Analysis with a Binary Dependent Variable." *American Journal of Political Science*, *42*4, 1260–1288.

Ben-David, Joseph. 1971. *The Scientist's Role in Society: A Comparative Study*. New York: Prentice-Hall.

Ben-David, Joseph, and Randall Collins. 1966. "Social Factors in the Origins of a New Science: The Case of Psychology." *American Sociological Review*, *31*4, 451–465.

Benford, Robert D., and David A. Snow. 2000. "Framing processes and social movements: An overview and assessment." *Annual Review of Sociology*: 611-639.

Biagioli, Mario. 1993. *Galileo, Courtier: The Practice of Science in the Culture of Absolutism*. Chicago: University of Chicago Press.

Bornhak, Konrad. 1900. *Geschichte der preussischen Universitätsverwaltung bis 1810*. Berlin: Georg Reimer.

Bourdieu, Pierre. 1984. *Distinction : a social critique of the judgement of taste*. Cambridge, Mass.: Harvard University Press.

Bourdieu, Pierre. 1988. *Homo academicus*. Stanford, Calif.: Stanford University Press.

Bourdieu, Pierre. 1996. *The Rules of Art: Genesis and Structure of the Literary Field*. Stanford: Stanford University Press.

Bourdieu, Pierre. 2004. *Science of Science and Reflexivity*. Chicago: University of Chicago Press.

Bourdieu, Pierre, and Loïc J. D Wacquant. 1992. *An invitation to reflexive sociology*. Chicago: University of Chicago Press.

Breiger, Ron L. 1974. "The Duality of Persons and Groups." *Social Forces, 53*2, 181–190.

Bremner, Maurice David Kaufman. 1964. *The story of dentistry, revised third edition*. Dental Items of Interest Publishing Company.

Brockliss, Laurence. 1996. "Curricula." Pp. 565-620 in *A History of the University in Europe: Volume 2, Universities in Early Modern Europe 1500-1800,* edited by Hilde de Ridder-Symoens. Cambridge: Cambridge University Press.

Broman, Thomas. H. 1996. *The Transformation of German Academic Medicine, 1750-1820*. Cambridge: Cambridge University Press.

Burris, Val. 2004. "The Academic Caste System: Prestige Hierarchies in PhD Exchange Networks." *American Sociological Review, 69*2, 239–264.

Cahan, David (Ed.). 2003. *From Natural Philosophy to the Sciences: Writing the History of Nineteenth-Century Science*. Chicago: University of Chicago Press.

Campbell, J. 2010. "Neoliberalism in crisis: regulatory roots of the U.S. financial meltdown." Pp. 65-103 in M. Lounsbury and P. Hirsch (eds.) *Markets on Trial*. Bingley, U.K.: Emerald Press.

Caplow, Theodore. 1964. *The sociology of work*. New York: McGraw-Hill.

Carroll, Glenn R. 1985. "Concentration and Specialization: Dynamics of Niche Width in Populations of Organizations." *American Journal of Sociology* 90(6):1262-1283.

Carroll, Glenn R., and Anand Swaminathan. 2000. "Why the Microbrewery Movement? Organizational Dynamics of Resource Partitioning in the U.S. Brewing Industry." *American Journal of Sociology* 106(3):715-762.

Cassedy, James H. 1983. "The flourishing and character of early American medical journalism." *Journal of the History of Medicine and Allied Sciences,* 38: 135-150.

Clark, William. 2006. *Academic Charisma and the Origins of the Research University*. Chicago: University of Chicago Press.

Coase, Ronald. 1993. “The nature of the firm.” Pp. 18-33 in *The nature of the firm : origins, evolution, development*. New York: Oxford University Press.

Collins, Randall. 1998. *The Sociology of Philosophies: A Global Theory of Intellectual Change*. Cambridge: Harvard University Press.

Cox, David R. 1972. “Regression models and life tables (with discussion).” *Journal of the Royal Statistical Society, Series B*, 34: 187-220.

Crane, Dianne. 1972. *Invisible Colleges: Diffusion of Knowledge in Scientific Communities*. Chicago: University of Chicago Press.

DiMaggio, Paul J. 1991. “Constructing an Organizational Field as a Professional Project: US Art Museums, 1920-1940.” Pp. 267-292 in *The New Institutionalism in Organizational Analysis*, edited by Paul J. DiMaggio and Walter W. Powell, Chicago: University of Chicago Press.

DiMaggio, Paul J., and Walter W. Powell. 1983. "The Iron Cage Revisited: Collective Rationality and Institutional Isomorphism in Organizational Fields." *American Sociological Revie*w 482: 147-160.

DiMaggio, Paul J., and Walter W. Powell Eds.. 1991. *The New Institutionalism in Organizational Analysis*. Chicago: University of Chicago Press.

Drori, Gili S. 2003. *Science in the Modern World Polity: Institutionalization and Globalization*. Stanford: Stanford University Press.

Emirbayer, Mustafa, and Victoria Johnson. 2008. “Bourdieu and organizational analysis.” *Theory and Society* 37(1):1-44.

Eulenberg, Franz. 1908. *Die Frequenz der deutschen Universitäten von ihrer Gründung bis zur Gegenwart.* Berlin: Oldenbourg Akademieverlag.

Eulner, Hans-Heinz. 1970. *Die Entwicklung der medizinischen Spezialfächer an den Universitäten des deutschen Sprachgebiete*s. Stuttgart: F. Enke.

Felter, Harvey Wickes. 1902. *History of the Eclectic Medical Institute, Cincinnati, Ohio*. Cincinnati.

Fligstein, Neil. 2001. *The architecture of markets : an economic sociology of twenty-first-century capitalist societies*. Princeton: Princeton University Press.

Fligstein, Neil, and Adam Goldstein. 2010. “The anatomy of the mortgage securitization crisis.” Pp. 29-70 in M. Lounsbury and P. Hirsch (eds.) *Markets on Trial*. Bingley, U.K.: Emerald Press.

Fligstein, Neil, and Doug McAdam. 2011. “Toward a General Theory of Strategic Action Fields.” *Sociological Theory* 29(1):1-26.

Fligstein, Neil, and Doug McAdam. 2012. *A theory of fields*. Oxford: Oxford University Press.

Frank, David J., and Jay Gabler. 2006. *Reconstructing the University: Worldwide Shifts in Academia in the 20th Century*. Stanford: Stanford University Press.

Freidson, Eliot. 1970. *Professional dominance: The social structure of medical care*. New York: Dodd Mead.

Freidson, Eliot. 2001. *Professionalism, the third logic: on the practice of knowledge*. Chicago: University of Chicago Press.

Frickel, Scott, and Kelly Moore. 2006. *The New Political Sociology of Science: Institutions, Networks, and Power*. Madison, WI: University of Wisconsin Press.

Frijhoff, Willem. 1996 "Patterns." Pp. 43-110 in *A History of the University in Europe: Volume 2, Universities in Early Modern Europe 1500-1800*, edited by Hilde de Ridder-Symoens. Cambridge: Cambridge University Press.

Gellner, Ernst. 1983. *Nations and Nationalism*. Ithaca, NY: Cornell University Press.

Gerbod, Paul. 2004. "Relations with Authority." Pp. 83-100 in *A History of the University in Europe: Volume 3, Universities in the Nineteenth and Early Twentieth Centuries 1800-1945*, edited by Walter Rüegg. Cambridge: Cambridge University Press.

Gieryn, Thomas. F. 1999. *Cultural Boundaries of Science: Credibility on the Line*. Chicago: University of Chicago Press.

Gieryn, Thomas F., George M. Bevins, and Stephen C. Zehr. 1985. "Professionalization of American Scientists: Public Science in the Creation/ Evolution Trials." *American Sociological Review*, *50*3, 392–409.

Go, Julian. 2008. *American empire and the politics of meaning : elite political cultures in the Philippines and Puerto Rico during U.S. colonialism*. Durham: Duke University Press.

Godechot, Olivier, and Alexandra Louvet. 2008. "Le localisme dans le monde académique: un essai d'évaluation." *La vie des idées* 22.

Goldstein, Adam and Neil Fligstein. n.d. "The Transformation of Mortgage Finance and the Industrial Roots of the Mortgage Meltdown." Working paper.

Gulati, Ranjay, and Martin Gargiulo. 1999. "Where Do Interorganizational Networks Come From?" *American Journal of Sociology* 104(5):1439-1493.

Haller, John S. 1981. *American medicine in transition, 1840-1910*. Carbondale: University of Illinois Press.

Haller, John S. 2000. *The people's doctors: Samuel Thomson and the American botanical movement, 1790-1860*. Carbondale: Southern Illinois University Press.

Haller, John S. 2005. *The history of American homeopathy: the academic years, 1820-1835*. Birmingham, NY: Haworth Press.

Halpern, Sydney A. 1992. "Dynamics of professional control: internal coalitions and crossprofessional boundaries." *American Journal of Sociology*, 97 (4): 994-1021.

Hannan, Michael T, and John Freeman. 1989. *Organizational ecology*. Cambridge, Mass.: Harvard University Press.

Hannan, Michael T., and John Freeman. 1977. "The Population Ecology of Organizations." *American Journal of Sociology* 82(5):929-964.

Harwood, Jonathan. 1993. *Styles of Scientific Thought: The German Genetics Community, 1900-1933*. Chicago: University of Chicago Press.

Harwood, Jonathan. 2005. *Technology's Dilemma: Agricultural Colleges between Science and Practice in Germany, 1860-1934*. Bern: Peter Lang.

Haug, Marie R. 1972. "Deprofessionalization: an alternative hypothesis for the future." *The Sociological Review*, 20 (1): 195-211.

Haveman, Heather A. (forthcoming). *Magazines and the making of America: modernization, community, and print culture, 1741-1860*. Princeton: Princeton University Press.

Heilbron, Johan. 1995. *The Rise of Social Theory*. Minneapolis: University of Minnesota Press.

Heilbron, Johan. 2004. "A Regime of Disciplines: Toward a Historical Sociology of Disciplinary Knowledge," Pp. 23-42 in *The Dialogical Turn: New Roles for Sociology in the Postdisciplinary Age*, edited by Charles Camic and Hans Joas. Lanham: Rowman & Littlefield.

Hubert, Lawrence, and James Schultz. 1976. "Quadratic Assignment as a General Data Analysis Strategy." *British Journal of Mathematical and Statistical Psychology* 29:190-241.

Jacobs, Jerry. A. 2013. *In Defense of Disciplines: Interdisciplinarity and Specialization in the Research University*. Chicago: University of Chicago Press.

Jarausch, Konrad. H. 1982. *Students, Society, and Politics in Imperial Germany: The Rise of Academic Illiberalism*. Princeton, NJ: Princeton University Press.

Jencks, Christopher, and David Riesman. 1968. *The Academic Revolution*. Garden City, NY: Doubleday.

Kay, Neil M. 1997. *Pattern in corporate evolution.* Oxford: Oxford University Press.

Kendall, L. T. 1996. “Securitization: A new era in American finance.” Pp. 1-16 in *A primer on securitization*. Cambridge Mass.: MIT Press.

Kett, Joseph. 1968. *The formation of the American medical profession*. New Haven: Yale University Press.

Kielbowicz, R. 1989. *News in the mail: the press, the post office, and public information, 1700-1800s*. New York: Greenwood Press.

Knemeyer, Franz-Ludwig. 1970. *Regierungs- und Verwaltungsreformen in Deutschland: zu Beginn des 19. Jahrhunderts*. Köln: Grote.

Knight, Frank H. 1964. *Risk, uncertainty and profit*. New York: Augustus M. Kelley.

Knorr-Cetina, Karin. D. 1981. *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science*. Oxford: Pergamon.

Kohler, Robert. E. 1982. *From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline*. Cambridge: Cambridge University Press.

Krackhardt, David. 1987. “QAP Partialling as a Test of Spuriousness.” *Social Networks* 9:171-186.

Krackhardt, David. 1988. “Predicting With Networks: Nonparametric Multiple Regression Analysis of Dyadic Data.” *Social Networks* 10:359-381

Kremers, E., Urdang, G., & Sonnedecker, G. 1963. *History of pharmacy, third edition*. Philadelphia, PA: J. B. Lippincott

Kuhn, Thomas S. [1974] 1977. “Second Thoughts on Paradigms.” Pp. 292-319 in *The Essential Tension: Selected Studies in Scientific Tradition and Change*. Chicago: University of Chicago Press.

Larson, Magali. S. 1977. *The Rise of Professionalism: A Sociological Analysis*. Berkeley and Los Angeles: University of California Press.

Latour, Bruno. 1988. *The Pasteurization of France*. Cambridge: Harvard University Press.

Lenoir, Timothy. 1997. *Instituting Science: The Cultural Production of Scientific Disciplines*. Stanford: Stanford University Press.

Lenoir, Timothy. 1998. "Revolution from Above: The Role of the State in Creating the German Research System, 1810-1910." *The American Economic Review, 88*2, 22–27.

Lepenies, Wolf. 1985. *Die drei Kulturen: Soziologie zwischen Literatur und Wissenschaft*. Carl Hanser Verlag.

Lewin, Kurt. 1952. *Field theory in social science : selected theoretical papers*. London: Tavistock Publications.

Long, J. Scott. 1997. *Regression models for categorical and limited dependent variables.* Thousand Oaks, CA: Sage.

Mantel, Nathan. 1967. "The Detection of Disease Clustering and a Generalized Regression Approach." *Cancer Research* 27(2): 209-220.

Martin, John Levi. 1999. "Entropic Measures of Belief System Constraint." *Social Science Research* 28: 111-134.

Martin, John Levi. 2003. "What Is Field Theory?" *American Journal of Sociology* 109(1):1-49.

McAdam, Doug. 1999 [1982]. *Political process and the development of black insurgency, 1930-1970*. Chicago: University of Chicago Press.

McCarthy, John D., and Mayer N. Zald. 1977 "Resource mobilization and social movements: A partial theory." *American journal of sociology*: 1212-1241.

McClelland, Charles. 1980. *State, Society and University in Germany 1700-1914*. Cambridge: Cambridge University Press.

McClelland, Charles. E. 1991. *The German Experience of Professionalization: Modern Learned Professions and Their Organizations from the Early Nineteenth Century to the Hitler Era*. Cambridge: Cambridge University Press.

McNeely, Ian. 2003. *The Emancipation of Writing: German Civil Society in the Making, 1790s–1820s*. Berkeley and Los Angeles: University of California Press.

McPherson, Miller. 2004. "A Blau space primer: prolegomenon to an ecology of affiliation." *Industrial and Corporate Change* 13(1): 263-280.

Meyer, John. W., and Brian Rowan. 1977. Institutionalized Organizations: Formal Structure as Myth and Ceremony. *American Journal of Sociology*, *83*2, 340–363.

Millerson, George. 1964. *The qualifying associations*. London: Routledge.

Moran, J. 1973. *Printing presses: history and development from the fifteenth century to modern times.* Berkeley: University of California Press.

Mullins, Nicholas C. 1972. "The Development of a Scientific Specialty: The Phage Group and the Origins of Molecular Biology." *Minerva, 10*1, 51–82.

Newman, Charles. 1957. *The evolution of medical education in the nineteenth century. London:* Oxford University Press.

Nyhart, Lynn K. 1995. *Biology Takes Form: Animal Morphology and the German Universities, 1800-1900*. Chicago: University of Chicago Press.

Pagel, Julius L. Ed.. 1901. *Biographisches Lexikon hervorragender Aerzte des neunzehnten Jahrhunderts*, mit einer historischen einleitung. Berlin und Wien: Urban & Schwarzenberg.

Panoskfy, Aaron. 2010. "A Critical Reconsideration of the Ethos and Autonomy of Science." Pp. 140-163 in *Robert K. Merton: Sociology of Science and Sociology as Science*, edited by Craig C. Calhoun. New York: Columbia University Press.

Pfeffer, Jeffrey, and Gerald R. Salancik. 1974. "Organizational Decision Making as a Political Process: The Case of a University Budget." *Administrative Science Quarterly, 19*2, 135–151.

Podolny, Joel M. 1993. "A Status-Based Model of Market Competition." *American Journal of Sociology* 98(4):829-872.

Polanyi, Michael. 1962. "The Republic of Science: Its Political and Economic Theory." *Minerva* 11: 54-73.

Popp, Elizabeth B. 2006. "Before the professional project: Success and failure at creating an organizational representative for English doctors." *Theory and Society*, *35* (2): 157-191.

Powell, Walter W., Douglas R. White, Kenneth W. Koput, and Jason Owen-Smith. 2005. "Network Dynamics and Field Evolution: The Growth of Interorganizational Collaboration in the Life Sciences." *American Journal of Sociology* 110(4):1132-1205.

Price, Derek. J. de S. 1963. *Little Science, Big Science:* New York: Columbia University Press.

Ringer, Fritz K. 1969. *The Decline of the German Mandarins: The German Academic Community, 1890-1933*. Cambridge: Harvard University Press.

Russell, E. S. 1916. *Form and Function: A Contribution to the History of Animal Morphology*. London: John Murray.

Quinn, Sarah. 2008. "Securitization and the state." Paper presented at the Annual Meeting of the American Sociological Association. Boston, Mass.

Rich, W. 1924: *The history of the United States Post Office to the year 1829*. Cambridge, MA: Harvard University Press.

Ritzer, George, and David Walczak, 1988. "Rationalization and the deprofessionalization of Physicians" *Social Forces, 67* (1): 1-22.

Rothstein, William G. 1972. *American physicians in the nineteenth century: from sects to science.* Baltimore: Johns Hopkins University Press.

Schofer, Evan., and John W. Meyer. 2005. "The Worldwide Expansion of Higher Education in the Twentieth Century." *American Sociological Review*, *70*6, 898–920.

Schwabe, Klaus. Ed.. 1983. *Die Regierungen der deutschen Mittel- und Kleinstaaten, 1815-1933*. Boppard am Rhein: H. Boldt.

Scott, W. Richard, and John W. Meyer, [1983] 1991, "The Organization of Societal Sectors: Propositions and Early Evidence," Pp. 108-142 in T*he New Institutionalism in Organizational Analysis*, edited by Paul J. Dimaggio and Walter W. Powell. Chicago: University of Chicago Press.

Scott, W. Richard, Martin Ruef, Peter Mendel., and Carol Caronna. 2000. *Institutional Change and Healthcare Organizations: From Professional Dominance to Managed Care*. Chicago: University of Chicago Press.

Sellon, Gordon, and Deena VanNahmen. 1988. "The securitization of housing finance." *Economic Review* 73(7):3-20.

Shapin, Steven. 1994. *A Social History of Truth: Civility and Science in Seventeenth-Century England*. Chicago: University of Chicago Press.

Slez, Adam, and John Levi Martin. 2007. "Political Action and Party Formation in the United States Constitutional Convention." *American Sociological Review* 72(1):42 -67.

Smelser, Neil. J. 2013. *Dynamics of the Contemporary University: Growth, Accretion, and Conflict*. Berkeley and Los Angeles: University of California Press.

Snow, David A., E. Burke Rochford Jr, Steven K. Worden, and Robert D. Benford. 1986. "Frame alignment processes, micromobilization, and movement participation." *American Sociological Review*: 464-481.

Stark, David, and Balázs Vedres. 2006. "Social Times of Network Spaces: Network Sequences and Foreign Investment in Hungary." *American Journal of Sociology* 111(5):1367-1411.

Starr, Paul. 1982. *The social transformation of American medicine*. New York: Basic Books.

Steffen, Monika. 1987. "The medical profession and the state in France." *Journal of Public Policy*, 7 (2): 189-208.

Steinmetz, George. 2007. *The devil's handwriting precoloniality and the German colonial state in Qingdao, Samoa, and Southwest Africa*. Chicago Ill.: University of Chicago Press.

Stevens, Mitchell L., Elizabeth A. Armstrong, and Richard Arum. 2008. "Sieve, Incubator, Temple, Hub: Empirical and Theoretical Advances in the Sociology of Higher Education." *Annual Review of Sociology,* 34: 127 -151

Stichweh, Rudolf. 1984. *Zur Entstehung des modernen Systems wissenschaftlicher Disziplinen: Physik in Deutschland, 1740-1890*. Frankfurt am Main: Suhrkamp.

Thoms, Herbert, ed. 1942. *Heritage of Connecticut Medicine*. New Haven.

Timmermans, Stefan. 2008. "Professions and their work: do market shelters protect professional interests?" *Work and Occupations,* 35: 164-88.

Toren, Nina. 1975. "Deprofessionalization and its sources: a preliminary analysis." *Work and Occupations, 2* (4): 323-337

Tuchman, Arleen. 1993. *Science, Medicine, and the State in Germany: The Case of Baden, 1815-1871*. Oxford: Oxford University Press.

Turner, R. Stephen. 1971. "The Growth of Professorial Research in Prussia, 1818 to 1848-Causes and Context." *Historical Studies in the Physical Sciences* 3:137-182.

Turner, R. Stephen. 1987. The Great Transition and the Social Patterns of German Science. *Minerva* 251: 56–76.

United States Census Bureau. 2006. *Historical statistics of the United States.* Washington: U.S. Census Bureau.

Uzzi, Brian. 1999. "Embeddedness in the Making of Financial Capital: How Social Relations and Networks Benefit Firms Seeking Financing." *American Sociological Review* 64(4):481-505.

Uzzi, Brian. 1996. "The Sources and Consequences of Embeddedness for the Economic Performance of Organizations: The Network Effect." *American Sociological Review* 61(4):674-698.

Walker, Mack. 1971. *German Home Towns: Community, State, and General Estate, 1648–1871*. Ithaca, NY: Cornell University Press.

Wasserman, Stanley, and Karen Faust. 1994. *Social Network Analysis: Methods and Applications*. Cambridge: Cambridge University Press.

Weber, Max. [1919] 1946. "Science as a Vocation." Pp. 129-157 in *From Max Weber: Essays in Sociology*, edited by H. H. Gerth and C. Wright Mills. Oxford: Oxford University Press.

Weber, Max. 1978. Economy and Society. 2 volumes, edited by Guenther Roth and Claus Wittich. Berkeley and Los Angeles: University of California Press.

Weiss, Harry B. and Howard R. Kemble. 1967. *The great American water-cure craze, a history of hydropathy in the United States*. Trenton: The Past Times Press.

Weisz, George. 2006. *Divide and Conquer: A Comparative History of Medical Specialization*. Oxford: Oxford University Press.

White, Harrison. C. 1970. *Chains of opportunity: system models of mobility in organizations*. Cambridge: Harvard University Press.

White, Harrison. C. 1992. *Identity and Control: A Structural Theory of Social Action*. Princeton University Press.

White, Harrison C. 2002. *Markets from networks : socioeconomic models of production*. Princeton, N.J.: Princeton University Press.

Whitley, Richard. 1984. *The Intellectual and Social Organization of the Sciences*. Oxford: Clarendon Press.

Whooley, Owen. 2013. *Knowledge in the time of cholera: the struggle over American medicine in the nineteenth century*. Chicago: University of Chicago Press.

Wilensky, Harold L. 1964. "The professionalization of everyone?" *American Journal of Sociology*: 137-158.

Wooldridge, J. M. 2002. Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: MIT Press.

Zloczower, Avraham. [1960] 1981. *Career Opportunities and the Growth of Scientific Discovery in Nineteenth-Century Germany*. New York: Arno.

APPENDIX: LIFE SCIENCE INSTITUTES AT THE GERMAN UNIVERSITIES

BERLIN

Table A-1: Life science institutes, University of Berlin

Discipline	Start Year	End Year
agriculture	1810	1828
anatomy	1810	–
botany	1810	–
zoology	1810	–
entomology	1818	1856
forestry	1821	1830
physiology	1855	–
pathology	1856	–
comparative anatomy	1858	1883
paleontology	1873	–
plant physiology	1873	–
chemical pathology	1874	–
experimental physiology	1877	–
histology	1877	–
botany	1878	–
physiological physics	1880	–
physiological chemistry	1882	–
zoology	1884	–
anatomy	1888	–
natural history	1888	–

Sources

Lenz, Max, 1910–1918, *Geschichte der Königlichen Friedrich-Wilhelms-Universität zu Berlin* (4 vols.), Halle: Buchhandlung des Waisenhauses.

Tenorth, Heinz-Elmar (ed.), 2012, *Geschichte der Universität Unter den Linden* (6 vols.), Berlin: Akademie.

Universität zu Berlin, Königliche Friedrich-Wilhelms, 1830–1914, *Amtliches Verzeichnis des Personals und der Studierenden der Königlichen Friedrich-Wilhelms-Universität zu Berlin*, Berlin: various publishers.

BONN

Table A-2: Life science institutes, University of Bonn

Discipline	Start Year	End Year
anatomy	1818	–
zoology	1818	–
botany	1820	–
agriculture	1847	–
natural history	1847	1887
physiology	1859	–
pathology	1862	–
agricultural chemistry	1868	–
botany	1868	–
comparative anatomy	1875	–
histology	1875	1887
paleontology	1882	–

Sources

Bezold, Friedrich von, 1920, *Geschichte der Rheinischen Friedrich-Wilhelms-Universität von der Gründung bis zum Jahr 1870*, Bonn: Marcus & Weber.

Künzel, Franz, and Otto Koll, 1897, *Festschrift zur Feier des fünfzigjährigen Bestehens der Königlich Preussischen landwirthschaftlichen Akademie Poppelsdorf*. Bonn: Universitäts- und Landesbibliothek

Universität Bonn, 1968, *150 Jahre Rheinische Friedrich-Wilhelms-Universität zu Bonn, 1818-1968*, Bonn: Bouvier.

Universität zu Bonn, Königlich Rheinische Friedrich-Wilhelms, 1833–1914, *Amtliches Verzeichniß des Personals und der Studirenden der Königlichen Rheinischen Friedrich-Wilhelms-Universität zu Bonn*. Bonn: various publishers.

BRESLAU (WROCŁAW)

Table A-3: Life science institutes, University of Breslau

Discipline	Start Year	End Year
agriculture	1811	1848
anatomy	1811	–
botany	1811	–
zoology	1811	–
comparative anatomy	1818	–
physiology	1839	–
plant physiology	1866	–
pathology	1868	–
agriculture	1881	–

Sources

Kaufmann, Georg, 1911, *Festschrift zur Feier des hundertjährigen Bestehens der Universität Breslau* (2 vols.), Breslau (Wrocław): Hirt.

Universität zu Breslau, Königliche, 1829–1914, *Personal-Bestand der Königlichen Universität zu Breslau*. Breslau (Wrocław): various publishers.

ERLANGEN

Table A-4: Life science institutes, University of Erlangen

Discipline	Start Year	End Year
anatomy	1743	–
natural history	1769	1859
botany	1770	–
agriculture	1824	1875
zoology	1832	–
pathology	1854	–
physiology	1862	–
comparative anatomy	1869	–

Sources

Engelhardt, Johann Georg Veit, 1843, *Die Universität Erlangen von 1743 bis 1843: Zum Jubiläum der Universität*, Erlangen: J. J. Barfus'sche Universitätsbuchdruckerey.

Kössler, Henning, 1993, *250 Jahre Friedrich-Alexander-Universität Erlangen-Nürnberg: Festschift*, Erlangen: Universitäts-Bibliothek.

Universität Erlangen, Königlich Bayerische Friedrich-Alexanders, 1830–1914, *Übersicht des Personalstandes der Königlich Bayerischen Friedrich-Alexanders-Universität Erlangen: nebst dem Verzeichnisse der Studierenden*. Erlangen: various publishers.

FREIBURG

Table A-5: Life science institutes, University of Freiburg

Discipline	Start Year	End Year
anatomy	1620	–
botany	1766	–
natural history	1775	1845
comparative anatomy	1821	–
physiology	1821	–
pathology	1822	–
zoology	1845	–
veterinary medicine	1865	1872

Sources

Mayer, Hermann, 1892-1893, *Die Universität Freiburg in Baden in der ersten Hälfte des XIX. Jahrhunderts* (2 vols.), Bonn: Hanstein.

Schreiber, Heinrich, 1857-1860, *Geschichte der Alberts-Ludwigs-Universität zu Freiburg im Breisgau*, Freiburg im Breisgau: Wangler.

Universität Freiburg, Albert-Ludwigs, 1836–1914, *Verzeichnis der Behörden, Lehrer, Anstalten, Beamten und Studierenden der Badischen Universität Freibur*g, Freiburg im Breisgau: various publishers.

GIESSEN

Table A-6: Life science institutes, University of Gießen

Discipline	Start Year	End Year
botany	1609	–
anatomy	1720	–
forestry	1824	–
pathology	1837	1878
zoology	1837	–
physiology	1843	–
comparative anatomy	1850	–
veterinary medicine	1850	–
agriculture	1871	–
pathology	1871	–

Sources

Carl, Horst, Eva-Marie Felschow, Jürgen Reulecke, Volker Roelcke, and Corina Sargk (eds.), 2007, *Panorama, 400 Jahre Universität Gießen: Akteure, Schauplätze, Erinnerungskultur*, Frankfurt am Main: Societät.

Universität Gießen (ed.), 1907, *Die Universität Gießen von 1607-1907: Beiträge zu ihrer Geschichte; Festschrift zur dritten Jahrhundertfeier*, Gießen: Töpelmann.

Universität zu Giessen, Großherzoglich Hessische Ludewigs, 1823–1914, *Personal-Bestand der Großherzoglich Hessischen Ludewigs-Universität zu Giessen*, Gießen: various publishers.

GÖTTINGEN

Table A-7: Life science institutes, University of Göttingen

Discipline	Start Year	End Year
botany	1736	–
anatomy	1738	–
natural history	1776	–
pathology	1838	–
comparative anatomy	1840	–
physiology	1840	–
agriculture	1851	–
agricultural chemistry	1854	–
physiological chemistry	1854	–
paleontology	1864	–
veterinary medicine	1870	–
plant physiology	1872	–
physiological chemistry	1881	–

Sources

Conradi, Philipp Friedrich, 1837, *Zur hunderjährigen Jubelfeier der Georgia Augusta zu Göttingen. Ein chronologisches Verzeichniß sämmtlicher Lehrer der Universität seit ihrer Stiftung im Jahre 1734*, Göttingen: Vandenhoek und Ruprecht.

Liebscher, Georg, 1893, *Das landwirtschaftliche Studium an der Universität Göttingen*, Berlin: Parey.

Pütter, Johann Stephan, Friedrich Saalfeld, and Georg Heinrich Oesterley der Jüngere, 1765–1838, *Versuch einer academischen Gelehrten-Geschichte von der Georg-Augustus-Universität zu Göttingen* (4 vols.), Göttingen: Vandenhoek.

Universität zu Göttingen, Georg-Augusts, 1831–1914, *Personal-Bestand der Georg-Augusts-Universität zu Göttingen*, Göttingen: various publishers.

GREIFSWALD

Table A-8: Life science institutes, University of Greifswald

Discipline	Start Year	End Year
anatomy	1750	–
botany	1763	–
natural history	1820	1850
comparative anatomy	1831	1856
agriculture	1834	1877
zoology	1851	–
pathology	1858	–
veterinary medicine	1865	1877
botany	1868	1877
physiology	1868	–

Sources

Alvermann, Dirk, and Karl-Heinz Spiess (eds.), 2006, *Universität und Gesellschaft: Festschrift zur 550 Jahrfeier der Universität Greifswald 1456-2006* (2 vols.), Rostock: Hinstorff.

Kosegarten, Johann Gottfried Ludwig, 1856–1857, Geschichte der Universität Greifswald mit urkundlichen Beilagen (2 vols.), Greifswald: Koch.

Universität zu Greifswald, Königliche, 1844–1914, *Amtliches Verzeichniss des Personals und der Studirenden auf der Königlichen Universität zu Greifswald*, Greifswald: various publishers.

HALLE

Table A-9: Life science institutes, University of Halle

Discipline	Start Year	End Year
botany	1698	–
anatomy	1727	–
natural history	1769	1815
comparative anatomy	1815	1880
zoology	1815	–
physiology	1844	–
pathology	1861	–
agriculture	1862	–
embryology	1876	1880
topographic anatomy	1876	1880
veterinary medicine	1877	–

Sources

Schrader, Wilhelm, 1894, Geschichte der Friedrichs-Universität zu Halle (2 vols.), Berlin: Dümmler.

Rupieper, Hermann J. (ed.), 2002, *Beiträge zur Geschichte der Martin-Luther-Universität Halle-Wittenberg, 1502-2002*, Halle (Saale): Mitteldeutscher.

Universität Halle-Wittenberg, Königlichen vereinigten Friedrichs, 1827–1914, *Amtliches Verzeichniss des Personals und der Studirenden auf der Königlichen vereinigten Friedrichs-Universität Halle-Wittenberg*, Halle (Saale): various publishers.

Universität Halle-Wittenberg, Martin-Luther, 2005, *Catalogus Professorum Halensis: Online-Lexikon hallischer Gelehrter*, online at: http://www.catalogus-professorum-halensis.de/.

HEIDELBERG

Table A-10: Life science institutes, University of Heidelberg

Discipline	Start Year	End Year
anatomy	1710	–
natural history	1784	1813
agriculture	1804	1838
forestry	1804	1838
zoology	1816	–
botany	1834	–
physiology	1844	–
agriculture	1852	–
forestry	1852	–
plant physiology	1863	1872
pathology	1866	–
agricultural chemistry	1872	1880
paleontology	1875	–

Sources

Borscheid, Peter, 1976, *Naturwissenschaft, Staat, und Industrie in Baden, 1848–1914*, Stuttgart: Klett.

Hautz, Johann Friedrich, 1862–1864, *Geschichte der Universität Heidelberg: nach handschriftlichen Quellen nebst den wichtigen Urkunden* (2 vols.), Mannheim: Schneider.

Tuchman, Arleen, 1993, *Science, Medicine, and the State in Germany: the Case of Baden, 1815-1871*, Oxford: Oxford University Press.

Universität zu Heidelberg, Ruprecht-Karls, 1835–1914, *Adressbuch der Ruprecht-Karls-Universität zu Heidelberg*, Heidelberg: various publishers.

JENA

Table A-11: Life science institutes, University of Jena

Discipline	Start Year	End Year
botany	1586	–
anatomy	1750	–
natural history	1779	1837
agriculture	1839	–
physiology	1843	–
comparative anatomy	1859	–
plant physiology	1864	1869
zoology	1865	–

Sources

Steinbach, Matthias, and Stefan Gerber (eds.), 2005, *"Klassische Universität" und "akademische Provinz:" Studien zur Universität Jena von Mitte des 19. bis in die dreißiger Jahre des 20. Jahrhunderts*, Jena: Bussert & Stadeler.

Universität Jena, Großherzoglich Herzoglich Sächsischen Gesammt, 1835–1914, *Verzeichniß der Lehrer, Behörden, Beamten und Studirenden auf der Großherzoglich Herzoglich Sächsischen Gesammt-Universität Jena*. Jena: various publishers.

KÖNIGSBERG (KALININGRAD)

Table A-12: Life science institutes, University of Königsberg

Discipline	Start Year	End Year
anatomy	1738	–
botany	1811	–
natural history	1820	1829
zoology	1834	–
physiology	1851	–
pathology	1863	–
agriculture	1869	–
veterinary medicine	1869	–
agricultural chemistry	1873	–
physiological chemistry	1878	–

Sources

Prutz, Hans, 1894, *Die Königliche Albertus-Universität zu Königsberg i. Pr. im neunzehnten Jahrhundert: zur Feier ihres 350jährigen Bestehens*, Königsberg (Kaliningrad): Hartung.

Universität zu Königsberg, Königlichen Albertus, 1835–1914, *Amtliches Verzeichnis des Personals und der Studirenden auf der Königlichen Albertus-Universität zu Königsberg i. Pr.*, Königsberg (Kaliningrad): various publishers.

LEIPZIG

Table A-13: Life science institutes, University of Leipzig

Discipline	Start Year	End Year
anatomy	1555	–
botany	1648	–
natural history	1815	1848
physiology	1840	–
physiological chemistry	1843	1860
zoology	1848	–
comparative anatomy	1853	–
botany	1855	–
agricultural chemistry	1866	–
histology	1867	1873
agriculture	1869	–
pathology	1869	–
agricultural physiology	1871	–
chemical pathology	1872	1879
topographic anatomy	1872	–
veterinary medicine	1872	–
physiological physics	1876	1877
physiological chemistry	1878	–
comparative anatomy	1880	–

Sources

Rektor und Senat, Universität Leipzig (eds.), 1909, *Festschrift zur Feier des 500 jährigen Bestehens der Universität Leipzig* (4 vols.), Leipzig: Hirzel.

Senatskommission zur Erforschung der Leipziger Universitäts- und Wissenschaftsgeschichte (eds.), 2009, *Geschichte der Universität Leipzig, 1409–2009* (5 vols.), Leipzig: Leipziger Universitätverlag.

Universität Leipzig, 1837–1914, *Personal-Verzeichniß der Universität Leipzig*, Leipzig: various publishers.

Universität Leipzig, 2009, *Catalogus Professorum Lipsensis*, online at: http://www.uni-leipzig.de/unigeschichte/professorenkatalog/

MARBURG

Table A-14: Life science institutes, University of Marburg

Discipline	Start Year	End Year
botany	1786	–
anatomy	1788	–
natural history	1817	1824
zoology	1824	–
physiology	1848	–
pathology	1863	–
paleontology	1880	–

Sources

Gundlach. Franz (ed.), 1927, *Catalogus professorum academiae Marburgensis: die akademischen Lehrer der Philipps-Universität in Marburg von 1527 bis 1910*. Marburg: Historische Kommission für Hessen und Waldeck. Online at: http://www.uni-marburg.de/uniarchiv/pkat/.

Hermelink, Heinrich, und Siegfried August Kaehler, 1927, Die Philipps-Universität zu Marburg 1527-1927. Elwert: Marburg.

Universität Marburg, 1832–1914, *Verzeichnis des Personals und der Studirenden auf der (Kurfürstlich-Hessischen Landes- Universität Marburg) Königlich Preußischen Universität Marburg*. Marburg: various publishers.

MUNICH

Table A-15: Life science institutes, University of Ingolstadt/Landshut/Munich

Discipline	Start Year	End Year
anatomy	1736	–
botany	1723	–
zoology	1805	–
agriculture	1806	1826
comparative anatomy	1827	–
comparative anatomy	1832	1861
paleontology	1832	–
zoology	1832	1861
physiological chemistry	1847	1865
agricultural chemistry	1848	–
physiology	1853	–
physiological physics	1857	1862
plant physiology	1874	–
pathology	1875	–
forestry	1878	–

Sources

Beckenbauer, Alfons, 1992, *Die Ludwig-Maximilians-Universität in ihrer Landshuter Epoche, 1800–1826*, Munich: Ludwig.

Prantl, Carl, 1872, *Geschichte der Ludwig-Maximilians-Universität in Ingolstadt, Landshut, München* (2 vols.), Munich: Kaiser.

Universität Landshut, 1804–1826, *Landshuter Universitäts-Taschen-Kalender*. Landshut: various publishers.

Universität zu München, Königlich Bayerische Ludwig-Maximilians, 1851–1914, *Amtliches Verzeichnis des Personals der Lehrer, Beamten und Studierenden an der königlich bayerischen Ludwig-Maximilians-Universität zu München*. Munich: various publishers.

ROSTOCK

Table A-16: Life science institutes, University of Rostock

Discipline	Start Year	End Year
anatomy	1614	–
natural history	1789	1865
botany	1792	–
comparative anatomy	1837	–
pathology	1837	–
physiology	1837	–
physiological chemistry	1880	–

Sources

Falkenberg, Paul, circa 1900, *Die Professoren der Universität Rostock von 1600 bis 1900*. Unpublished manuscript, online as *Catalogus Professorum Rostochiensium* at: http://cpr.uni-rostock.de/

Heidorn, Günter (ed.), 1969, *Geschichte der Universität Rostock 1419-1969: Festschrift zur Fünfhundertfünfzig-Jahr-Feier der Universität*, Berlin: Deutscher Verlag der Wissenschaften.

Rektor der Universität Rostock, 1994, *575 Jahre Universität Rostock. Mögen viele Lehrmeinungen um die eine Wahrheit ringen*. Reich: Rostock.

TÜBINGEN

Table A-17: Life science institutes, University of Tübingen

Discipline	Start Year	End Year
anatomy	1592	–
botany	1663	–
natural history	1801	1834
agriculture	1817	–
forestry	1818	–
agricultural chemistry	1834	1864
zoology	1837	–
physiology	1845	–
physiological chemistry	1846	–
comparative anatomy	1857	1875
pathology	1869	–
forestry	1887	–

Sources

Born, Karl Erich, 1967, *Geschichte der Wirtschaftswissenschaften an der Universität Tübingen* 1817–1967, Tübingen: J. C. B. Mohr (Paul Siebeck).

K. Statitisch-Topographische Bureau, 1877, *Statistik der Universität Tübingen*, Stuttgart: Lindemann.

Klüpfel, Karl, 1877, *Die Universität Tübingen in ihrer Vergangenheit und Gegenwart dargestellt*, Leipzig: Fues.

Universität Tübingen, Königlich Württemburgische, 1843–1914, *Verzeichniss der Beamten, Lehrer, und Studirenden der königlich württemburgischen Universität Tübingen,* Tübingen: various publishers.

WÜRZBURG

Table A-18: Life science institutes, University of Würzburg

Discipline	Start Year	End Year
anatomy	1724	–
natural history	1803	1868
botany	1809	–
comparative anatomy	1829	–
physiology	1848	–
zoology	1850	–
pathology	1853	–
comparative anatomy	1858	–
histology	1865	–
embryology	1877	–

Sources

Süß, Peter, 2002, *Kleine Geschichte der Würzburger Julius-Maximilians-Universität*, Würzburg: Schoningh.

Universität Würzburg, Königlich Bayerische Julius-Maximilians, 1831–1914, *Personalbestand der Königlich Bayerischen Julius-Maximilians-Universität Würzburg*, Würzburg: various publishers.

Wegele, Franz Xaver, 1882, *Geschichte der Universität Würzburg* (2 vols.), Würzburg: Stahel.