The Interaction of Embedded Actors and Exogenous Events: The Emergence of Proteomics

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Abstract

This paper examines the influence of exogenous events within the emergence of an organizational field focusing on which actors becomes institutional entrepreneurs and how these institutional entrepreneurs enable exogenous events to influence an endogenous institutional change process. Focusing on the emergence of proteomics as an institutional change process, it is the success and legitimacy of embedded actors that enables and encourages these actors to take action. The confluence of successful embedded actors who agree with a new logic and an exogenous event transforms embedded actors into institutional entrepreneurs. These institutional entrepreneurs then function as a conduit that translates the influence of exogenous events to the emergence process through their actions and reactions.

Key words: institutional entrepreneurs, institutional change, exogenous events, emergence

1. Introduction

Proteomics is a relatively new academic field centered on studying the protein complement of genes and protein expression from a systems perspective. The emergence of proteomics represents an interesting case of institutional entrepreneurship because of how the interplay of legitimate scientists, a novel perspective, and exogenous events influenced the progress of this institutional change process. The new logic surrounding the therapeutic potential of proteomics captured the interest and support of scientists who initiated the institutional entrepreneurship process by pursuing proteomics research. As translated into the process of emergence by the reactions of institutional entrepreneurs, exogenous events played an important and ongoing role in the development of proteomics as a field. While prior research explores the role of exogenous factors as an impetus for institutional change (Greenwood, Suddaby, & Hinings, 2002; Hoffman, 1999; Meyer, Brooks, & Goes, 1990), this research focuses on the permeability of process boundaries to exogenous influences by addressing exogenous events as an ongoing influence on an institutional change process. Specifically, this work examines how embedded actors become institutional entrepreneurs and how the ongoing interaction between institutional entrepreneurs and exogenous events influences the change process.

To address these questions, I draw on institutional theory as the theoretical foundation for exploring the emergence of proteomics. Exploring emergence of an institution and the role of institutional entrepreneurs engages institutional theory (DiMaggio & PoIll, 1983; Meyer & Rowan, 1977; Scott, 1995) reaching back to its social constructionist roots (Berger & Luckman, 1967). However, the institutional perspective often receives criticism for ignoring agency and the conditions under which actors initiate change. This work contributes to the growing effort to address these criticisms by examining how exogenous events operate with the activities of institutional entrepreneurs to influence an institutional change process.

This research theorizes the co-evolutionary nature of the relationship between exogenous events, institutionally embedded actors, and endogenous processes by casting institutional entrepreneurs as the conduit that translates the influence of exogenous events within an endogenous institutional process. Specifically, three types of exogenous events emerged from studying the emergence of proteomics: political change, technological change, and socio-cultural change. I trace the effects of these changes on the emergence of proteomics, with a particular eye towards the actions of institutional entrepreneurs in response to these changes. In the case of proteomics, changes in each of these environments posed different kinds of opportunities and challenges to institutional entrepreneurs.

2. Theory

2.1 Institutional Entrepreneurship

The study of institutional entrepreneurship contributes to the larger body of work within institutional theory by specifically addressing the processes and actors involved in the creation or alteration of institutions (DiMaggio 1988; Fligstein 1997: Rao, Morrill, & Zald, 2000). Institutional entrepreneurship relates to the "activities of actors who have an interest in particular institutional arrangement and who leverage resources to create new institutions or to transform existing ones" (Maguire, Hardy, & Lawrence, 2004: 657). Specifically, institutional entrepreneurs intentionally mobilize resources to introduce new organizational forms and institutional logics (Jain & George, 2007). The body of research addressing institutional entrepreneurship continues to grow and extend our understanding of this process across emerging (Garud, Jain, & Kumaraswamy, 2002; Maguire et al., 2004), stable (Greenwood & Suddaby, 2006), and crisis contexts (Hoffman, 1999; Munir, 2005). This work also extends our understanding of the processes involved in institutional change by addressing the seeds (Hoffman, 1999; Munir, 2005), key processes (Maguire et al., 2004), and conflict (Durand & McGuire, 2005; Garud et al., 2004) involved in the emergence of an organizational field, which Scott (1995: 56) defined as "a community of organizations that partakes of a common meaning system and whose participants interact more frequently and fatefully with one another than with actors outside the field." However, work examining the process differentials across various contexts and developmental stages, as I do here, continues to be important in developing our understanding of institutional entrepreneurship (Maguire et al., 2004).

Our focus on exogenous factors can help resolve the paradox of embedded agency (Seo & Creed, 2002) in which institutional actors initiate and foster change in the institutional contexts in which they are embedded. Current approaches to this paradox focus on actors' social locations, particularly on actors on the periphery of fields where they have more potential to become detached from the existing institutional logic (Battilana 2006; Haveman & Rao, 1997; Kraatz & Moore, 2002; Leblebici, Salancik, Copay, & King, 1991). For instance, drawing on network and contradictions theory, Greenwood and Suddaby (2006) identified boundary bridging and boundary alignment as features of network location that operate with institutional contradictions to decrease the embeddedness of elite members within an organizational field and to motivate them to act as institutional entrepreneurs. Also, Holm (1995) approached the question of embedded agency from a nested systems perspective, finding that external events informed endogenous change, which resulted from within field contradictions.

Taken together, the work of Greenwood, Suddaby, and Holm supports a perspective that acknowledges the role of endogenous institutional contradictions while explaining the role of exogenous events in a manner that can incorporate institutional entrepreneurship from various areas within an institutional field. This perspective is particularly relevant to an understanding of emerging academic fields where leading scientists within an existing discipline often spur the initiative to pursue a divergent line of inquiry. I build on this perspective by considering more fully the nature of exogenous events and how they affect institutional entrepreneurship. Just as diverse or widely-cast social networks can be the conduits for new information and alternative logics to enter into highly institutionalized arenas, exogenous events occur, by definition, outside of a recognized institutional field and possess the potential to influence endogenous institutional processes. Similar to the influence of social networks, the actions and ideas of embedded actors translate the influence of exogenous events into a given institutional context. Effective institutional entrepreneurs can use these events as opportunities to alter existing logics and introduce change into existing industries, markets, or other recognized areas of economic life.

As a case of institutional entrepreneurship, the seeds of change for the emergence of proteomics are predominately endogenous as they resided in the unanswered questions of existing fields; However, exogenous events, such as technological advances, political factors, and social and cultural norms, provided the means to begin to address these questions (Ouzounis & Valencia, 2003). Hence, exploring the emergence of proteomics addresses institutional entrepreneurship in an emerging context marked by the confluence of endogenous and exogenous factors. This context allows us to theorize more fully about the relationship among institutional entrepreneurs, exogenous events, and the outcomes of institutional entrepreneurship.

2.2 Institutional Theory

The social constructionist roots of institutional theory assert that institutions are the result of ongoing social interactions that yield an ordered knowledge structure to serve as a common frame of reference for action (Berger & Luckman, 1967; Granados, 2005; Weick 1979, 1993).

While social construction addresses why institutions exist, institutional theory focuses on how and when the resulting social constructions obtain the status as accepted features of the environment (DiMaggio & Powell, 1983; Meyer & Rowan, 1977; Scott 1995). Therefore, a social constructionist perspective embodies the possibility of institutional change by acknowledging that shifting interests influence social actions and interactions that in turn create changes in the resulting social constructions (Berger & Luckman, 1967).

However, institutional theory received criticism for struggling to explain non-isomorphic change (Dacin, Goodstein, & Scott, 2002; Leblebici et al., 1991; Scott, 1987) like the emergence of a new organizational field. In response to this criticism, a stream of work purports that the trigger for non-isomorphic change is exogenous to the field (Greenwood et al., 2002; Hoffman, 1999; Meyer et al., 1990). This perspective is consistent with the idea that instances of institutional entrepreneurship often occur around exogenous triggers (Meyer, 1982) or discontinuities (Clemens & Cook, 1999; Davis, Diekmann, & Tinsley, 1994; Fox-Wolfgramm, Boal, & Hunt, 1998). While this focus on exogenous shocks preserves the view of institutions as sources of stability (Scott, 2001), it actually moves away from the social constructionist roots of institutional theory by casting the event as the central element of disruption as opposed to attributing the disruption to the theorization around the event (Munir, 2005).

I reconcile the role of exogenous events within an endogenous institutional change process by first emphasizing that the exogenous events influence, but do not necessarily initiate, the change process. Embedded institutional actors sow the seeds of change in the presence of a within field contradiction, of which an exogenous event or discontinuity becomes part if given meaning through the existing theorization (Munir, 2005). Specifically, I purport that embedded institutional actors determine and enable the influence of exogenous events. Second, I purport that the influence of exogenous events is not localized to the inception of the change process; the influence of exogenous events occurs throughout the institutional change process.

2.3 Exogenous Events and Institutional Logics

Institutional logics are, according the Friedland and Alford (1991: 243), "symbolic systems, ways of ordering reality, and thereby rendering experience of time and space meaningful." Institutional logics are the cultural-cognitive schemas that exist in recognized areas of social life that bring order and allow individuals create meaning and guide decision-making (Lounsbury, 2007). Thorton and Ocasio (1999) examine the power of institutional logics in their study of the higher education publishing industry. They found that organizational-level executive decision making and succession rates were determined by the overarching logic that governed the industry in a given era, highlighting the influence of the institutional environment in which organizational decisions are made. Actors in the real world, however, enter into and out of a variety of institutional spheres and posses a repertoire or toolkit of various logics upon which they may draw in the situations they encounter (Swidler 1986; Clemens 1993). For example, women were effective agents of political and electoral change because they were able to import the logic associated with one institutionally recognized area of life [the family] into another [politics] (Clemens 1993).

Even as agents of change engage in such transposition, these logics are typically treated as distinct, both in the actors' minds and in scholars' analysis of their actions. The distinct nature of institutional logics and the salience of boundaries around them present challenges to actors who are deeply embedded in a sphere dominated by a single logic. Because institutions and institutional logics become taken for granted and appear to actors as "the way things are" and "the way things ought to be" (Aldrich and Fiol 1994), innovation and change can be difficult because entrepreneurs' perceptions and intentions are fundamentally shaped by prevailing institutional logics. Recognizing that change does occur, However, recent research has considered the paradox of embedded agency (Creed and Seo 2002; Leca and Neccache 2006). In this work, the primary mechanism used by institutionally embedded agents is social network size and diversity. Actors who can draw on social network resources that span institutional boundaries and logics are able to plug into alternative logics and to incorporate them into their efforts towards change (Battilana 2006). I extend this discussion by suggesting that it is the legitimacy and success of an embedded actor that acts as a mechanism that predisposes these individuals to become agents of change. Once predisposed by their stature and success, the actor becomes an institutional entrepreneur by adopting of a new logic. With this said, I avoid casting the institutional entrepreneur as the "heroic" actor as discussed in Suddaby et al. (2010) by emphasizing that certain institutional actors can become predisposed to becoming institutional entrepreneurs by engaging in usual everyday activities (Lok, 2010).

I argue that exogenous events are also potentially crucial factors that enable institutional entrepreneurs to overcome their embeddedness and initiate institutional change. The effects of exogenous changes, shocks, or jolts on organizations have been under consideration for some time. Meyer (1982: 515) recognized that "environments often surprise organizations," and strategic responses to environmental changes have to be constructed *de novo*. Although orthodox neo-institutional theory suggests that an innovative and revolutionary response to environmental change is nearly impossible for institutionally embedded actors and organizations, as it was for those in the early thrift industry (Haveman and Rao 1998), exogenous change may provide the impetus for the innovative change carried out by institutional entrepreneurs. Such events may allow new actors (who are more likely to carry new logics) to enter into existing institutional spheres, lend credibility to alternative logics, or change the more general cultural or strategic climate in which logics prevail (Davis et al. 1994; Ruef and Scott 1998).

3. Methods

Since the aim is to generalize from the case of proteomics to institutional entrepreneurship theory, the research design is naturalistic inquiry (Garud et al., 2002; Lincoln & Guba, 1985). Specifically, this study is an instrumental case study (Stake, 1994) that employs a qualitative approach to investigating emergence with the goal of extending existing theory and gaining additional insight regarding the process of institutional entrepreneurship (Lee, Mitchell, & Sabylinski, 1999). A qualitative inductive approach, such as naturalistic inquiry, is appropriate because the social and interactive elements of institutional emergence (Berger & Luckman, 1967) create a socially complex and opaque process (Elsbach & Kramer, 2003). Furthermore, emergence is a historical process that requires descriptive event sequencing to understand and identify causality, and inductive techniques are best for analyzing these situations (Lee, 1999).

Following Garud et al. (2002), I drew on various archival data sources to construct a descriptive history of proteomics. These archival data sources included published interviews, historical accounts, and academic publications of key institutional entrepreneurs; on-line publications of proteomics organizations; and publications of the scientific community. The comparison across the various sources of data achieved a degree of triangulation (Jick, 1979) that I augmented with a second wave of quantitative data collection.

The primary focus of the quantitative data collection was to highlight the historical trends in the founding of proteomic organizations and in the publication of proteomic books and serials as a measure of the emergence of proteomics. The emergence of proteomics is novel enough that more traditional sources were of very limited use. For instance, the *Encyclopedia of Associations* (Thomson Gale) yielded only seven proteomics associations. Hence, collecting information on proteomic organizations and their founding dates was an open and broad web-based effort facilitated by the existence of several proteomics web portals and communities. As of June 2007, this search revealed over 200 organizations with founding dates for 129 of these organizations ranging from 1975 through 2006. This group of proteomic organizations includes firms, research centers, and societies.

The collection of information on proteomic books and serials employed the Library of Congress catalogue, in addition to supplementary web-based searches. As of June 2007, this search revealed over 150 books and serials with the corresponding dates of initial publication.

4. The Emergence of Proteomics

> "Proteomics is the integrated study of proteins and their biological functions and processes…" (Malsch, 2003)
>
> "Proteomics is the systemic study of the many diverse properties of proteins in a parallel manner with the aim of providing detailed descriptions of the structure, function and control of biological systems in health and disease." (Patterson & Aebersold, 2003)
>
> Proteomics is the study of the structure, function, and expression of all the proteins encoded within genome sequences (Molecular and Cellular Proteomics, 2005).

While specific definitions may vary slightly as demonstrated above, a convergence indicates that proteomics centers on the identification and analysis of proteins (*Science Watch*, 2004). Proteomics represents a new institutional logic since the perspective and research approach distinguishes proteomics from either protein chemistry or biochemistry. While protein chemistry takes a reductionist approach that focuses on protein sequencing and component identification, proteomics aims to study relevant patterns of proteome expression from a systems perspective (Patterson & Aebersold, 2003).

An interest in the study of protein structure and function dates back over 50 years within biochemistry (Molecular and Cellular Proteomics, 2005). The first determination of primary protein structure occurred in 1953 when F. Sanger determined the structure for insulin which earned him the Nobel Prize for chemistry in 1958 (Biemann, 2007; Nobel Lectures, 1964) (Biemann, 2007). Over twenty years later in 1977, yet still pre-dating the term "proteomics," Leigh Anderson and Norman Anderson engaged in the first systematic "proteomic" investigations of human plasma (Anderson & Anderson, 1977; Plasma Proteome Institute, 2006).

Leigh Anderson and Norman Anderson continued to spearhead even larger initiatives in the area of protein identification by proposing the Human Protein Index (HPI) initiative to Congress and chairing the HPI Task Force in 1980, respectively (Anderson, Matheson, & Anderson, 2001). Despite these early initiatives and the long history of questions surrounding protein structure and function, there was only one proteomics-related company in existence, Large Scale Biology co-founded by N. Leigh Anderson and Norman Anderson, when Wilkins coined the term *proteome* and indirectly its derivative *proteomics* in 1994 (Garber, 1999; Plasma Proteome Institute, 2006). Furthermore, the recognition and momentum of large scale proteomics initiatives did not occur until the inaugural meeting of the Human Proteome Organization (HUPO) and the launching of the Human Proteome Project, a global bio-scientific initiative in 2001 (Steinberg, 2001). Consequently, the emergence of proteomics from its nascence in the 1950's through the early 2000's represents a context to study the embedded agency of the scientists who became key institutional entrepreneurs and the role of exogenous events on the change process.

4.1 From Embedded Actors to Institutional Entrepreneurs

In the emergence of proteomics interested researchers became institutional entrepreneurs as they worked to generate interest and research in the budding discipline. The researchers spurring this process had well-established individual legitimacy, which enables them to occupy what Maguire et al. (2004) describe as "subject positions," that are able to build coalitions by connecting stakeholders and access resources as a result of their legitimacy. The legitimacy of these scientists involved in the emergence of proteomics both enabled and primed these scientists to function as subject positions in an effort to support a new logic. Given their stature as leading scientists and subject positions, these individuals were expected to be leaders. Hence, within the emergence of proteomics the success of the scientists positioned them to advance the new logic.

For the twenty years spanning the failure of the original HPI proposal and the launch of the Human Proteome Project, a core of dedicated and highly respected researchers from various fields kept protein analysis afloat. Norman Anderson and N. Leigh Anderson (a father and some pair, respectively) represent two central players in the emergence of proteomics as a field. N. Leigh Anderson received his Ph.D. in molecular biology from Cambridge University, in England, and Norman Anderson received his Ph.D. in biochemistry from Duke University in 1951 (Plasma Proteome Institute, 2006). In addition to the development of the Human Protein Index (HPI) proposal and the leadership of the HPI Task Force, the Andersons continued to contribute to the advancement of proteomics with the work of their laboratory at Argonne National Laboratory (the precursor to the current Large Scale Proteomics Corporation) (Anderson et al., 2001).

Another important name in the continued advancement of proteomics is Rudolf (Ruedi) Aebersold who received a Ph.D. in biology from the University of Basel in Switzerland in 1983 (*Science Watch*, 2004). Distinguished by the impact of his work, Aebersold published articles about the nature of proteins, as Ill as the technologies that enable the study of protein structure and function. A co-founder of the Institute for Systems Biology in 2000, Aebersold published 25 papers over the ten year span from 1994 – 2004, recording over 100 citations for each.

Along with the efforts of the Andersons and Ruedi Aebersold, proteomics continued to advance in small organizations around the globe such as the laboratories of Denis Hochstrasser (Geneva, Switzerland), Joachim Klose (Berlin, West Germany) Julio Celis (Aarhus University, Denmark), and James Garrels (Cold Spring Harbor Laboratory, New York) (Anderson et al., 2001). Together these scientists maintained a resolve to establishing the legitimacy of proteomics as a new field from the initial HPI Proposal in 1980 through the inaugural meeting of the Human Proteome Organization in 2001.

Proposition 1: Embedded actors are predisposed to becoming institutional entrepreneurs when their success and legitimacy intersects with the support or adoption of a new logic.

4.2 Emergence of Change: Institutional Entrepreneurs, New Logics, and Exogenous Events

The nascence of proteomics occurred as respected scientists interested in pursuing questions about the proteome and proteome expression acted on technological advances to solidify the nascence of proteomics by providing robust and efficient empirical investigations. The presence of pre-existing discussion and unanswered questions about the proteome highlights the importance of social construction, or theorization (Greenwood et al., 2002). The influence of technological advances resulted from the discretion of institutional entrepreneurs who chose to incorporate new technologies to advance the new logic. The pre-existing discussion and unanswered questions enabled new technologies to be disruptive based on the processes of social construction. Similar to the nascence of proteomics, the nascence of bioinformatics, "…defined as the computational handling and processing of genetic information…" (Ouzounis & Valencia, 2003: 2176) also occurred when the advances in computer science enabled pre-existing algorithmic problems in molecular biology to be addressed (Ouzounis & Valencia, 2003).

The two key technologies of proteomics are two-dimensional (2-D) gel electrophoresis for protein separation and mass spectrometry for protein identification (Garber, 1999). In 1958, five years after the first determination of protein structure for insulin, a mass spectrometry method was developed for the determination of protein structure (Biemann, 2007). Similarly, advances in molecule separation techniques for large stable molecules, such as proteins, did not emerge until the 1960's. For instance, the automation of Edman degradation (Edman & Begg, 1967) emerged from within biochemistry in the late 1960's (Biemann, 2007), but even this technique was slow and had poor sensitivity which hampered budding proteomic studies (Patterson & Aebersold, 2003). The advent of two-dimensional electrophoresis in 1975 increased the speed and sensitivity of protein separation, which made Edman degradation obsolete and greatly benefited proteomic initiatives (Aebersold, 2003).

As summarized in Table 1, from 1958 through 1999 technological advances in protein separation and analysis continued to improve the feasibility of large scale proteomic investigations, which proteomic scientists embraced to further their initiatives within the new logic. Overlapping with the interests of biochemistry, molecular biology elevated protein research to the scale of "big science." The Molecular Anatomy (MAN) program of Oak Ridge National Laboratory, the first large scale multidisciplinary effort to address biological issues, incorporated an initiative to resolve the problem of efficiently separating complex protein mixtures during the 1960's (Anderson et al., 2001). The termination of original MAN program left the resolution of complex protein mixtures unresolved; However, the Andersons revived the MAN program within their Argonne National Laboratory beginning in 1976 (Anderson et al., 2001). The MAN program at Argonne later culminated in an article representing the immediate precursor of the Human Protein Index (HPI) proposal, which suggested that the mapping of all proteins within every human cell had become feasible (Anderson et al, 1980).

Table 1: Key Technological Advances

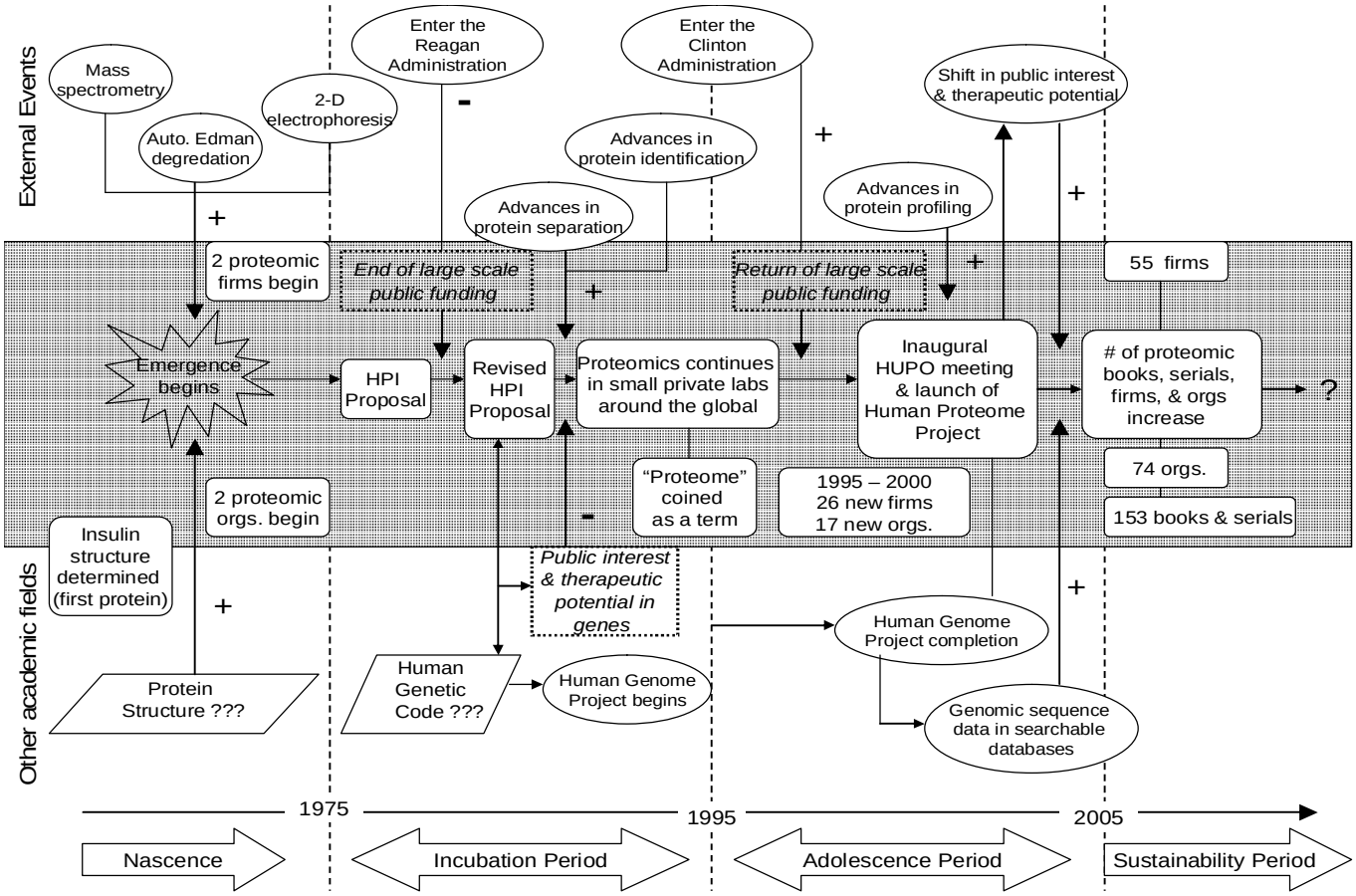
Year	Technology	
1958	Mass spectrometry *protein identification*	Biemann (2007)
1967	Automatic Edman degredation *protein separation*	Edman & Begg (1967)
1975	2-D gel electrophroesis *protein separation*	Klose (1975), O'Farrell (1975)
1988	Electrospray ionization (ESI) *generating ions for mass spectrometry*	Fenn et al. (1989)
	Matrix assisted laser desorption/ionization (MALDI) - *generating ions for mass spectrometry*	Karas & Hillencamp (1988)
1993	Peptide mapping computer tools	Aebersold (2003)
1999	Isotope coded affinity tags (ICAT) *gel independent protein profiling*	Gygi et al. (1999)

Proposition 2: Institutional change occurs at the intersection of successful embedded actors who support a new logic and relevant exogenous events.

4.3 The Progression of Change: Institutional Entrepreneurs and Exogenous Events

The commitment of a dedicated core of scientists acting as institutional entrepreneurs sustained the emergence of proteomics over four decades. Figure 1 presents a process map of the emergence of proteomics that graphically organizes important elements within the process coupled with the influence of exogenous factors. The ovals depict exogenous events that influence the progression of emergence as resources employed by institutional entrepreneurs or as obstacles to be overcome. The solid rectangles depict the initiatives and activities of institutional entrepreneurs that are endogenous to the change process. The dashed rectangles depict salient implications resulting from exogenous events. The parallelograms depict open questions or tensions within existing fields. Vertical arrows illustrate exogenous influence on the process of emergence, and horizontal arrows illustrate temporal progression.

Figure 1: Process Map of Endogenous and Exogenous Influences on the Emergence of Proteomics



Key to the initiation and continued process of emergence, institutional entrepreneurs engage in theorization and build coalitions by appealing to the diverse interests of various stakeholders in the process (Maguire et al., 2004). For instance, the formation of the Human Protein Index (HPI) Task Force reflects the efforts of the Andersons as subject positions who were able to build a coalition and access resources as a result of their legitimacy across of broad range of stakeholders. The HPI Task Force membership included leading researchers, representatives of major commercial organizations, and representatives providing liaison with governmental institutions such as the National Institutes of Health, the Department of Energy, and NASA (Anderson et al., 2001).

However, during the emergence of proteomics exogenous events represented key factors that influenced the coalition building of key scientists. Specifically, shifts in public interest and political support were key exogenous events acted upon by proteomic scientists. Soon after the flurry of activity leading to the founding of the HPI Task Force, the emergence of proteomics abruptly stagnated, and "The immediate cause was the election, in 1980, of the Reagan administration and the consequent shift away from large scale, federal research projects." (Anderson et al., 2001: 6)

A similar chain of events also hampered the development of solar powered technologies when the Reagan administration made drastic cuts in the funding for solar technologies which reversed prior governmental policy in this area (Beattie, 1997). Consistent with an institutional perspective where legitimacy and connections to the external environment are keys to survival (Meyer & Rowan, 1977), the sudden deprivation of large scale monetary funding from federally funded research projects precipitated by political change represented an exogenous event caused proteomic scientists to change their actions and efforts.

For instance, the initiatives of the Andersons initially centered on the development of a database describing all human proteins (*Science Watch*, 2004). The failure of the initial HPI proposal spurred the Andersons to create a revised proposal in 1983. In an effort to generate additional interest and strengthen the coalition of supporters, the 1983 revision of the Human Protein Index (HPI) included both gene and protein projects in an effort to avoid a potential schism between nucleic acid scientists and protein chemists (Anderson et al., 2001). The proteomic scientists altered their coalition building efforts in response to the political change; however, the political change that restricted funding for large scale research studies and the shift in public interest were exogenous events that hampered the emergence of proteomics.

While the HPI initiative lost momentum, the Human Genome Project launched with major federal support and funding, as well as widespread public and private interest centered on the perceived potential for disease treatment (Anderson et al., 2001) in 1990. Following an institutional perspective, more pervasive legitimacy and greater access to resources vaulted the emergence of genomics past that of proteomics. In particular, the presence of federal backing and widespread interest across public and private realms indicates that genomics possessed stronger sociopolitical legitimacy, which relates to the "acceptance by key stakeholders, the general public, key opinion leaders, and governmental officials of a new venture as appropriate and right." (Aldrich & Ruef, 2006: 186) While overshadowed by the human genome project, proteomic scientists continued their entrepreneurial efforts small organizations and laboratories across the globe.

Milestones in the progression of proteomics indicate the ability of proteomic scientists to manage these constraining exogenous events by focusing their efforts internally within the emerging field. In 1994, a Ph.D. candidate named Marc Wilkins of Macquarie University coined the term "proteome" which he defined as the protein complement of the genome (Australian Proteome Analysis Facility, 2006). In 1995, fifteen years after the original Human Protein Index (HPI) proposal, the first dedicated proteomics research center began operation in Australia as a governmental research center: the Australian Proteome Analysis Facility (APAF) (Australian Proteome Analysis Facility, 2006; Garber, 1995). By 1999, seven proteomics companies were in operation (Garber, 1999).

Several exogenous events enabled proteomic scientists to revive and accelerate the emergence of proteomics. First, another political change occurred. The start of the Clinton administration and the return of large scale public funding (Service, 2003) were key events that provided proteomic scientists with the opportunity to pursue larger initiatives. Second, key technological opportunities emerged from the completion of the human genome sequence in 2000 - 2001 (Oak Ridge National Laboratory, 2006). The availability of genomic sequence data in searchable databases facilitated proteomic data analysis (Anderson et al., 2001; *Science Watch* 2004). Lastly, the completion of the human genome project also contributed to the advancement of proteomics by reviving public and private interest in the therapeutic potential of understanding the corresponding proteins encoded in genes (Molecular & Cellular Proteomics, 2005). Hence, these events enabled proteomic scientists to once again build coalitions that crossed institutional boundaries and to resume the larger scale studies needed to accelerate the emergence of proteomics from a niche interest of faction of scientists to a legitimate area of academic and therapeutic interest.

Proposition 3: Even beyond nascence, exogenous events continue to influence the endogenous change process as interpreted and acted upon by institutional entrepreneurs.

4.4 Proteomics: The Institutional Outcomes

The continued process of social construction and legitimization across multiple levels (e.g. groups, organizations, and institutions) must continue for the budding field to achieve its own legitimacy. Specifically, the establishment of stable links and relationships with existing institutions indicates the institutionalization of a new field (Maguire et al., 2004).

For proteomics, the proliferation of organizations, publication outlets, conference forums, a specific definition of the subject matter, and public resources indicate that existing institutions accept proteomics as a new field (Fisk, Brown, & Bitner, 1993; Ouzounis &Valencia 2003). In line with a discursive perspective (Philips, Lawrence, & Hardy, 2004), the proliferation of texts, textbook classifications, publication outlets, and journal citation maps represents an important benchmark in the institutionalization of a new organizational field in the academic community (Glasner & Rothman 1994).

Hence, I further dissect the impact of exogenous factors on the emergence of proteomics by examining the proliferation of proteomic firms, organizations (i.e. societies and research centers) and publications relative to key exogenous events as shown in Figures 2a and 2b. Figure 2a illustrates the growth of proteomic firms and organizations relative to selected milestones and exogenous events in the emergence proteomics. Figure 2b adds the proliferation of proteomic books and serials. Tracking the emergence of proteomic organizations and firms separately acknowledges that the efforts of institutional entrepreneurs can be toward the social and cultural aspects of their field, characterized as institutional entrepreneurship, or towards the economic activities associated with more traditional definitions of entrepreneurship. The similarity of the trends in the proliferation of proteomic organizations and firms suggests that both types of entrepreneurship are similarly impacted by exogenous events; however, traditional entrepreneurship seemed to outpace institutional entrepreneurship until the later years. Taken together these figures illustrate that after a slight acceleration in the early 1980's the pace of emergence was relatively flat until the late 1990's when the pace of organizational founding and publication increased substantially.

Figure 2a: Growth of Proteomic Organizations & Key Events

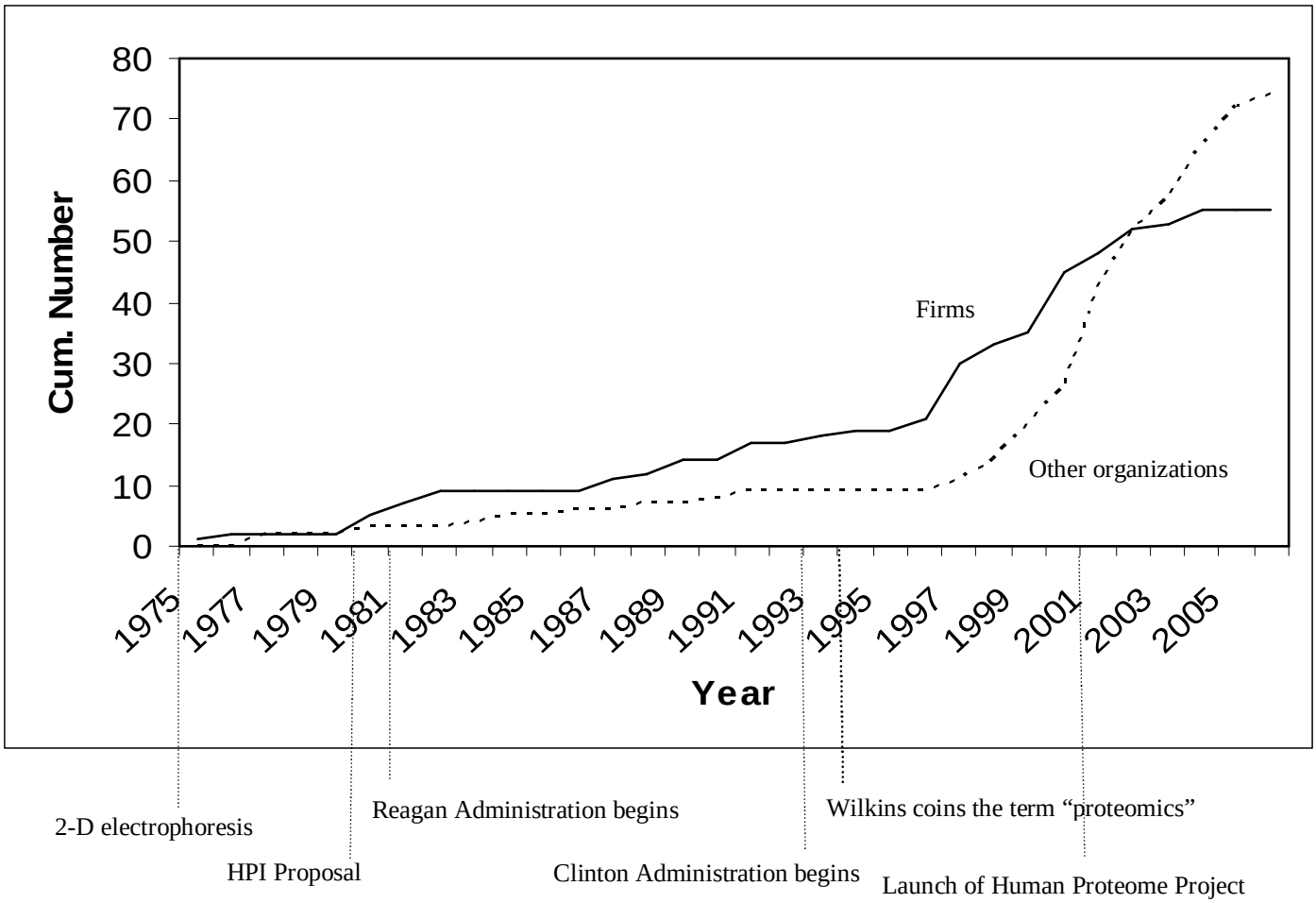
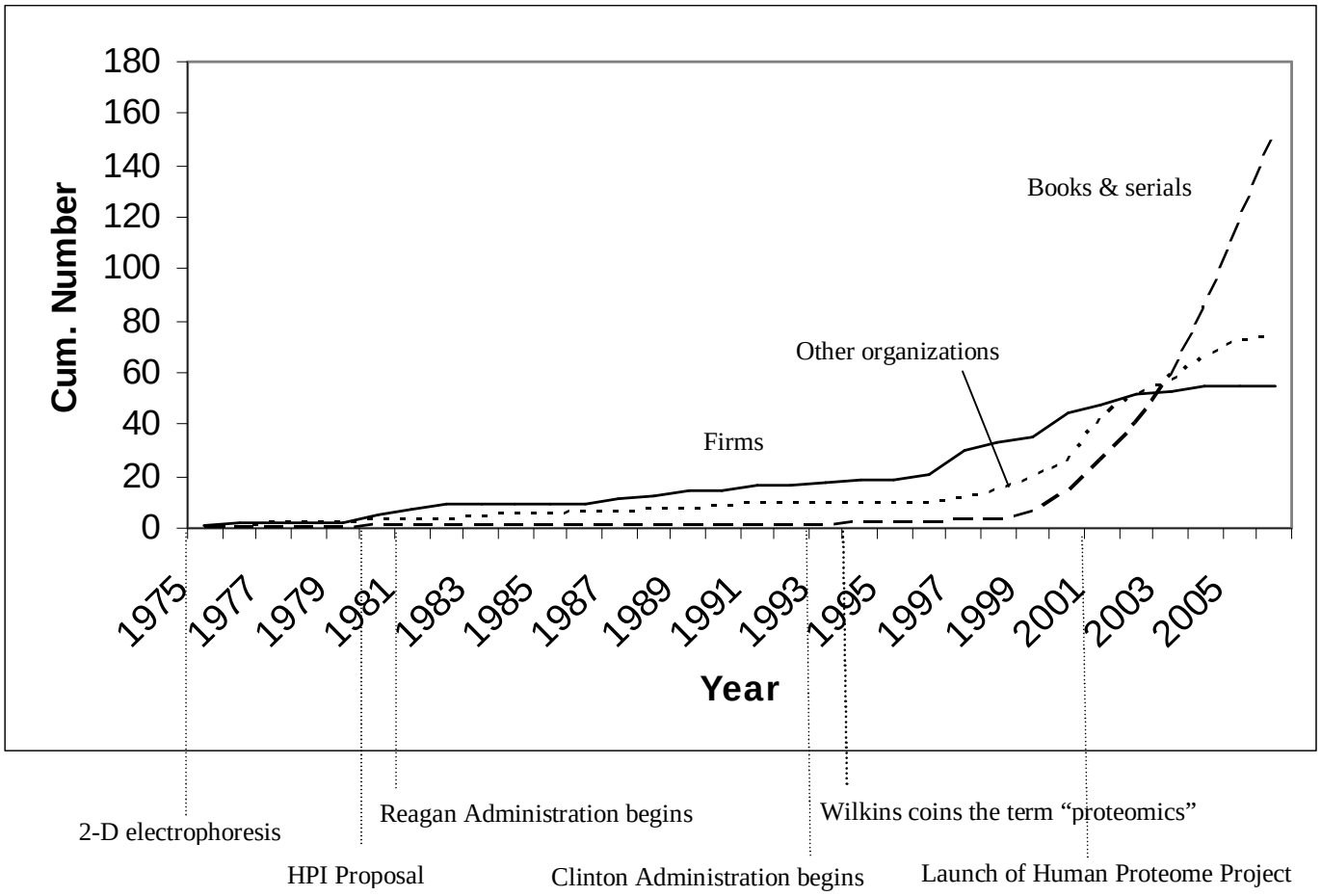


Figure 2b: Growth of Proteomic Organizations, Publications, & Key Events



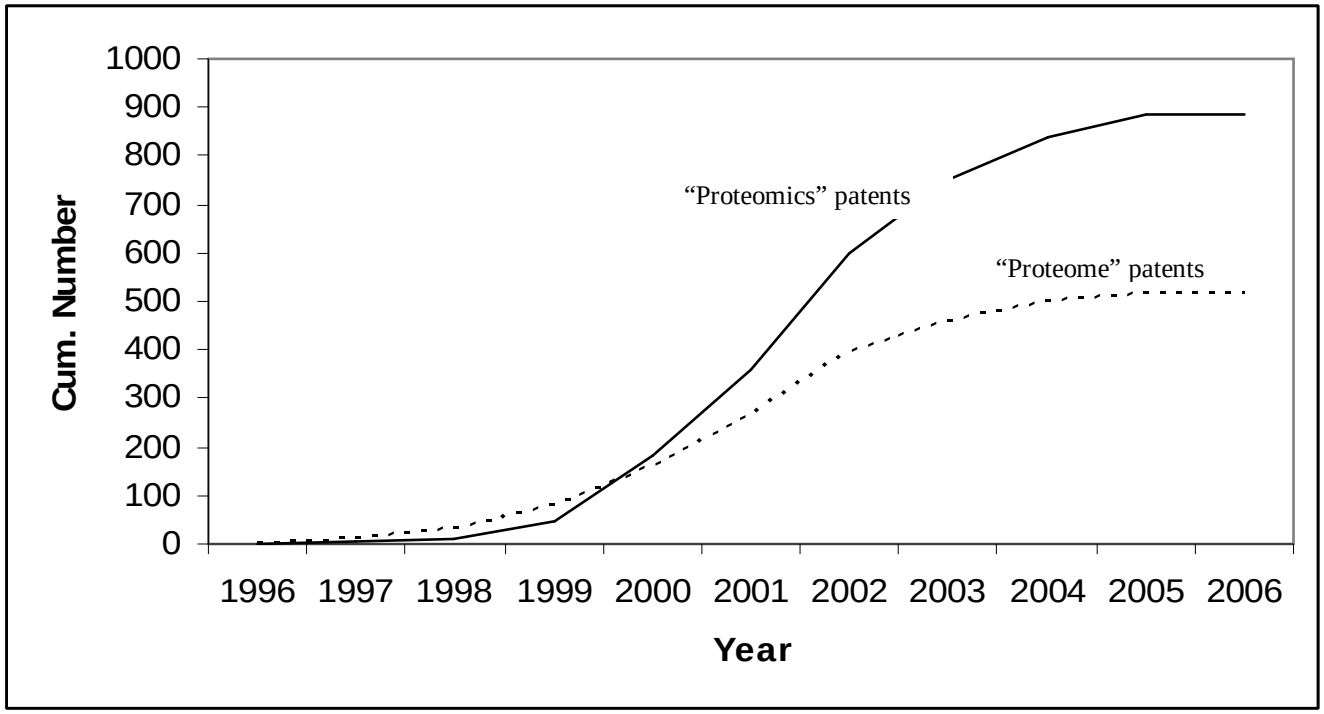
While the early efforts of institutional entrepreneurs resulted in the initial and revised Human Protein Index (HPI) proposals in 1980 and 1983, the beginning of the Reagan administration and the related decrease in public funds seemed to represent a strong negative influence on the process of emergence. Another period of accelerated organizational founding and publication did not begin until later in the 1990's after several more exogenous developments. First, the Clinton administration began and ushered in the return of public funding. Second, the completion of the Human Genome Project precipitated a shift in public interest and therapeutic potential from genes to proteins, in addition to providing a key technological advance in the form of searchable databases. The accounts of institutional entrepreneurs echo the importance of these events in the emergence of proteomics as many key players identified technological advances and large-scale funding as key aspects enabling the growth of proteomics (Anderson et al., 2001; *Science Watch*, 2004).

In the emergence of proteomics, an increase in organizational founding before the subsequent increase in publication suggests the importance of organizational development within the institutionalization of an emerging field. By providing a population for existing institutions to connect with, organizational founding fosters and enables the institutionalization of an emerging field. At the time of the initial Human Protein Index (HPI) proposal in 1980, which was unsuccessful, only eight proteomic organizations existed and just one proteomic related publication existed. However, by the inaugural meeting of the Human Proteome Organization (HUPO) in 2002, a global scientific initiative, 104 proteomic organizations and 40 proteomic publications existed. The limited number of proteomic organizations in 1980 provided little opportunity for the institutionalization of the new field through the development of stable relationships and links with existing institutional players. While the relationship probably embodies a reciprocal dimension where institutionalization also encourages organizational founding, the role of connections with the larger environment in achieving legitimacy (Maguire et al., 2004; Meyer & Rowan, 1977) suggests that organizational presence is an important aspect in the institutionalization of a new field.

Proposition 4: Organizational founding fosters institutionalization by increasing the density of connections within the budding institution, and with key players in the external environment.

The patenting trend shown in Figure 3 also raises the following questions regarding the status of proteomics as a field: 1) Will proteomics be able to maintain its status as an independent academic discipline, and 2) Does the apparent lull indicated by a decreased rate of new patents foreshadow an early decline for proteomics? Questions about the sustainability of a new institution acknowledges the idea that perpetual legitimacy is not a given. Similar to the legitimacy of rules, practices, and other institutional structures, (Lawrence, 1999) the legitimacy of a field depends on ongoing reproduction through continued social action. This stage of emergence explicitly returns to the social constructionist roots of institutional theory by incorporating the need for ongoing interaction to not only create, but to maintain an institution.

Figure 3: Patent Activity



The emergence and demise of home economics exemplifies the challenge of sustainability and the influence of exogenous events, such as shifts in public interest and demographics. By the turn of the 20th century home economics emerged as a multidisciplinary field that integrated science, the family, and communities; and that legitimated higher education for large numbers of American women (Division of Rare & Manuscript Collections, 2001). In the early 20th century interest in the revitalization of rural communities and agriculture, and an interest in the Progressive Era programs in more urban areas (Division of Rare & Manuscript Collection, 2001) provided legitimacy and resource access for home economics. However, another societal shift in the perception of women's roles in the late 1950's and early 1960's cast home economics as "old fashioned," which precipitated changes such as the renaming of the College of Home Economics to Human Ecology at Cornell University (Division of Rare & Manuscript Collections, 2001). These shifts in societal perception and interests eroded the legitimacy of home economics and compromised the access to resources to support its existence.

5. Discussion

In much of the existing work on institutional change, exogenous factors are treated as an afterthought, often invoked to explain the variance that is left unexplained by endogenous process. This work considered the influence of exogenous events throughout the institutional change process. Throughout the decades long emergence of proteomics exogenous events influenced the progress of this institutional change process. Furthermore, this work highlights the role of institutional entrepreneurs as the conduit that carries and translates the influence of the exogenous events within the institutional change process.

Institutional entrepreneurs, such as the proteomic scientists, that embrace new logics are able to use their success as institutional actors to transcend institutional boundaries and build external legitimacy in an effort to create a new institutional field. As the evolution of proteomics reveals, institutional entrepreneurs may alternate their focus internally or externally as warranted by the nature of exogenous events; however, the dedication of these scientists to establishing proteomics as a new field and their willingness to become less embedded within existing institutions fostered the development of proteomics as a separate new field.

The early founders of the field predominantly engage in strategic agency and employ leveraging to mobilize resources as they work to garner support and momentum for the existence and identification of their new discipline (Dorado, 2005). Since institutional change is a process heavily influenced by the power and interest of various stakeholders (Fligstein 1997; Seo & Creed 2002), the success of institutional entrepreneurs resides in their ability to shape their initiatives to the conditions of the field and to connect with the interests of effected stakeholders (Maguire et al., 2004). The emergence of proteomics provides support for this idea in addition to illustrating that exogenous events impact the change process as institutional entrepreneurs react to the events that impact their ability to build coalitions and the garner the support across key stakeholders.

Hence, the emergence of proteomics illustrates that exogenous events come to influence institutional change as institutional entrepreneurs react to these events. In particular, institutional entrepreneurs reacted to exogenous events that either impacted their ability to build coalitions across key stakeholders outside of the budding field or their ability to further institutionalize the new field itself. For instance, the institutional entrepreneurs acted on technological advances to expand and increase proteomic studies that contributed to a body of knowledge. As exogenous events, technological advances enabled institutional entrepreneurs to institutionalize the new field.

On the other hand, institutional entrepreneurs reacted to political changes and shifts in the public interest because these events influenced their ability to build legitimacy and ties across key stakeholders. In 1980 the change in the presidential administration limited the ability of the institutional entrepreneurs to build coalitions and to secure large scale funding which stifled emergence as indicated by a plateau in the number of new proteomic organizations and publications as shown in Figure 2b. However, later in the 1990's another change in the presidential administration, the return of large scale funding, and the return of public interest were exogenous events that enabled institutional entrepreneurs to return to building legitimacy and ties to key stakeholders. As shown in Figure 2b, a substantial increase in both the number of proteomic organizations and publications coincided with these events.

Viewing institutional entrepreneurs as conduits into an endogenous change process also provides insight that addresses the paradox of embedded agency. First, this perspective integrates what were previously considered mixed findings by providing an explanation for how embedded agency emanates from across various positions within their fields. Hence, the legitimacy and success of embedded actors predisposes them to become institutional entrepreneurs. Also, the emergence of proteomics reveals that the confluence of successful subject positions, new logics, and the opportunities afforded by exogenous events represent key factors in precipitating institutional change. Second, this perspective posits that exogenous events as interpreted and acted on by institutional entrepreneurs are relevant and ongoing factors in establishing the trajectory and potential outcome of an institutional change process. Lastly, the use of exogenous events within the entrepreneurial effort does not preclude the idea that embedded agency results from within field contradictions or other field conditions such as uncertainty or unsolved problems (Hardy & Maguire, 2008). Institutional entrepreneurs used technological advances to address a set of unanswered questions within existing fields to launch proteomics, but these technological advances would have been meaningless without the presence of the unanswered questions and the actions of institutional entrepreneurs.

6. Conclusion

By definition, an emerging field can be accurately construed as "new" once an accepted set of assumptions regarding the central focus, methods of research, and relevant literature are established by a community of researchers (Busenitz, West, Shephard, Nelson, Chandler, & Zacharakis, 2003). However, will the emergence of proteomics be sustained? This question emerges so soon because some institutional entrepreneurs of proteomics, such as the Andersons, recently called for the reintegration of molecular biology across genomics, proteomics, and cybernomics (the study and manipulation of the regulatory architecture of cells) (Anderson et al., 2001).

On the other hand, the number of proteomic companies has increased to more than 300 companies with at least 480 collaborations in 2011 (*Business Wire*, 2011). In conclusion, I propose that the struggle between the sustainability of proteomics and the reintegration of proteomics into molecular biology will most likely hinge on the interplay among the interests of institutional members within the new field and the opportunities presented by exogenous events.

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