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SCIENCE TRANSFORMED? REFLECTIONS ON PROFESSED CHANGES IN KNOWLEDGE PRODUCTION

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Abstract. Universities are central institutions in the current knowledge society. Their role is to provide new scientific and technological knowledge, to educate people to serve the society and to alleviate societal problems of various kinds. Because of their importance, universities have been streamlined to make them more efficient and capable of fulfilling their scientific, economic and social missions. Simultaneously, the separate institutional spheres of science, university, government, industry and the civil society have intermingled giving rise to many theoretical interpretations that underline the professed radical change of universities and sciences. Of these theories, the current article focuses on two, namely, the Mode-2 knowledge production and triple-helix of university-industry-government relations. The triple-helix model claims that the increasing interaction between university, industry and government has given rise to a new kind of research that not only seeks to advance knowledge but also tries to attain commercially viable products. The Mode-2 thesis, in turn, argues that science is being fused with other forms of social practice, such as industrial development and societal problem-solving. The present article summarizes the major viewpoints of these theories and reflects on the commentary given to them. To better understand their vices and virtues, the article also analyzes their distinct theoretical statuses and claims that Mode-2 represents a specific kind of sociological theory, the diagnosis of an era, while triple helix is more ambiguous combining three types of theory, namely, diagnoses of an era, general sociological theories and empirically-based research theories. The article is brought to an end by emphasizing the need for a more inductive analysis of the developments taking place in the current academia.

1. Introduction

Within the current knowledge society, universities are central knowledge producing institutions. Their role is to provide new scientific and technological knowledge for the renewal of industrial bases of different countries, to educate people to work in different roles in society and to alleviate the societal and environmental problems of our age. The societal role of universities and sciences has also been reflected in major reforms in different countries. To combat social, economic and environmental hazards, governments have prioritized certain areas of development, such as biotechnology (Gottweis 1998), and created advisory bodies to review scientific and technical information (Jasanoff 1994). At the level of national innovation systems (Lundvall 1992), universities have been streamlined and merged to make them more efficient and capable of fulfilling their social and economic missions (Pelkonen *et al.* 2010). Universities are thus becoming organizational actors with strategic goals and effective internal management systems. This has also engendered new kinds of governance structures within universities, such as creating a stronger role of central authorities in determining organizational goals and strengthening the role of individual leaders (Bleiklie & Kogan 2007). Supported by major external funding instruments, new initiatives under the rubric of the third mission of the university have also been introduced (Nedeva 2007).

The new societal role of the university is by no means novel in a historical perspective (Geiger 1988). What is new in the current situation is, however, the broad structural movement towards an intermingling of the previously separate institutional spheres of science, government, industry and the civil society (Kleinman & Vallas 2006). In the literature, this transformation has given rise to many interpretations that underline the fact that universities and sciences have become isomorphic with other societal organizations and activities. Among the theories that have fostered this kind of understanding in the fields of science and technology studies, higher education research and research policy are the Mode-2 knowledge production (Gibbons *et al.* 1994), triple helix of university-industry-government relations (Etzkowitz 2003a), academic capitalism (Slaughter & Leslie 1997), entrepreneurial university (Etzkowitz *et al.* 2000a&b, Clark 1998, Marginson & Considine 2000), as well as post-academic (Ziman 2000) and post-normal science (Ravetz 1999).

Of these alternative theoretical models, the current article focuses on the first two notions, namely, the Mode-2 knowledge production and the triple-helix theses. These theories are the most famous and cited examples of the above-mentioned transformation theories with 2 471 (Mode 2) and 1 292 (triple helix) citations in the SciVerse Scopus bibliographic database[1].

[1]Retrieved on May 16, 2012.

Both of the conceptualizations are similar in the sense that they claim that a radical transformation with respect to knowledge production has taken place. Characterized as the "triple helix" by Henry Etzkowitz (2003a), the increasing interaction between previously isolated institutional spheres of the university, government and industry has given rise to the kind of research that not only seeks to advance scientific knowledge but also tries to attain commercially viable products. This is precisely what the Mode-2 thesis argues, too: it states that science is becoming fused with other forms of social practice, such as industrial development or societal problem-solving (Gibbons *et al.* 1994). Given the strong influence of these models in science and technology studies, higher education research and research policy debates, I shall ask in this article: What is the theoretical status of these models and do they provide a reasonable basis for interpreting actual empirical developments?

The present article is structured as follows: After briefly summarizing the major viewpoints of these two theories, I shall delve into the commentary given about them. When doing so I shall suggest that the Mode-2 thesis represents what some scholars have called the diagnosis-of-the-era theorizing. The theoretical status of the triple-helix model, on the other hand, is more ambiguous, as it combines elements drawn not only from the diagnoses of the era but from general social theories and research theories, too. The article will be brought to an end by emphasizing the need for a more inductive analysis of the developments and contradictions taking place in the current academia.

2. Mode-2 Knowledge Production

The thesis about the Mode-2 knowledge production was developed by Michael Gibbons, Helga Nowotny, Peter Scott and co-workers (Gibbons 2000a, Gibbons *et al.* 1994, Nowotny *et al.* 2001) during the early 1990s. Sprouting from a project funded and guided by the Swedish Council for Research and Planning, the work sought to develop "a useful heuristic for those seeking to understand what is changing in the sciences and what this implies for the future of our principal knowledge producing institutions" (Gibbons *et al.* 1994, p. viii). During the subsequent years, the Mode-2 thesis became a popular topic of interest rousing intensive academic discussion and stimulating a wide range of empirical research projects.

According to Nowotny *et al.* (2003, pp. 181-184), the analysis emerged from a set of trends and tendencies present in science and technology policy. First, there has been an increase in the steering of research priorities by means of top-down approaches of thematic research programmes and foresight exercises. This has, in turn, diminished opportunities for directing

science bottom-up, for instance, by using open calls for research proposals. The second trend, the growing commercialization of science, has been evident in terms of an increasing search for alternative research funding sources by academics in the face of declining public research budgets and of the attempts by universities to protect their intellectual property rights. Science has thus become privatized instead of remaining freely available on a public domain. Finally, the third trend, the increasing accountability of science, refers to the growing emphasis placed upon the management of research and, especially, on the use of research assessment exercises by national science and technology funding agencies. Having become professionalized activities the assessments have been transferred away from the hands of collegial academic bodies into those of special governmental agencies and university task forces.

As a result of these trends and tendencies, knowledge production has altered: it has changed from the "Mode-1 knowledge production" to a new mode called "Mode 2." According to Gibbons *et al.* (1994), the Mode-1 type of research designates reliable academic knowledge produced within autonomous disciplinary contexts. In this sort of research, there was only a little direct linkage between academic research conducted at universities and societal application of knowledge. As a result of this, boundaries between universities and other social institutions were clear and clean-cut, and academics were quite autonomous in terms of choosing their research topics and problems.

Compared with the Mode-1 science, which subscribes to reliable academic knowledge produced within autonomous disciplinary contexts, Mode-2 research takes place in "the context of application", which ascribes to the mutual interpenetration of scientific knowledge and the larger society. The relationship between science and society has thus become reflexive, meaning that not only does science "speak to society", as has always happened, but "society now speaks back to science". In the simplest of terms, this "reverse communication" is what the authors mean when they speak about contextualization of knowledge production meaning that its scope is expanded so that problems of various societal groups and organizations are set as starting points of research (Nowotny *et al.* 2001, pp. 50, 65, 106). The contextualisation has slowly crept into the very core of science while some parts of science have simultaneously oriented outwards. This has taken place via various mechanisms, such as more intensive university-industry relations, national R&D programs, or increasing consulting by academics. These developments indicate that knowledge production currently occurs within open and shifting boundaries, and is managed for the achievement of particular useful purposes. Gibbons and others call this imperative of usefulness and state that it is present in knowledge production from the

very beginning of research projects (Gibbons *et al.* 1994, p. 4).

Science, in this view, does not have an intrinsic character in its own right but becomes intermingled with the rest of society in a place called "agora", *i.e.*, a piazza where public meetings were held in ancient Greece. According to Gibbons (1999, p. C83), agora is the space where science meets the public. As elaborated by Nowotny (2003), it is, in fact, a metaphor: "a public space, which is neither state, nor market, neither public, nor private, but all of this in different configurations. Indeed, the agora is everywhere". It has also been characterized as a place in which science and scientists receive feedback from society, namely, from the consumer and civil movements, media, research funding agencies and business life (Nowotny *et al.* 2001, pp. 206-207). The end-result of this is "socially robust knowledge", which is being produced in order to increase economic prosperity of nations, to pay attention to the needs of the users of technologies and to solve various kinds of ethical problems (ibid., p. 166).

The new kind of Mode-2 knowledge, which emerges from the agora, can be characterized as follows: it is transdisciplinary, organizationally heterogeneous, socially accountable and reflexive as well as subject to new kinds of quality control procedures. Of these epithets, transdisciplinarity refers to the mobilization of a whole range of theoretical perspectives and research methodologies in the work of solving practical problems. The creative act here lies in "the capacity to mobilize and manage these perspectives and methodologies, their 'external' orchestration, as in the development of new theories or conceptualizations, or the refinement of research methods, the 'internal' dynamics of scientific creativity" (Nowotny *et al.* 2003, p. 186).

Organizational heterogeneousness, in turn, stands for the fact that Mode-2 knowledge is produced in "virtual" communities that span across national and cultural boundaries. Mode-2 research communities are open organizations that have permeable boundaries, which makes it possible for new actors and organizations, such as think-tanks, consultancies and societal interest groups, to take an active role in the research process (Nowotny *et al.* 2003, p. 187). As s result of this, knowledge production is no longer firmly institutionalised in a single setting with homogeneous skills and experience, such as the university, but is carried out in multiple "temporary work teams and networks which dissolve when a problem is solved" (Gibbons *et al.* 1994, p. 6). Various locales and practitioners are thus involved in knowledge production, spanning from researchers from different academic disciplines to industrial scientists and other societal actors.

Social accountability and the reflexivity of the Mode-2 research implies that the research process can no longer be characterized as an objective investigation of the social or natural world but instead can be seen as "an intense (and perhaps endless) 'conversation' between research actors and

research subjects". In other words, "problem-solving environments influence topic-choice and research-design as well as end-uses" (Nowotny *et al.* 2003, p. 187). Nowadays, various groups of people are more aware than before of the ways in which science and technology affect nature and society. As a result of this, they also are interested in influencing the research process. Social accountability thus permeates the whole of the research process, from the definition of research problems to the interpretation and diffusion of the end-results (Gibbons *et al.* 1994, p. 7).

Finally, Mode-2 knowledge is subject to new kinds of quality control procedures. Because knowledge production no more relies on stable disciplinary structures, the traditional form of academic quality control – peer review – is no longer applicable. Instead, the quality of the research outcomes is "determined by a wider set of criteria which reflects the broadening social composition of the review system" (Gibbons *et al.* 1994, p. 8). Due to the more intensive interaction among various kinds of actors, strong social responsibility and accountability permeate the Mode-2 research. This is to say, a broader set of social interests act as new quality control criteria vis--vis the internal scientific peer review of Mode-1 science (ibid., p. 32-33).

Despite the general shift from Mode 1 to Mode 2, there is not, however, any clear historical demarcation line where the former ceased and the latter started. Instead, the change has been gradual and, at present, both modes are said to coexist (Gibbons *et al.* 1994, pp. 9, 14). According to the protagonists of the model, a prime example of Mode-2 science is biotechnology, where researchers no longer try to reveal "the basic principles of the world" but seek to produce specific commercial applications and understand "concrete systems and processes" related to such applications (ibid., pp. 23-24, 147). The main differences between the two modes of knowledge production are depicted in Table below.

The contextualization of knowledge not only pertains to the ways in which new knowledge is being produced but also applies to the institutional structure of university. The authors state, that the demarcation between universities and other organizations, such as industrial enterprises, has eroded and university scientists have become more responsive to the needs of industry. Universities have therefore become "stretched" institutions encountering competitive and even contradictory demands, such as missions to produce new scientific knowledge and to satisfy mass education demands (Gibbons *et al.* 1994, pp. 70-89, Nowotny *et al.* 2001, pp. 79-94). When it comes to the relationship between scientific research and commercial development, the different societal roles of the university may be mutually sustaining, too. This is the case, for instance, with "hybrid institutions" (*e.g.*, small and medium-sized high-tech companies) that play a decisive role in increasing the contacts between universities and industries

TABLE 1. Descriptions used by Gibbons (2000b, p. 40) to differentiate the two modes of knowledge production.

Mode-1 Knowledge Production	**Mode-2 Knowledge Production**
Problems set and solved in a context governed by the interests of a specific academic community	Knowledge produced in the context of application
Disciplinary knowledge	Transdisciplinary knowledge
Homogeneity of skills	Heterogeneity of skills
Hierarchical organizations that tend to preserve their forms	Flat hierarchies and transient organizational structures
Less socially accountable and reflexive	More socially accountable and reflexive
Quality control based on peer review	Expanded system of quality control which is based on a wider, more temporary and heterogeneous set of practitioners, collaborating on a problem defined in a specific and localized context

(Gibbons *et al.* 1994, pp. 137-138, 144). Biotechnology, again, is a field of study where these developments have been most prominent. In that area, the traditional separation between university and industry has broken down as university-based scientists not only routinely move into entrepreneurial roles but governments worldwide encourage academics to team up with outside firms or, alternatively, to start up their own companies (Nowotny *et al.* 2001, p. 60).

The emergence of Mode-2 science is not an isolated phenomenon but parallels wider transformations in society, too. As claimed by Gibbons (2000a, p. 160), openness in knowledge production "reflects, and is reflected in, the emergence of a more open type of society." The whole of society has thus become transgressive, meaning that such modern categories as science, politics, culture and the market have become subject to the same co-evolutionary trends and have started to invade each other's domains (Nowotny *et al.* 2001, p. 4). As a result of this, it has become increasingly difficult to determine where one institution ends and the other begins. The end-result of this is the Mode-2 society, which is characterised by "an overall increase in complexity which embraces a pervasive uncertainty in social relations, greater institutional permeability, the emergence of new forms of economic rationality, the emergence of a greater degree of self-organization

amongst social actors, and a profound shift in our perceptions of time and space" (Gibbons 2000a, p. 160). Emphasising the convergence between the institutions of university, industry and government the concept of Mode-2 society shifts the argument in the direction of the triple-helix view, a theory which will be addressed next.

3. Triple Helix of University-Industry-Government Relations

A closely related idea to the Mode-2 knowledge production is "the triple helix of university-industry-government relations" introduced by Henry Etzkowitz (1998) during the mid-1990s. Having emerged from Etzkowitz's earlier research on university-industry relations the triple helix is a metaphor representing the close interaction and, indeed, increasing overlap between previously separate institutional spheres of the university, industry and government. The basic idea behind the metaphor is simple: it states that in the era of knowledge society, university, industry and government have equal roles in enhancing innovation through more intensive mutual interaction. According to Etzkowitz *et al.* (2007), the triple-helix model, depicted below, comprises three basic elements:

1. a more important role for the university in fostering innovation,
2. a movement toward more intensive interaction and collaboration between the institutions of university, industry and government, and
3. transformation of the conventional functions of the above-mentioned institutions so as to take the role of the other.

In the knowledge-based society, the central function of the triple-helix interaction is to stimulate innovation. This is especially pursued by new, hybrid forms of organizations and networks located at the section areas of the triple-helix model. According to Etzkowitz & Viale (2010, p. 596), the whole of society is being transformed "as public-private dichotomies in knowledge, institutions, organizations and roles evolve from pure-bred to hybrid". Because different countries have dissimilar histories before entering into the knowledge-based society, the model takes, however, different configurations in different parts of the world (Etzkowitz & Leydesdorff 2000). Etzkowitz *et al.* (2007) differentiate between three distinct routes to triple-helix relations.

In the first of them – the statist Triple Helix I, which is found, for instance, in the former Soviet Union and China – the nation state encompasses the university and industry and directs their mutual relationships through central planning and coordination mechanisms. Here, it is the role of the government to pull the other two spheres into collaboration with one another to foster successful innovation.

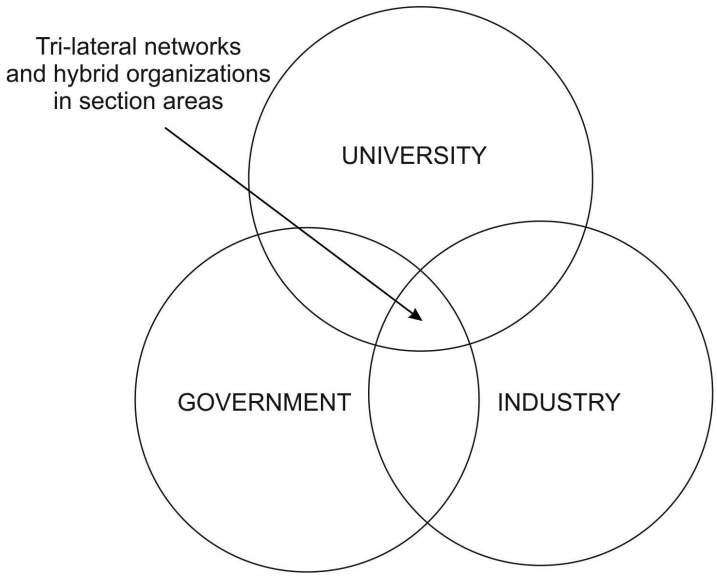

Figure 1. The triple-helix model (adapted from Etzkowitz 2003a, p. 302).

The second triple-helix configuration – the *laissez-faire* Triple Helix II exemplified by the Unites States, Canada and Sweden – consists of three separate institutional spheres with strong borders and highly circumscribed relations among them. In this model, each institution has a single purpose: For the university it is to provide research and educated personnel. The role of the government is limited to solving problems that inhibit the proper operation of the free market. Industry, in turn, consists of independent firms operating in a competitive market environment so as to turn scientific inventions into commercial innovations.

Finally, the third variant of the model – the interactive Triple Helix III – denotes a knowledge infrastructure made up of overlapping, yet relatively independent institutions that take the roles of each other and produce hybrid organizations. In this variant, which is sought for in most of the countries, the "objective is to realize an innovative environment consisting of university spin-off firms, tri-lateral initiatives for knowledge based economic development, and strategic alliances among firms (...), government laboratories, and academic research groups" (Etzkowitz & Leydesdorff 2000, p. 112). Here, the role of the university is to contribute to firm-foundation and regional development, in addition to its traditional missions of scientific research and higher education. The government seeks to support commercialization of university research by means of providing tax incentives, venture capital and developing a regulatory environment. The industry, in

turn, pursues its economic mission in addition to taking "the role of the university in developing training and research, often at the same high level as universities" (Etzkowitz *et al.* 2007, p. 16). According to Etzkowitz *et al.* (ibid.), the Triple Helix III is the type of institutional relations presently sought after by most countries and regions.

As often claimed by Etzkowitz, countries all around the globe are presently on the threshold of a new era: the next great transformation, already well underway, is the coming of the Triple Helix III, that is, the increasing interaction and overlap between the university, industry and government. The characteristic feature of this radical change is the fact that it leads to the transformation of each of the three institutions mentioned above. While the Mode-2 thesis underlined the de-institutionalization of the current mode of knowledge production the triple-helix model suggests, in a similar vein, that universities and industries are taking the roles of each other; that is, universities start to emphasize entrepreneurial tasks simultaneously as industrial enterprises take on the academic dimension of sharing knowledge and training employees (Etzkowitz *et al.* 1998, Etzkowitz *et al.* 2007). Such a dynamic is currently evident, for instance, at the level of research practice: By putting forth the notion of "an entrepreneurial science", Etzkowitz draws attention to the simultaneous presence of theoretical, methodological and commercial dimensions of research and highlights the integration of academic investigation with corporate activity (Etzkowitz 1998, pp. 826-827).

Etzkowitz & Leydesdorff (1997, 1998 & 2000) claim, indeed, that the economic logic is strengthening within universities, consequently boosting the commercialization of academic knowledge and transformation of the traditional university into an entrepreneurial organization. This process begins, according to Etzkowitz (2011), through internal transformation of academic research groups into "quasi-firms". Research groups that are called quasi-firms are firm-like entities that are managed by professors who no longer work at the laboratory bench but devote most of their time and energy to acquiring research funds, managing collaborative relations and taking care of other organizational tasks (Etzkowitz 2003b). Once these quasi-firms start directly to participate in the capitalization of knowledge and technologies, the university begins to transform itself into an entrepreneurial one.

The "entrepreneurial university" involves the incorporation of the traditional academic mission – "the extension of knowledge" – into a compatible relationship with the "capitalization of knowledge". In other words, scientists in many fields start to look at their research results from the viewpoint of commercial potential in addition to theoretical and methodological advancement (Etzkowitz 1998, pp. 824-829). The entrepreneurial university

is thus a hybrid organization which incorporates "the third mission" of the university – that is, economic development – alongside scientific research and higher education. Being supported by national and supra-national innovation policies this entails, at the level of the university organization, establishment of technology transfer offices, science parks and business incubators, as well as various kinds of administrative offices and committees that respond to problems and opportunities created by emergent entrepreneurial activities (Etzkowitz 2003b, Etzkowitz 2011).

The entrepreneurial science that sprouts from the triple-helix relations becomes institutionalized not only at the level of the university organization but at the normative structure of science, too. Here, Etzkowitz (2011) builds on the work of a famous sociologist Robert K.Merton. According to Merton (1942/1959), science is characterized by a particular kind of cultural ethos that guides the appropriate scientific practice and supports the goal of science – the extension of certified knowledge. The ethos of science is manifested by a set of institutionalized imperatives – universalism, communism, disinterestedness and organized scepticism[2] – that reward those who follow the norms of science and sanction those who violate them.

The norms of science as articulated by Merton are not compatible with entrepreneurial science, which seeks to privatize knowledge and gain economic benefits from it. According to Etzkowitz (2011), a normative change in academic science is, therefore, going on. Instead of defining entrepreneurial scientists as deviant, the new set of norms, currently emerging, supports entrepreneurship. During the 1980s, for instance, as the US patent legislation was altered, the Mertonian norm of communism, *i.e.* collective ownership of scientific findings, was modified to "'limited secrecy', with research results kept under wraps until their economic value could be protected" (ibid., p. 551). Etzkowitz claims that the same holds for disinterestedness, too: Scientists are no longer required to disengage their personal interests from their work but they may have personal economic and social interests that drive their research problems (ibid., p. 552; also Dzisah 2010). The new emerging norms of science do not, however, replace older norms once and for all but become conflated with them. This is done in various ways, for instance, by showing that entrepreneurial activities are in accor-

[2]Merton (1942/1959) describes the norms as follows. Universalism requires that the evaluation of scientific claims is made using pre-established impersonal criteria: "the acceptance or rejection of claims [...] is not to depend on the personal or social attributes of their protagonist; his race, nationality, religion, class and personal qualities are as such irrelevant (ibid., p. 553). Communism states that findings of science are to be kept a product of social collaboration and are thus owned by the scientific community. Disinterestedness refers to the pattern of scientists to disengage their personal interests from their work, implying a virtual absence of fraud in science. Finally, organized scepticism refers to the tendency of the scientific community to avoid making claims on issues that are not yet firmly supported by data.

dance with research and teaching through the establishment of technology transfer organizations, or by means of creating organizational policies to deal with conflicts of interests. In doing so, universities "produce rationalizations to show how old norms are not violated by new forms of behaviour, thus laying the foundations for normative change" (ibid., p. 561).

In Etzkowitz's (2002a, p. 121) perspective, the emergence of the entrepreneurial university is an irresistible, unavoidable development: it "is not so much a matter of evolution, the capture and retention of change events, but of an internal dynamic working itself out." Because of this internal dynamic, the emergence of the entrepreneurial university is not confined to some particular countries or regions but is a phenomenon observable all over the world (Etzkowitz *et al.* 2000a&b). In his research, Etzkowitz has found examples of entrepreneurial universities from the United States (Etzkowitz 2002b), the Netherlands (Etzkowitz *et al.* 2007), Canada (Etzkowitz *et al.* 2007) and Sweden (Etzkowitz & Klofsten 2005). Furthermore, he is convicted that this tendency will become even stronger in the future: "The University of the Future" will be a business incubator entirely. That is, the technology transfer and incubation of new firms will convert from happenstance into a permanent activity, taking place in each and every department. Even the potentially controversial activities of the contemporary university – academic research, higher education and societal service – do not hinder this development as the university incorporates these functions and reconciles their apparently contradictory objectives (Etzkowitz 2002a, p. 127). In effect, various kinds of problems are just symptoms of the changing role of the organization. These will disappear as the new type of university takes hold: "the 'opposing' norms and orientations are reinterpreted, emphasizing harmony rather than disharmony, mutual reinforcement rather than detraction from each goal" (Etzkowitz 2003b, p. 116).

Having been initiated in the mid-1990s, the constant flow of research associated with the triple-helix model and the entrepreneurial university has evidenced the vitality of the original idea. The research utilizing the model has gained momentum by means of an international Triple Helix Association[3] and a set of regular triple-helix conferences. Because these institutions gather together not only academic researchers but policy-makers and administrators, too, triple helix has evolved from being a descriptive framework and an analytic tool into a normative model used in many countries and regions to foster technological innovation and economic growth. An early example of developmental use of triple-helix was a stage model of knowledge-based regional development, which consisted of four phases:

[3] http://www.triplehelixassociation.org/

1) developing the idea of a new regional model,
2) starting new activities,
3) the consolidation and adjustment of activities and
4) self-sustaining growth (Etzkowitz & Klofsten 2005).

Later on, the developmental models based on the triple-helix idea were directed at improving the innovation systems of the third world countries by means of putting the basic elements of an innovation system in place and by enhancing the circulation of people, ideas and innovations between the three helices (Dzisah & Etzkowitz 2008).

Furthermore, the analytical and developmental use of the model in such diverse societal settings as Germany, Sweden, China, Brazil and Ethiopia has led to theoretical divergence of the model from the original idea. Etzkowitz, in collaboration with Zhou, has, for instance, proposed a distinct concept of sustainability triple helix to complement the innovation-related triple helix described above. The central difference between the two is to substitute public for industry in order to account for issues of public concern, such as controversies over new technologies (Etzkowitz & Zhou 2006). Another major theoretical development within the triple-helix literature is the difference made between neo-institutional or neo-corporatist interpretation of the triple helix, represented by Etzkowitz, and the systems-theoretical evolutionary model developed by Leydesdorff (1996, 2000 and 2005) and Viale and co-workers (Viale & Campodall'Orto 2002, Viale & Pozzali 2010). Only time will tell whether or not these and other developments will lead to a strengthening of the triple-helix model or cause its gradual disintegration into competitive rival camps.

4. Reflections on the Two Models

Clearly, as brought out by some commentators (Audétat 2001, Krücken 2002, Shinn 1999, Weingart 1997), the Mode-2 thesis and the Triple-Helix model are important attempts to come to grips with many recent phenomena concerning the university research, its societal application and the broader institutional framework within which universities currently operate. For instance, they draw attention to the practicality of research, to the direct collaboration between university research groups and industrial enterprises as well as to the emergence of hybrid modes of activity. It might well be that some of these, such as the extensiveness and the diversity of university-industry networks, are signs of something new coming up; that is, they are cues for fundamental changes taking place in some high-technology industries, such as biotechnology (*e.g.*, Powell *et al.* 2005). Moreover, it has been claimed that the significance of these relations has increased over time: The excitement about industrial involvement in university research should

thus not be received with a déjà-vu attitude but rather the distinctive nature of the current situation should be appreciated. First, the industry is willing to make huge, long-term contractual commitments supporting university research. Second, the universities are apparently eager to seek out these contracts. Third, there is a whole diversity of new arrangements that have been worked out by governments and universities to facilitate technology transfer, such as those listed in the previous sections (Geiger 1988).

4.1. CONTESTED CHARACTERISTICS OF MODE 2

Since its publication in 1994, the thesis about the emergence of the Mode-2 knowledge production (Gibbons *et al.* 1994) has been very influential in the field of science, technology and innovation studies. Most of the citations it has received are, according to Hessels & van Lente (2008) positive, treating the model as an accepted description of the changes in the sciences during the recent decades. These articles, however, do not usually scrutinize the key contents of the Mode-2 thesis but use it as a general conceptual framework for empirical research that is being reported. An example of this sort of research is the description of orphan drug networks by Crompton (2007) who examines the ways in which the lay public contributes to the knowledge production in medicine. Another example is provided by Bruun *et al.* (2005) who use the distinction between Mode 1 and Mode 2 in classifying university departments and provide policy recommendations on that basis for smooth transition from Mode 1 to Mode 2 research education.

In addition to such positive applications of Mode 2, a significant part of the literature takes the legitimacy of the model as a contested issue and puts its validity to the test (Hessels & van Lente 2008). This literature can be grouped into two categories:
1) studies that empirically investigate the legitimacy of individual attributes given to Mode 2 and
2) those that criticize the model's political underpinning and normative character.

When it comes to the first group of research, the theory is generally regarded as fairly problematical. In addition to the fact that it has been seen to underestimate the relevance of path-dependent trajectories and the boundaries of established scientific organizations and institutions (Jansen 2002, Krücken 2003, Shinn 1999), the model's assertion that the nature of scientific research has altered during the recent decades has been questioned. In contrast to the claim made by Gibbons and others, Etzkowitz & Leydesdorff (2000, pp. 115-116), for instance, state that Mode-2 science is not a new phenomenon at all. Referring to a dissertation by Merton (1938), the authors argue that about half of the discoveries in the seventeenth cen-

tury had their origins in attempts to solve the problems of navigation, mining and so forth. Therefore, rather than being a novel phenomenon, the Mode-2 type of research was the original form of science prior to its institutionalization into the university system in the nineteenth century. Similarly, Godin (1998, pp. 470-474; also Pestre 2003 and Edqvist 2003) refer to a number of historical studies and claim that research has always shifted between fundamental and applied spheres. Indeed, there is a long tradition in science and technology studies claiming that science always should be seen in relation to society (*e.g.*, Bernal 1967). In line with this, Muller (2000, p. 79; also Fuller 2000, pp. 79-80), in turn, argue that the Mode 2 thesis over-dichotomizes the evolution of science and presents it as two discrete ideal types that probably never existed in a pure form in the real world. On the other hand, Rip (2000, pp. 35-36), describing the European Renaissance from the 14th to the 16th centuries, states that the ambivalent position of the so-called professors of secrets, who collected recipes from different crafts and sold them to sponsors, closely resembles that of present-day biotechnologists and other scientists working in commercially important areas.

In addition to the historical perspective, different characterizations of the Mode-2 science have been subjected to empirical scrutiny. When it comes to the transdisciplinarity, that is, the claim according to which the Mode-2 research is pursued by a diverse range of specialists to solve practical, social problems, Bonaccorsi (2010) suggests that collaboration across specialisms may be motivated, not only by efforts to solve societal problems, but by intrinsic, internally driven motivation to produce valid knowledge, too. Godin (1998) and Weingart (1997), in turn, reject the claim that recombination of different disciplines is a new phenomenon. In their perspective, research has always involved an amalgamation of elements coming from different fields of research. Weingart also notes that one should be very careful when speaking about transdisciplinarity: What may appear to be trans- or interdisciplinary research at the research program level may well turn out to be disciplinary research at the level of actual research practice.

The Mode-2 science also involves a heterogeneous combination of actors coming from different walks of life. In their bibliometrical study, Godin & Gingras (2000) indeed find that there is an increase in the share of scientific publications that includes non-university actors as contributors. On the basis of data coming from Norway, Gulbrandsen & Langfeldt (2004, p. 246) come to an opposite conclusion: "With the exception of a few, entrepreneurially oriented professors, we find little support for the 'Mode 2' proposition that these sectors [*i.e.*, basic and applied research, JT] are converging". Weingart (1997), in turn, claims that the issue is very much contingent upon the country and field of research under investigation. Because

organization of research differs from country to country and from industry to industry, as does the type of knowledge, careful comparison is needed "to distinguish fact from fad" (Weingart 1997, p. 595).

The Mode-2 knowledge production is also characterized by novel types of quality control. According to Gibbons *et al.* (1994, p. 8), Mode-2 knowledge is determined by "a wider set of criteria which reflects the broadening social composition of the review system". Positive results supporting this thesis are provided by Hemlin & Rasmussen (2006) who argue on the basis of illustrative case examples from Scandinavia, that traditional quality control is giving way to quality monitoring. In other words, the emphasis is being shifted from the cognitive control of products of science to an ongoing organizational monitoring of entire research processes. Interestingly enough, the attempt by Albert *et al.* (2012) to empirically test the possible change in quality control procedures in the field of Canadian health sciences produces opposite results: The vast majority of academics are aligned with the traditional Mode 1 peer-review. Similar kinds of results are presented by Gulbrandsen & Langfeldt (2004) on the basis of Norwegian data.

This sort of counter-evidence lends support to the judgment that the Mode-2 thesis is very controversial in terms of empirical evidence. Therefore, it seems to be the case that the model overstates the change science has undergone while simultaneously dismissing relevant earlier literature and empirical research results. Given the fact that the validity of the different attributes of the Mode-2 knowledge production are contentious there seems to be no reason to tie them together under a common heading – the Mode 2 (Hessels & van Lente 2008). Doing so, makes the model seem "one-eyed and reductionist," mainly focusing on "a relatively small – albeit significant and dramatically changing – domain of the vast diverse landscape of science in society" (Elzinga 2002, p. 3). This conclusion is further substantiated by empirical evidence provided by Ylijoki *et al.* (2011) as well as Heimeriks *et al.* (2008) who claim that scientific enterprise is a very heterogeneous entity as a whole. We might thus let Mode 2 go away, as such, and concentrate our future efforts on better understanding the different kinds of trends that are going on in different kinds of sciences in different countries.

An additional point of criticism has been that the Mode-2 thesis has a close affinity to the political neo-liberalism and the language of innovation policy (Häyrinen-Alestalo 1999, Krücken 2002, Shinn 2002, Weingart 1997). Terry Shinn (1999, p. 172), for instance, maintains that the Mode-2 argument easily links to "a partisan political agenda and ideology" rather than "a serious-minded history and sociology." Hence, it seems that "The New Production of Knowledge" is neither a solid empirical study nor a general sociological theory, but rather a type of theory Noro (2000) calls a diagnosis

of the era (also Tuunainen 2002). As discussed by Noro, diagnoses of the era usually are normative and seek to generate new topical insight instead of building elaborate theoretical models or data-bound research theories. As such, diagnoses are messages sent out from scholarly discussion to a wider learned public. Their primary place is not so much within scholarly deliberation but rather in broader societal and political debate. Therefore, as noted by Noro, one should not simply seek to verify or rebut their general vision; that would be way too difficult because of their overly-abstract nature.

Given the wide publicity and heated debate over the central characteristics of the Mode-2 thesis, this seems to be true indeed. Many scholars have explicitly noted that the advantage of the model is that it gives food for thought and opens up new interesting questions (Edqvist 2003, Krücken 2002, de la Mothe 2003, Strathern 2003). These kind of "performative histories" (Godin 1998) may thus be effectively used in policy-making, as illustrated by Mode 2 in the context of South African higher education policy (Kraak 2000). The strong affinity of Mode 2 with the diagnoses of the era is further substantiated by Gibbons's (1994, p. viii) avowal that the style of the work was largely set by a governmental agency, namely, the Swedish Council for Planning and Coordination of Research, and that the book should be taken as a "heuristic for those seeking to understand what is changing in the sciences and what this implies for the future of our principal knowledge producing institutions."

4.2. AMBIGUOUS NATURE OF TRIPLE HELIX

Whereas the Mode-2 thesis has over the years been expanded into an increasingly abstract and encompassing theory concerning the place of knowledge production in the post-modern age, the triple helix has a stronger empirical footing. When it comes to the thesis according to which there is increasing interaction between different institutional spheres of society, the empirical research done in different countries confirms the thesis on a general level. One example of the countries studied is Finland, which belongs to the leading knowledge-based economies in the world (*e.g.*, Dahlman *et al.* 2007).

Drawing from the triple-helix idea, Kaukonen & Nieminen (1999) claim that there has been a long-term transition in Finland towards more intensive university-industry-government relations. These connections began to evolve in the late 1970s, as research expenditures increased substantially in private industry and in governmental research institutes while the relative share of research funding of universities declined. As a result of this development, which continued throughout the 1980s and 1990s, the entire

Finnish research system was gradually restructured and the priorities of the national science and technology policy were altered (Kaukonen 1987, p. 24; Nieminen & Kaukonen 2001). The authors, then, assume that these changing funding patterns and the related competitiveness-oriented innovation policy reveal a transformation of the relationships between universities and industries. Although the statistical data used by Nieminen & Kaukonen (2001) did not allow for the analysis of actual interactions between universities, government and industries, the authors (Nieminen & Kaukonen 1999, p. 338; also Kivinen & Varelius 2003) argue that it is justified to speak about the development of "a Finnish Triple Helix." Similar results emphasizing a general transition towards closer interaction between the three institutional spheres of society have also been found in other countries, including the United States (Giesecke 2000), Germany (Leydesdorff & Fritsch 2006), Sweden (Benner & Sandström 2000), Singapore (Leong *et al.* 2008, Wong 2007), Malaysia (Razak & Saad 2007), China (Zhou & Peng 2008), Mexico (Rivera Vargas 2010) and Brazil (Etzkowitz *et al.* 2005).

As a result of the more intensive interaction across institutional spheres, different kinds of intermediary organizations, such as foundations, associations and consortia, have developed on the inter-institutional borderland. While drawing attention to these certainly is the strength of the triple-helix model, it is regarded as its weakness, too. Amy Scott Metcalfe (2010), for example, complains that the model is limited in its reliance on the three institutional sectors of the university, industry and government. In her view, this structural bias inhibits understanding of the influences sprouting from other kinds of organizations, including independent actors like patenting and licensing companies and technology transfer units. In agreement with this, Nina Suvinen *et al.* (2010) propose that the intermediary organizations should be implemented in the triple-helix model as independent elements, in addition to which their differential roles in dissimilar regional or sectoral circumstances should be appreciated. One approach to this direction is provided by the process-oriented model of an intermediary organization developed by Metcalfe (2010, pp. 507-509).

According to the triple-helix model, the increasing interaction between university, industry and government not only brings about the birth of intermediary actors but also induces transformation of each of the institutions, either through innovative individuals (Göktepe-Hultén 2008) or changing governmental policies (Zhou & Peng 2008). As maintained by Etzkowitz (2003a), this holds true for all major organizations, including the traditional university, the transformation of which into an entrepreneurial university is a major line of research within the triple-helix literature. Catholic University of Leuven (KU Leuven) is an early example of a European university, which has transformed itself into an entrepreneurial mould (Etzkowitz *et*

al. 2007). Already since the 1970s, the university established a technology transfer unit, KU Leuven Research and Development (LRD), which played an essential role in the development of entrepreneurial capabilities of the university's personnel. Unlike other Flemish universities, where technology transfer was managed through regular university administration, LRD enjoyed considerable autonomy at KU Leuven while still being integrated into the university structure. LRD was free to manage the revenues earned from entrepreneurial activities, which helped it to create a broad spectrum of advisory, co-ordinating, administrative and clearing services that made it a model for other universities in terms of supporting academic entrepreneurship. The results of LRD in promoting commercial activities were substantial: at the turn of the millennium, the university owned 171 patents, in addition to which it co-ordinated 58 spin-offs and provided 24 per cent of KU Leuven's R&D budget. Other case examples of operating or emerging entrepreneurial universities include the prestigious US universities, such as MIT (Etzkowitz 2002b) and Stanford University (Etzkowitz 2003b) as well as the University of Saskatchewan in Western Canada (Etzkowitz *et al.* 2007), Lund University in Sweden (Göktepe-Hultén 2008) and the University of Singapore (Leong *et al.* 2008, Wong 2006). Initial steps towards entrepreneurial activities in universities have also been found in China (Zhou & Peng 2008).

This empirical evidence is convincing in demonstrating that commercial exploitation of research results has become an all the more important mission of contemporary universities. Etzkowitz and his co-workers (Etzkowitz 2002a & 2003b, Etzkowitz *et al.* 2000a, Etzkowitz *et al.* 2008) pursue, however, a stronger interpretation of the recent developments than this. They not only assert that some universities are increasingly engaged in supporting entrepreneurship through auxiliary structures and functions, such as technology transfer units, but claim that the university's evolvement into an entrepreneurial one is an all-encompassing, inevitable and global phenomenon covering all types of organizations in each and every country. Furthermore, economic functions, such as incubation of new firms, will be spread throughout the university structure: Incubation will be decentralized, that is, it will become a regular feature in each department or academic unit (Etzkowitz 2002a, p. 127). This bold thesis is often substantiated by chronicling the histories of MIT and Stanford and holding that other institutions worldwide are emulating these models. While this is evidently true for some universities, as indicated above, there are opposite findings, too, that assert that only a minority of academics and universities are highly-oriented towards financial activities (*e.g.*, Albert 2003, Deem & Johnson 2003, Harrison & Leitch 2010, Philpott *et al.* 2011).

Further evidence on the problematic nature of the entrepreneurial uni-

versity thesis is provided by studies that shift the analytical focus away from the university organization to the actual practices that take place at the grass-roots level of university departments. Juha Tuunainen (2005), for instance, studied a case of a hybrid firm at the University of Helsinki, Finland. A hybrid firm is a company that straddles the public and private spheres of activity. It is a commercial enterprise which is still located "within the university and dependent on the university for a degree of administrative and financial support" (Etzkowitz *et al.* 2000b, p. 320). Because the staff of such a firm occupies academic and company positions concurrently, the hybrid firm may be regarded as a useful touchstone for the viability of the entrepreneurial university model in practice. In the case analyzed by Tuunainen, serious conflicts emerged between the members of the hybrid firm and the university administrators. As a result of this, the hybrid entity was eventually abandoned and the firm sealed away from the university department in a peripheral organizational position, with the business incubator operating in a science park. Tuunainen takes this case as counter-evidence for Etzkowitz's assertion that commercial impulses penetrate the entire university organization in a straightforward and thorough manner. In contrast to this, he suggests that a distinction should be made between special intermediary structures that assist technology transfer within the university and the core academic units, such as departments. While the auxiliary parts of the university may, indeed, reach out to the corporate world, the academic core may still dissociate itself from entrepreneurship. These results were later augmented by another study with essentially similar kinds of results (Tuunainen & Knuuttila 2009).

Commenting on this case study, Etzkowitz & Zhou (2008) draw attention to a normative shift that is probably going on in the case university: The initial negative reaction of the university administration to the existence of the hybrid firm may not remain valid in the long run. In their perspective, the normative change within evolving entrepreneurial universities incorporates gradual resolution of conflicts by means of re-interpretation of the commercial activities as broadly compatible with existing university activities. This is to say, controversies over entrepreneurship are indications of ongoing transformations and they will be reconciled in terms of new normative structures that make business activities compatible with the advancement of knowledge (Etzkowitz 2011). Tuunainen & Knuuttila (2008), in their study on the normative change at the grass-roots level of the university departments did not find, however, any sign of this but concluded that the scientific community and the university institution are still largely operating according to some rather stable, traditional norms of science, such as the primacy of teaching and research over commercialization and the collective ownership of research results. In comparison to academics, the role

of technology transfer officials in the maintenance of boundaries between organizations is different; these professionals make efforts to accommodate academic and commercial norms for one another while simultaneously protecting academia from direct entrepreneurial influence by setting the terms of exchange between the two institutional spheres (Sanders & Miller 2010).

So, what should be concluded on the basis of a debate like this? First, the point made by Etzkowitz & Zhou (2008, p. 633) is evident: To pursue entrepreneurial science is a highly risky venture in a university bound by traditional principles of separation between research and commercial activities. Finding a balance between commercial activities and research and teaching is, thus, an ongoing practical debate, the results of which are far from certain. The second lesson to be learnt from the case example is the fact that a more differentiated understanding of the university's internal structure should be made within the triple-helix literature. Otherwise put, universities are complex entities that may simultaneously incorporate contradictory activities in different parts of their organization. It is thus questionable to make broad generalizations about the university's overall development without simultaneously acknowledging that goals and missions may differ from one internal unit to another. Third, universities and disciplines they cater for are dissimilar: While universities may lean towards commercialization, this general pattern may be differentiated, not only by university type (Häyrinen-Alestalo *et al.* 2000) but also according to scientific disciplines and specialties; some universities and departments may be nearer to industry than others (*e.g.*, Martinelli *et al.* 2008, Mathieu *et al.* 2008, Nieminen & Kaukonen 1999, Ylijoki 2003). This does not necessarily retard their economic impact, however. As concluded by Mathieu *et al.* (2008, p. 678), universities do not need to turn "all entrepreneurial" in an organizational sense to contribute to national or regional prosperity.

Finally, it is important to note here that the triple-helix thesis is not intended to be an empirical description or analytic device only; it involves a strong political aspect as well. In line with this, Dzisah & Etzkowitz (2008) suggest that triple helix should be regarded as a developmental method of creating more effective innovation systems especially in developing countries. Despite the limited analytical capacity of the triple-helix model (Suvinen *et al.* 2010) several scholars have made attempts to develop the innovation systems of their particular countries by using the triple helix as a normative ideal and methodological tool. Examples of this involve the application of the triple helix as a motor for developing telematics in Portugal (de Castro 2000) or university-industry relations in Latin America (Sutz 2000). Etzkowitz (2003a, p. 334), too, refers to the triple helix as providing a useful framework for knowledge-based economic and social development. On the basis of comparisons made between the USA, Japan, Sweden and

Brazil, he and his co-workers (Etzkowitz *et al.* 2008), for instance, suggest that it is high time to make massive investments in the technology transfer and translational research capacity especially in Europe so as to foster the development of entrepreneurial universities. Whereas the triple helix in this mould clearly represents just another version of the diagnosis-of-the-era type of theorizing, the growing body of empirical research counterbalances and neutralizes at least some of its normative tendency and over-theorization, as noted by Elzinga (2002, pp. 15, 25).

In summary, then, the two theories are substantially different from one another with regard their theoretical statuses. While the Mode-2 thesis clearly represents diagnoses of the era type of thinking, the nature of the triple-helix model is more ambiguous. It may be characterised as a hybrid entity that combines an increasing amount of empirical evidence, overt normative orientation and a complex systems-theoretical underpinning (Leydesdorff 1996, 2000 & 2005). This means, in other words, that it involves aspects of all kinds of sociological theory discussed by Noro (2000), namely,
1) the diagnosis of the era,
2) research theories, *i.e.*, theories that are directly linked to empirical evidence of particular phenomena, and
3) general sociological theories that address very broad issues like the constitution of society or culture.

5. Conclusion

I began this article by reviewing the recent literature according to which science and the university have dramatically changed in their character. Of the many alternatives that have tried to capture the typical features of this transformation, I chose to focus on two prominent conceptualizations, namely, Mode-2 knowledge production and the triple helix of university-industry-government relations. I summarized the main points of these theories and considered criticisms directed at them. What might be concluded from such an endeavor?

Given the fact that the two theories were dissimilar in terms of their theoretical statuses, their assessment must acknowledge that difference. To begin with, I claimed that Mode-2 knowledge production was representative of diagnosis-of-the-era type of theorizing. Such "performative histories" (Godin 1998) are messages sent out from scholarly conversation to a wider learned public. As such, their primary place may not be so much within scholarly discussion but rather in broader societal and political debate. Therefore, as noted by Noro (2000), one should not simply verify or rebut their general claims. Because they usually contain components that are being developed at the levels of general sociological theories or

empirically-based research theories, some parts of the diagnoses of the era may be subjected to sociological perusal. Mode 2 did have such elements. For instance, it made use of empirical research to substantiate its claim that the emphasis in science is being shifted from fundamental research towards a more applied orientation. Due to its all-embracing character, empirical research cannot, however, confirm or refute these sorts of general claims, as was evidenced by the controversial research results concerning different attributes of the Mode-2 knowledge production. What empirical research can do is effectively point out issues that could be better appreciated by such "diagnoses." In this respect, it was concluded in this article that the Mode-2 thesis was far too generalized and biased to provide an adequate description of today's science and university, in addition to the fact that it did not distinguish between many internal dimensions of academic research, such as differences between disciplines.

The triple helix, on the other hand, was far more ambiguous with regard its theoretical status. I claimed that it was not exclusively an example of diagnoses of the era but sought to be a research theory as well. In conjunction with many other scholars, Etzkowitz has endeavored to establish a strong linkage between the general claims of the triple-helix model and empirical data, thereby making the theory more amenable to empirical scrutiny than would be the case with Mode 2. During the ensuing debate, at least two issues have become clear. First, there can be little doubt that in recent years universities have changed in many respects. Analysts have attributed these changes to the emergence of the global knowledge economy, new public policy priorities and increased economic competition between nations. For instance, as noted by Kleinman & Vallas (2001, p. 455) "universities are increasingly viewed as mechanisms for enhancing national competitiveness." Second, while not wanting to question such general statements, which may be too obvious to contest, I would argue that the changes universities are going through are neither uniform nor pervasive. Instead of being isomorphic to one another, there are vastly different kinds of universities in today's world. Moreover, each university is comprised of various activities that are not always mutually harmonious. Therefore, it is questionable as to whether or not any all-embracing conceptualization of the transformation of the university is defensible as such.

In summary, what is problematic with the conceptualizations addressed in this article is the fact that they tend to describe transformation of science and the university through indistinct and totalizing language, which glosses over all too many important conceptual, social and institutional dimensions of academia. Instead of overarching claims, then, scientific work and universities should be seen as complex and occasionally contradictory entities whose developmental trajectories are shaped by multiple – and often

contradictory – historical, political and cultural characteristics. Addressing these in terms of inductive empirical research would, in my opinion, give good starting points for further understanding the role of the university in the current knowledge society.

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