Science in a New Mode:
Good Old (Theoretical) Science vs.
Brave New (Commodified) Knowledge Production?

Tarja Knuuttila
Helsinki Collegium for Advanced Studies
Fabianinkatu 24 (P.O. Box 4)
00014 University of Helsinki
FINLAND
Tel. +358 (0) 9 191 24466
Fax +358 (0) 50 342 0423
tarja.knuuttila@helsinki.fi

Abstract The present transformation of the university system is conceptualized in terms of such terminologies as "Mode-2 knowledge production" and the "entrepreneurial university." What is remarkable about these analyses is how closely they link the generally accepted requirement of more socially relevant knowledge to the commercialization of university research. This paper critically examines the Mode-1/Mode-2 distinction through a combination of philosophical and empirical analysis. It argues that, from the perspective of actual scientific practice, this Mode-1/Mode-2 distinction and the related transition thesis do not stand closer scrutiny. Theoretical "Mode-1" science shares "Mode-2" features in being also problem-oriented, interventive and transdisciplinary. On the other hand, the empirical case on language technology demonstrates that even in "Mode-2"-like research, undertaken in the "context of application," scientists make a distinction between more difficult scientific problems and those that are considered more applied or commercial. Moreover, the case shows that the need to make such distinctions may even become more acute due to the compromises imposed by the commercialization of research.

Keywords commercialization, new knowledge production, modeling, representation, technoscience, language technology

1. Introduction

Since the 1980s a "novel" genre of science policy discussion has emerged that targets the transition assumed to be taking place in contemporary academic science. Several analyses have addressed the more (socially) relevant research that universities are expected to produce, also discussing the pivotal position of universities in the new knowledge economy. The assumed transition of the university system is conceptualized by such terminologies as "Mode-2" knowledge production (Gibbons et al. 1994; Nowotny et al. 2001), "Triple Helix" of University-Industry-Government relations and "entrepreneurial university" (Etzkowitz & Leydesdorff 2000; Etzkowitz 2004, 2003, 2008; Dzisah & Ezkowitz 2011), "academic capitalism" (Slaughter & Leslie 1997; Slaughter & Rhoades 2004), "post-academic science" (Ziman 1994, 2000) and "strategic research" (Rip 2002a , 2004).

As already hinted at in the list of these newly coined terminologies, it is noteworthy how closely the generally accepted requirement of more socially contextualized and relevant scientific knowledge is linked to the commercialization of university research (cf. Irzik 2010). For Etzkowitz, for example, the "third mission" of universities boils down to contributing to economic growth (e.g., Etzkowitz 2004). The "entrepreneurial university" develops as traditional universities incorporate private business activities into their activities by hybridizing them with public academic work. Although Mode-2 literature does not give commercial activity such a focal role, it is possible to find from Gibbons et al. (1994), and Nowotny et al. (2001), passages such as: "Operating the new dynamical competitive environment means working with regimes of knowledge production similar to Mode-2, which are based on both competition and collaboration and the ceaseless reconfiguration of resources, knowledge and skills" (Gibbons et al. 1994, 47). What seems clear is that the transition into Mode-2 knowledge production provides a more favorable setting for "entrepreneurial university" than the traditional Mode-1 science. The authors of academic capitalism (Slaughter & Leslie 1997; Slaughter & Rhoades 2004) and post-academic science (Ziman 1994, 2000) are more cautious and critical as to the effects of the commercialization of academia, but they also think that the commodification of knowledge and academic research is here to stay.[1]

The commodification of knowledge, narrowly defined, refers to the commercialization of university research in terms of patenting and licensing, and founding university spin-off companies, but commodification can be considered as a more all-pervasive phenomenon where "all kinds of scientific activities and results are predominantly interpreted and assessed on the basis of economic criteria" (Radder 2010, 3). These activities are exemplified by such incidents as the increasing practice of cost-based accounting among sub-units in a university organization and the way academics have become increasingly affected by the profit motive and market-like behavior in their efforts to secure external grants (Slaughter & Leslie 1997).

Even though business practices and social accountability are thus increasingly permeating also the academic world, there are good reasons to ask whether this has changed the nature of scientific knowledge and the ways it is produced and justified. No clear answer to this question seems to have emerged as the discussion on the Mode-2 thesis shows. Numerous critics have challenged the transition from Mode-1 to Mode-2 by questioning either the alleged novelty of Mode-2 or the timing of the break between the two modes. Thus some critics have claimed that the *transition* from Mode-1 to Mode-2 is not corroborated by the actual historical record (e.g., Weingart 1997; Godin 1998; Shinn 2002). They have typically argued, on historical grounds, that several Mode-2 characteristics (for Mode-2 characteristics, see below) were already part of the traditional, or Mode-1 research (e.g., Carrier 2011; Etzkowitz & Leydesdorff 2000; Shinn 2002). On the other hand, another group of critics has taken the transition thesis for granted, but have proceeded to argue that the Mode-2 research started already earlier than in the 1980s (e.g., see Schiemann 2011, Jamison 2011). And yet there are those who argue that Mode-1 itself is historically situated and not an original format of research (e.g., Rip 2002b).

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[1] For different kinds of perspectives to entrepreneurial university and commercialization of academic research, see Clark 1998, Marginson and Considine 2000, Krimsky 2003, and Mirowski 2011.

Although these criticisms show that the *transition thesis* and its historical accuracy can be contested on several grounds, they are also contradictory among themselves.[2] What appears to be needed, then, is philosophical discussion targeting the conceptual basis of the transition thesis. Consequently, instead of trying to embark on any ambitious, large-scale historical analysis, this paper subjects the transition thesis to a philosophical scrutiny, combined with a grass-roots level empirical case on the commercialization of language technology. The Mode-2 thesis has also generated an immense body of literature on the socio-political aspects of the new knowledge production, but this discussion has tended to stay at a rather general level. In contrast, what is at issue here is how well the transition thesis really describes *the actual scientific practice*.

The first part of this paper focuses on the Mode-1/Mode-2 distinction by taking a closer philosophical look at scientific modeling and representing. It argues that the distinction between Mode-1 and Mode-2 cannot rest on the distinction between *representing and intervening*, and neither is the argument from *technoscience* successful in this respect. The second part of the paper argues, on the basis of an empirical case that, even in engineering-oriented research undertaken in the context of application, one can distinguish between those problems that are more basic or fundamental and those that are more applied and less scientifically rewarding. Thus the philosophical-cum-empirical analysis of this paper points in the same direction as some of the aforementioned historical analyses: the Mode-1/Mode-2 distinction is, at least in the way it is used by the Mode-2 analysts, misleading as regards the actual scientific practice. Theoretical modeling undertaken in a traditional disciplinary matrix displays many characteristics that come close to those ascribed to Mode-2. On the other hand, in what seems like a prime example of Mode-2 knowledge production one can still discern several goals and values of traditional academic research. These goals and values are threatened by commercialization as shown by the empirical case.

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[2] In their implicit concentration on commercialization, the proponents of the Mode-1/Mode-2 distinction have largely neglected the earlier distinction between "little" and "Big science," where Big science refers to the large-scale, state-financed multidisciplinary research and development that had its origin in the military effort during the Second World War (cf. de Solla Price 1963; Weinberg 1967).

2. The Mode-1/Mode2 distinction from the perspective of scientific practice

2.1 Mode-1 vs. Mode-2 knowledge production

If Marx had a lot to say about the capitalist society and remarkably little about its successor, the communist society, the contrary is the case with proponents of Mode-2.[3] Mode-1 science does not get too much attention; the focus is on the characteristics of Mode-2 knowledge production. It is as if we were expected to know already what Mode-1 science is. This is particularly the case with the original formulation of the Mode-2 thesis in the book *The New Production of Knowledge* (Gibbons et al. 1994—hereafter NPK), whose treatment of Mode-1 is surprisingly scant. According to NPK, Mode-1 science is generated within a disciplinary, primarily cognitive, context. It is hierarchical and "homogeneous," and its success is evaluated by disciplinary peers (ibid., 1-3, 33). As to its content, it is merely claimed that it is "the complex of ideas, methods, values and norms that has grown up to control the diffusion of the Newtonian model of science to more and more fields…" (ibid., 167). *Re-Thinking Science* (Nowotny et al. 2001—hereafter RTS), in turn, depicts Mode-1 science as "traditional science," which keeps apart the internal and external forces influencing science, as well as pure and applied science. It aims to be objective, disinterested, context-free, and universal, thereby erecting "the triple myth of One Science, One Scientist, One Nature" (ibid., 111).

In contrast to the discipline-based Mode-1 science, Mode-2 knowledge production is organized around a particular application (Gibbons et al. 1994, 3).[4] It is a conglomeration of five features, the most important of which is the aforementioned feature of being generated in the "*context of application*." Secondly, it is *transdisciplinary*, meaning that it mobilizes different theoretical perspectives and practical methodologies making the discipline-based university structure less relevant in

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[3] It is rather odd that Gibbons et al. 1994 and Nowotny et al. 2001 focus on modes of knowledge production that are claimed to be typical of a certain kind of society—e.g., Mode-1 knowledge production is typical of modernist society, while Mode-2 knowledge production is typical of postmodern society—without any reference to Marx and his conception of the forces and relations of production.

[4] In some passages Nowotny et al. (2001) contrast Mode-1 *science* to Mode-2 *knowledge production*—as if the term knowledge production is more appropriate as regards the Mode-2. This is bound to awaken the suspicion that maybe they are not talking that much about science anymore, but rather an entirely different kind of research, like that performed in the R&D departments of large corporations.

its generation (e.g., Nowotny et al. 2001, 89). The transdisciplinarity of Mode-2 is linked to its *heterogeneity*; it is produced in a variety of organizations, including industrial labs, governmental agencies and spin-off companies. This kind of knowledge production, Gibbons, Nowotny et al. believe, is more *reflexive* in incorporating multiple views as well as being bound to introduce *novel forms of quality control*, which constitute the fourth and fifth specific characteristics of Mode-2.[5]

The question is whether these characteristics of Mode-2 make a coherent whole—there seems to be no reason why all these different characteristics should add up to a constellation having enough stability to be called a new mode of production (Rip 2002b, 104-105). Moreover, in view of the (already extensive) critical discussion on the Mode-2 thesis there seems to be no evidence for the claims concerning its reflexivity and new forms of quality control (cf. the review article on the thesis of the new knowledge production and its reception by Hessels and van Lente 2008). On the other hand, the institutional environment of knowledge production seems to have become more heterogeneous as regards the kinds of organizations producing scientific knowledge (ibid., 751).[6] But has this changed institutional setting really changed the content of science? In particular, has it become "transdisciplinary" and more "contextual" as a result? To get a better grip on this question, more should be known about the alleged Mode-1 science.

2.2 Theoretical modeling as Mode-1 science?

Several critics have questioned the transition thesis on historical grounds, but there are also good philosophical reasons to doubt it. From the philosophical perspective, the various characterizations given to the Mode-1 science smack of an official, though dated ideology of science to which also philosophers have importantly contributed. In the traditional rhetoric, science is typically defended as an institution that aims at

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[5] It should be noted how narrowly the relevance and social contextualization of scientific research is understood by the proponents of Mode-2 as the problems of developing countries or equality and solidarity on the global scale does not even enter into their considerations (cf. de Sousa Santos 2010).

[6] If one looks back far enough even this is not the case: in the early part of the twentieth century, there were more scientists working in non-profit organizations than in universities, and corporate researchers have won Nobel prizes throughout the last century (see Mody 2011).

disinterested and objective theoretical knowledge of the natural (or social) world. The possibility of useful applications is, according to this view, based on the fundamental understanding provided by "basic science." Thus the Mode-2 theorists are right, among other things, in claiming that Mode-1 establishes a dichotomy between basic science and applied science—except that their analysis seems to be based on how science has been justified in past science-policy talk and not on any analysis of the actual scientific practice. Thus the question that needs to be addressed is whether Mode-1 is rather a purposeful science-policy construct than any description of science as it used to be. Namely, it may well be that the scientific practice has not changed as much as the ways in which we understand and justify it.

It is difficult to answer the aforementioned question on the basis of Mode-2, or entrepreneurial university, literature as the proponents of the new knowledge production refrain from discussing the content of science or its epistemic practices, staying firmly on the level of the *organization* of scientific research. Thus if one wants to find a criterion for judging whether the actual scientific practice has really changed radically, one needs to consult other bodies of literature. Indeed, several philosophers and sociologists of science have also espoused claims concerning the transition that is currently happening in science—providing scientific rationales for them, too. Typically, they invoke either the notion of *technoscience* (Ihde & Selinger 2003) or the *distinction between representing and intervening* (cf. Hacking 1983). These two arguments are often presented as intertwined. For example, Carrier and Nordmann (2006) claim that in present scientific research a markedly technological orientation can be observed that has had a significant impact on the objects, goals, and methodology of science (see also Nordmann 2011). Theoretical representation is shifted to the background as scientific research focuses on useful artifacts, properties, and options for intervention. Rather than understanding nature, scientific research aims at shaping it. Although the argument from technoscience and the distinction between representing and intervening are often run together, they need not be. Consequently, I will consider them separately.

2.2.1 Representing vs. intervening?

One way to defend the transition thesis is to distinguish between representation and intervention, that is, to claim that Mode-1 focuses on *representing* the world theoretically and Mode-2 in turn on *intervening* in it materially (cf. Hacking 1983). But can representing and intervening be distinguished so clearly from one another? The first thing to note is that although a division of labor between modelers and experimentalists can be discerned in modern sciences, the natural sciences, as Hacking has put it, have since the seventeenth century been "the adventure of the interlocking of representing and intervening" (1983, 146; see also Radder 2011). Consequently, representing and intervening seem to feed on one another. A second, more genuinely philosophical point is this: Representational practices in science are *themselves* based on various kinds of aims, being more problem-oriented and interventional than what they seem at first sight. *The idea of theoretical activity as that of representing the world truthfully is not necessarily too fruitful a perspective to the actual representational practices of science*. As the recent philosophical discussion on modeling and scientific representation shows, it is difficult to draw a clear-cut distinction between representing and intervening even in the case of theoretical modeling. It thus seems worthwhile to inquire in more detail how several philosophers of science have come to such a conclusion.

The problem of scientific representation has been widely discussed in the recent philosophical discussion on modeling. The majority of philosophers tend to agree that, to give us knowledge, models have to represent their real-world target systems, but the problem is how to account for scientific representation. That is, how do scientific models, which are the primary means of theoretical work in most scientific fields nowadays, relate to their real-world target systems? The earlier, widely accepted view—the semantic conception of theories—provided a straightforward answer to this question. Theoretical models specify structures that are either structurally isomorphic or otherwise similar to the observable phenomena or the underlying structures of the real-world systems (e.g., van Fraassen 1980; French & Ladyman 1999; Giere 1988). It is important to note that such an account of models and representation fits Mode-1 science as described by both NPK and RTS. It legitimizes the disciplinary approach, as the objective of modeling is to represent specific real-world systems as accurately as possible—and representation is based on a privileged layer in the model (i.e., the structure) that corresponds to the structure of some particular real-world target system.

Numerous critics have recently pointed out that the semantic notion of representation does not satisfy the formal and other criteria we might want to affirm of representation (see especially Suárez 2004; Frigg 2006). The problems can be situated in the attempt to analyze representation in terms of a two-place correspondence relationship between a representational vehicle (the model) and a real object (the target system). Apart from the philosophical problems of casting representation in these terms, it seems that the isomorphism requirement is too demanding in regard to actual scientific representations, and the mere similarity, in turn, too vague for epistemic purposes. The pragmatist alternative is to circumvent the traditional problems by making the representational relationship an accomplishment of representation-users. Consequently, what is common among the different pragmatic approaches is the focus on the intended uses of models and the denial that representation may be based only on the respective properties of the representative vehicle and its target object (e.g., Bailer-Jones 2003; Suárez 2004, 2010; Giere 2010). But this has the consequence that there is no determinable relationship between a model and some real target system. It all depends on the aims of the representers, the questions (scientific and other) that guide model construction and use, as well the audiences addressed.

Indeed, largely apart from the very interest in the topic of representation, a new discussion on models has emerged that loosens their epistemic value (at least partly) from representation and considers them as independent objects (Morrison 1999; Morrison and Morgan 1999; Weisberg 2007; Godfrey-Smith 2006). This move has an important implication: Considering models as independent objects requires one to address them as *concrete artifacts* that are constructed in view of certain *epistemic purposes* and whose cognitive value derives largely from our *interaction* with them (Knuuttila & Merz 2009). Consequently, models can be considered as multifunctional *epistemic tools* (Boon & Knuuttila 2010; Knuuttila 2011). In modeling we construct artificial worlds through which we can study various theoretical conjectures (cf. Weisberg 2007; Godfrey-Smith 2006). As artifacts, models are tools for articulating, finding out and bringing about rather than depicting the world truthfully. This artifactual nature of models plays out their interactional characteristics: we learn from models by interacting with them, that is, by building them, and trying out different things with them—which in turn explains why models are regularly valued for their *performance* and their *results* or *output*.

Approaching models from an artifactual perspective has important consequences for the Mode-1 claims. Firstly, theoretical models as well as Mode-2 objects—of which the RTS authors offer the human genome mapping *project* as an example—are the results of problem-solving activities. Secondly, the construction of scientific models is also driven by technological possibilities, and available computational and mathematical methods. And last but not least, a closer look at modeling activities reveals its extraordinarily cross-disciplinary—or transdisciplinary—nature: scientific modeling is driven by general representational tools, computational templates, and modeling methods, which are locally adapted to various tasks, taking into account the specific characteristics of the field of application (see Humphreys 2004).

2.2.2 Technoscience

The transdisciplinarity of modeling relates to that aspect of *technoscience* that is born with generic technologies. They typically have a wide range of potential applications as "new types of technologies … in search of problems" (Jamison 2011, 100). Some of the features of the alleged Mode-2 follow from characteristics of generic technologies. Their transdisciplinarity, for example, can be attributed to the fact that their application to specific problems requires knowledge and skills from a variety of specialists from diverse fields: from those who have the methodical and technological know-how and from those who have the subject-specific knowledge. But if one considers mathematical methods as technologies—and surely the computational sciences are as critically dependent on mathematical methods as on digital computers—it is easy to see that this kind of transdisciplinarity has been part of theoretical modeling since its mathematization. For example, the developers of mathematical economics and biology in the nineteenth and early twentieth century adapted formalisms and methods from physics by way of analogical reasoning—in this process the pioneers of mathematical economics and biology thus needed knowledge, apart from economics and biology, also from physics, chemistry, and mathematics (see e.g., Mirowski 1989; Israel 1993)

Apart from providing scientific research powerful *tools*, novel technologies and methods constitute also new *objects* of research. This is one reason why some proponents of technoscience have supposed it to be more instrumental than the earlier theoretical understanding. This supposed instrumentality of technoscience, coupled with the problem-orientation of engineering sciences have led Mode-2 theorists to assume that the new mode of knowledge production will generate new kinds of theoretical structures and research methods (e.g., Gibbons et al. 1994, 168). In the light of engineering sciences, this conclusion seems, however, too hasty. There need not be any difference, in principle, between the scientific approaches taken towards either the man-made artifacts or the natural objects and systems.

Novel engineering sciences, like information technology, nanotechnology and synthetic biology, are the pet sciences of Mode-2 and technoscience theorists. They, like engineering sciences in general, aim to produce new artificial or synthetic entities or parts—or control, intervene or prevent some properties of materials or behaviors of processes and devices (Boon & Knuuttila 2009). However, to do so, engineering *scientists* build various kinds of models, ranging from mathematical models and simulations to synthetic models. Theoretical models in engineering sciences allow for reasoning about artificial objects or instrumentally mediated interventions in the world, for instance about how to generate a material property, how to make an efficient process, or how to avoid an undesirable phenomenon in a device. These models involve hypothetical properties and processes, and they incorporate measurable physical variables and parameters. Usually, they also include some dimensions, or materials, of typical configurations of certain systems (cf. Boon & Knuuttila 2009). Often, the devices, processes, or materials investigated do not yet exist, but must be created, by using models as epistemic tools in designing them. What is important to note is that in their modeling endeavors, the engineering scientists are studying phenomena in much the same fashion as other natural scientists do.

A classic example from the early nineteenth century is how Sadi Carnot (1986[1824]) translated the functioning of heat engines into a theoretical problem concerning the phenomenon of producing motion by heat. The Carnot model of an ideal heat engine led to conceptual novelties and contributed to the subsequent development of thermodynamic theory. Thus scientific research pertaining to the functioning of devices need not be fundamentally different from what is commonly understood as "pure" or "theoretical" natural science (cf. Knuuttila & Boon 2011). The scientific goals of engineering sciences are usually related to concrete problems with what is in accordance with Mode-2, but within scientific practice this amounts to theoretical modeling of a phenomenon, which aims at understanding it scientifically in view of the original goal. Also, the construction of artificial or engineered things may be theoretically motivated, as the new practice of synthetic modeling shows. In the field of synthetic biology, researchers engineer genetic regulatory networks from genes and proteins, embedding them into a natural cell environment to study whether and to what extent biological systems work in the same way as engineered artificial systems do (Loettgers 2009; Knuuttila & Loettgers 2011). Accordingly, some synthetic biologists have described their approach as "basic science through engineering" (Cookson et al. 2009).

In sum, above I have discussed theoretical modeling, which should, *a priori*, be among those scientific activities to which the Mode-1 label most closely applies. Recent philosophical discussion has, however, revealed many such sides of scientific modeling that are considered as Mode-2 properties by the advocates of the new production of knowledge. Moreover, there is no principled difference between the theoretical activity of engineering sciences and natural sciences (given, of course, that there are sizable differences among different scientific disciplines and fields already among natural sciences). Next, I will continue questioning the Mode-1/Mode-2 divide by inspecting what seems like a perfect exemplar of Mode-2 commercialized research through an empirical case study from the field of language technological research.

2.3 Language technology as Mode-2 science?

Language technology is one of those practically geared and application-oriented areas of technological research that most clearly shows Mode-2 characteristics. Language technology studies and develops methods of natural language processing: its numerous application areas include computer-assisted language learning, machine translation, machine learning, information extraction and speech technology. The field is markedly transdisciplinary in that it makes use of knowledge and know-how from computer science, electrical engineering, statistics and linguistics, gathering together researchers simultaneously from both academia and the commercial world. In addition to new ideas, well-functioning tools are also traded within this instrumentally oriented research community, which shows that it has even developed new means of quality control other than peer review of academic articles.

The following story of the commercialization of one particular language-technology research group operating in a public comprehensive university in Finland exemplifies many problems of commercialization. Most important, however, for the argument of this paper is that in the process of commercialization the members of the group were forced to reflect upon what constitutes scientific research proper, and what does not. Interestingly, even in this area, the researchers thought that some lines of research were more basic than others, and that some tasks were mere application that had, despite many practical challenges, no real scientific value. Thus even inside what seems like genuine Mode-2 research, one can discern a strand of more innovative basic research that is not so clearly bound to specific contexts of application. Yet the central claim of the proponents of Mode-2 is that it has overcome this kind of distinction between more basic or fundamental, and more applied research.

3. The contradictions of commercialization

By the end of 1999, the author of this article contacted the co-leader of one Finnish language-technology group, which had, already since the 1980s, been specialized in developing multilingual language-technology tools. The group had been very successful in both academic and commercial terms: it had done cutting-edge research in the field of language technology for two decades, simultaneously spinning off three firms from out of its research. Two of the three spin-offs were still in business and doing relatively well. The professors in charge of the group were (and still are) ardent spokespersons for the entire language-technology branch, not only in Finland, but across the entire Nordic region.[7] Thus the language-technology research group was supposed to provide a prime example of entrepreneurial science in combining an ambitious academic research program with commercial success. However, the author soon learned that the group had only recently broken up, as many of its major researchers had left academia. So, instead of trying to discover the recipe for the previous success of the language-technology research group, the task became that of analyzing what went wrong and why. From the interviews, informal discussions, and diverse documents emerged a narrative of the language-technology research group that saw its academic path erode as it became more commercially successful.[8]

3.1. The beginning of commercialization

The language-technology research group in question started commercializing its research from its initial infancy in the 1980s. This development was largely a direct consequence of its research agenda. The empirically based approach of the group towards developing language-independent theories and tools, specifically in the management and analysis of unprocessed text, bred important early applications. These breakthroughs, particularly in computational morphological disambiguation, instantly propelled the group to the center of attention, with orders from large Finnish companies and government offices, which needed new language-technology applications, especially word-processing tools. These orders were managed through the department's administration and written in the form of formal research contracts. The resulting money and equipment were more than welcome in the department, which had, like many other small departments in the humanities, constant problems in gaining funding for its activities. Nonetheless, the department had some difficulty in fitting the extra income gained from the contracts within its yearly

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[7] Before the late 1990s, practically all language-technology companies founded in the Nordic countries were of Finnish origin. Their origins can, in most cases, be traced back to individual researchers or research groups at Finnish universities (Arppe 2005).

[8] The data utilized in this case is gleaned from documents over a time-span of nearly twenty years, including research proposals and reports, publications and external evaluations. Moreover, twenty-four interviews were conducted in 2000 and 2004. The interviews were semi-structured and lasted typically from one to three hours and involved members of the language-technology research group, employees, as well as owners of spin-off companies. The analysis is also informed by research field notes on the informal discussions with various actors in these institutions.

budget, as no clear procedures existed for chargeable service and research at the university in those days. Simultaneously, the professor who led both the group and the department began to think that the commercial orders they received had nearly nothing to do with scientific research. In his opinion, the personnel at the university was expected to do research rather than to engage in commercial activities:

> It was sort of selling. Those contracts were not genuine research contracts in the sense that we would have needed to do research to execute what stood in them. In fact, we just sold programs that were already made here. […] Of course, some configuring work was done.

Eventually, in 1987, the professor and the principal researcher of the group (who later also became a professor in the same department) decided to establish a company into which all commercial activities were transferred. The company grew rather slowly in the beginning, relying on projects of diverse kinds for which it hired researchers from the department typically for a few months at a time. In the mid-1990s the company started to grow faster due to large contracts with a big international information-technology company. However, as a result of this commercial success internal tensions started to grow within the group owing to disagreements concerning the ownership of intellectual property and the allocation of academic credits.

3.2. Balancing academic credits with intellectual property rights

One of the ways in which the tension between the two institutional orders, university research and commercial activity, broke out in the case of the language-technology research group was related to the characteristic ways the two activities categorize their achievements and "ownership." Whereas the origin or "ownership" of ideas in science has traditionally been indicated by credit given to colleagues, the more formally defined intellectual property rights indicate ownership in business. In business, property ownerships convey to the owner both the exclusionary right, that is, the right to exclude others from using his/her property, and the right to appropriate economic returns (Owen-

Smith 2006).[9] In contrast to property ownerships, scientific articles do not have such exclusivity and others can use your findings to further their own research. The more others use your results, the more you are likely to get references, credit—and research money. On the other hand, in science there is usually no monetary cost involved in giving others credit.[10]

In the case of the language-technology research group, the disagreements concerning the economic rewards were due to the generational shift in the research done in the department. As the research program of the language-technology research group advanced it succeeded in acquiring, on a consistent basis, significant amounts of external research funding, including some big international research projects. To execute them the group hired several young scientists who licensed the programs they developed in the academic projects to the company owned by the professors. Soon the younger generation began to think that their contribution to the economic activities of the professors' company should have been institutionalized in the form of shares of the company. Despite some preliminary negotiations, this did not happen, which created a poisoned atmosphere within the group. The younger generation attributed the reluctance of the professors to accept them as shareholders to their inability to recognize that, despite their pioneering work, the technology was no longer the fruit of the professors' research only. Thus, interestingly, the disagreement on the distribution of the commercial benefits also unleashed a latent struggle within the group concerning academic priorities and credits: the professors' assumed priority as regards the research done by the language-research group was contested by the younger generation in their research articles. Firstly, the younger generation was eager to single out predecessors for the professors' "original" innovations and, secondly, they delineated some other forerunners to their own work than that of their professors.

The disagreements relating to academic credits worsened as the professors' company started to market the licensed programs as if they were developed in the

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[9] Interestingly, in a private conversation the other professor (who was also the other owner of the spin-off company) said that in his opinion commercialization in their branch no longer has any societal service function of making something available to the market, but rather that it is solely based on excluding and hindering others.

[10] Of course, this does not mean that the exchange of research results and ideas would be open in academia either. It is often hindered by academic status competition (cf. Vallas & Kleinman 2007).

company. The field of language technology gathers together researchers both from the university and the commercial world. Apart from new ideas, also well-functioning tools are all highly appreciated and traded within this instrumental community (cf. Mody 2006). However, as the company sold the programs as if they were developed by the firm and not by the researchers of the department, the researchers felt that they never received academic credit for them. The roles of younger faculty in developing the technology utilized by the professors' firm remained partly unrecognized, even in the academic context. The situation was described by one of the younger researchers:

> We travelled abroad a lot in those days and nearly every time we presented our work, we were asked how our work was related to that of [the professors' company], that is, didn't [the company] do it much better…. [W]e were thus not given the credit we deserved.

The members of the group faced a rather fundamental question: how should the economic rewards of collective research be distributed? As there were no clear answers to this question, the disagreements escalated to involve the academic priority and credit as well.

3.3. The erosion of the successful research program

Apart from the strife over intellectual property rights and academic credit, difficulties were also brewing on other fronts. After a long period of academic and commercial success, the department received, in the late 1990s, a very disappointing research assessment evaluation. The evaluation report stated that:

> Given the high degree of excellence that the department achieved in the eighties and early nineties, the results for the period covered by this evaluation are disappointing. Considering the level of support and the number of people involved one would expect to see more interesting results and more scientific output.

The evaluators were worried about the impact the commercial ties were having on the kinds of research being conducted and the overall research focus of the department. In their opinion, there was a real danger that the group's initial success in commercialization was shifting the research focus from "scientifically interesting but 'difficult' issues to problems whose solutions might be more financially rewarding"—although they admitted that the commercial success of the methods developed "validate the value of scientific work." Moreover, they were also worried that the "presence of competing commercial interests in the same department gets in the way of a free exchange of ideas." Indeed, the exclusiveness of commercial property rights and the related secrecy do not fit well with the academic norm of open communication. In this respect, the situation faced by the research group was further complicated by the fact that, frustrated with their exclusion from the professors' company, the younger generation set up a company of their own in 1997. This created a secretive atmosphere also *within* the group, which the other professor put in the following terms:

> For some years already we have had the problem that the whole truth has not been laid out on the table either in our internal discussions or in our publications. [...] It is a big ethical problem, indeed. How much can you hide—and still act as a credible academic researcher [...] ?

A disagreement concerning one doctoral dissertation provides a telling example of the contradictions the researchers of the group encountered while simultaneously trying to fulfill the requirements of both academia and business. The doctoral candidate in question belonged to the group of younger researchers who had established their own company. He was accused of being intentionally vague in describing a new parser he had been developing. The university grading committee made the following remark concerning the thesis:

> XX [...] has on some important points, especially when it comes to algorithmic descriptions and design principles, refrained from the

> scientifically detailed descriptions that would have been desirable. This is contrary to the principle of openness that is central to science.

In the interview, the doctoral candidate in question explained that he had only acted in a way that had become a departmental convention.

As for the other worry of the evaluators—the apparent turning from the "difficult" issues to the easier but financially more rewarding problems—the professors themselves started to consider that their very success in gaining external funding also contributed to the eventual erosion of the successful scientific research program. They argued that external grant requirements exerted strong pressure on researchers to meet grant objectives, and the numbers of projects that the researchers of the department were simultaneously involved in prevented fresh and innovative initiatives. As the other professor noted:

> I am a bit worried about this development [towards commercially motivated projects]: money pours in of course, and the students get funding, but these projects usually have rather short time spans and concrete problems, which need to be solved in one way or another. One danger is that PhD theses are not finished, but that what is being done is usually beneficial for somebody, but does not really add to the academic competence of the younger researchers.

Last but not least, the evaluators also shared some of the fears of the faculty who, since the early 1990s, had been complaining about the narrow focus of the Department of General Linguistics, where the language-technological research took place.

3.4. Convergent Cultures

Consequently, as time passed, the combination of academic research and commercialization became problematical from the perspective of academic research and teaching, which started to become increasingly compromised and skewed towards the aims of the commercial activities. Indeed, studies on the university-industry interactions have highlighted the increasing institutional convergence between the two (Vallas & Kleinman 2007; Owen-Smith 2006; Kleinman & Vallas 2006). As Vallas and Kleinman pointed out, this convergence is asymmetrical in that “the market pressures and entrepreneurial practices increasingly pervade academia, even as university-like codes and practices are adopted by science-intensive firms” (2007, 7). Interestingly, because of the academic interests of the actors involved, the intermingling of academic research and commercialization in the case of the language-technology group did not work well from the perspective of commercial activity either.

The advocates of entrepreneurial university and innovations systems often seem to assume that innovative academic research spawns good commercial products. However, the development of the entire language-technology branch in Finland shows the naiveté of this kind of thinking. Turning academic research into viable commercial products is both time and resource consuming, and there is the likelihood that advanced technology might not necessarily be a unique selling point—which is well illustrated by language technology. Firstly, language technology provides no such fantastic visions for luring in venture capitalists as, for instance, biotechnology does. Secondly, it is an embedded technology that is not visible to most of the end-users. Thirdly, the market for the language-technological tools is dominated worldwide by one big company, and fourthly, the products are easily reproduced and copied. Also, the small size of the companies within the Finnish language-technology sector and the fact that the entire industry was based on spin-offs from university research caused problems.

As regards the prospects of combining academic research with commercial activity, academics might—in addition to policy makers—place too high hopes on it. Most of the academic owners and employees of the two spin-off firms admitted in interviews that they had a more optimistic vision of how to sell the programs developed than what turned out to be the case. The younger researchers who set up their own firm indicated that their intention was to continue academic research in tandem with managing the company. However, they discovered that this was practically impossible. The former CEO of the younger researchers’ company reflected upon the lessons learned:

> Innovation is just a tiny piece of a certain product, and that again is just a tiny bit of the whole process of getting the product into the international market and to be able to also sell it there. The programs made by the university researchers are not ready, to say the very least. We were more optimistic about that in the beginning. But the needs of the users are so different. […] Because of this it is not conceivable that—making marketable products—would be done as a secondary occupation in the academic world.

In addition to their small size, and lacking financial support, the academic company culture of the spin-offs proved to be commercially unproductive. When in the 1990s the company owned by the professors was expanding heavily, the managers who were recruited from the business sector discovered that the culture of the spin-off company was too heavily bound to the values of academia. One of the former chief executives of the professors' company complained about the perfectionist attitude of the employees—who were recruited from academia—as well as about their "slight contempt" for simple commercial tasks. A former sales manager of the professors' company summed up the contradiction between academic research and the needs of commercialization in the following way:

> When the company started to grow out of its earlier research-group-like guise in the 1990s, *we found out that the interests of research and those of the company were not necessarily congruent*. […] Those things that were "hot" in academia, like speech technology, were still far from anything that could be commercialized, and things that would have been easily converted into marketable tools, such as terminology extraction and spell check, were no longer considered interesting on the research side. [11]

[11] This was because they were considered as "solved problems" which had advanced to the "engineering phase" of "small incremental advances," as one of the interviewees put it.

These differences in aims became apparent when the company started facing commercial problems during the *Dot-com Bubble*. It had invested too heavily in developing speech technology which, in retrospect, turned out to be overly optimistic (given the state of speech technology by that time). Moreover, the professors, who still sat on the executive board, were reluctant to dismiss personnel, which consisted largely of their former students. Thus, the company became financially strained and was eventually sold off to a larger corporation, in which merger the professors withdrew themselves from business activity. On the other hand, at the end of the 1990s, the key younger researchers—somewhat unwillingly—gave up their academic careers and moved to work for their newly formed company. Practically speaking, this meant the end of the language-technology research group. Consequently, the conflicts ensuing from hybridizing academic work with business were resolved by separating the two activities from each other.

3.5. The prospects of commercialized Mode-2 science?

From the perspective of the transition thesis, the development of the language-technology research group ran oddly against the tide of the official research policy: the group began its commercialization process long before the widespread notion of academic capitalism gained common currency in Finnish academia, and the group dissolved in an entirely different institutional context in which the outspoken science policy was to enhance the commercial application of the academic research. The group faced many problems that the existing literature on commercialization of academic research has investigated, like the issues concerning the openness of scientific discussion and the concentration of the research on commercially relevant projects. Commercialization also proved to be harmful to the scientific collaboration among the researchers of the group. From the commercial point of view, on the other hand, the experiences of the language-technology group cast solid doubts concerning the commercial viability of university start-ups. The question that must be asked is whether academics can be considered the right actors for business activities, given their characteristic interests and motivations (cf. Göktepe-Húlten 2010; Gulbrandsen 2005).

What seems interesting regarding the Mode-2 contentions is how the members of the language research group faced, at various stages of the commercialization process, the problem concerning which parts of their language-technological development could be counted as genuine academic research. Firstly, the very establishment of the first spin-off was due to these kinds of considerations. Secondly, the strong commercial orientation of the group led to the erosion of the quality of research, as more commercially or financially relevant problems were chosen instead of more scientifically motivated ones. On the other hand, the problem of the spin-offs was their overly academic orientation: the researchers-cum-entrepreneurs were *still* more interested in developing high-tech tools than in developing marketable products. The language-technology group attempted to straddle two competing ends: While academic research in the field of language technology focuses on novel theoretical ideas, original solutions and the principles of a "good way of doing things," in the commercial world, the emphasis is placed on usability, supplementary services, and existing demand. No new mode of knowledge production, not to mention "entrepreneurial science," emerged from the attempts of the group to engage simultaneously in the two activities. Instead, the researchers of the group, more or less reluctantly, ended up choosing either academia or business.

The commercialization of the language-technology research group also provides a good example of how simplistic it is to suppose that scientific research could primarily take place in the context of (commercial or other) application. Innovations can take a long time to mature and the crucial inventions behind them are often made well before the technical, not to mention the commercial, possibilities of utilizing them even exist. As a corollary, the future applications of scientific discoveries are often unexpected. For instance, the two-level morphology, on which a large part of the commercial activities of the language-technology research group was founded, can be traced back to the generative model of the phonological structure of the English language, developed by Chomsky and Halle (1968), and to the discussions on general modeling of phonetic or phonological structure (Jakobson et al. 1952). Moreover, the whole branch of language technology would not have existed without digital computers—and the kinds of computers also make a difference. Namely, the language-technology research group was established at the beginning of 1980s when personal computers were still a rarity. The technology they were developing made use of multi-programming operating systems with virtual memory in a university setting, which was—at the beginning—a serious obstacle for its commercialization. It took more than ten years for the research group to turn the two-level model into a substantial commercial income because the first operating system that allowed for running multiple applications with genuinely flexible and sufficient virtual memory spread broadly to the consumer market only with the introduction of *Windows 95*.

Already a decade has now passed since the dissolution of the language-technology group. The language-technological research at the home department of the group has moved on. The spin-off company of the younger generation stagnated after a promising start, and one central researcher has moved back to the university department from the firm. In the meanwhile also the context of language-technological research has changed substantially: due to Free/Open-Source Software, the domain of language technology appears to be also on the verge of moving beyond the entrepreneurial mode already (cf. Stallman 2002; Freeman 2007).[12] The practices of free and open software development seem to fit better into academia than the imperatives of business activity. It will be interesting to see whether, and on what conditions, anything like that could happen in other, more investment-heavy fields like biotechnology.[13]

4. Conclusion: Whatever happened to Mode-2?

In the discussion on Mode-2 and "the entrepreneurial university", the two have, more often than not, coalesced: the coming of the new application-oriented mode of knowledge seems to be tailor-made for the proponents of the entrepreneurial university. And this happy message has not fallen on deaf ears. However, despite the "Mode-2" policies adopted by many if not most research funding agencies, recent research shows that these policies seem not to have been so effective as hoped for—in particular they have not

[12] To be sure, the availability of free program code was a norm among the academic researchers even before the dawn of commercialization. For instance, the second flagship innovation of the language-technology research group, constraint grammar, never received the international recognition it deserved due to its early commercialization. Though the professors' company distributed it free of charge to research institutes, it never spread as widely, because researchers were not given access to the code.
[13] For a collection of articles on knowledge as a commons in the digital era, see Hess and Ostrom 2007.

succeeded in encouraging a qualitatively different kind of scientific research (e.g. Kurath 2009; Hessels & van Lente 2010; Bartunek 2011). This study suggests some answers to this conundrum. Firstly, a closer look at actual scientific practices shows that it is difficult to make any clear-cut distinction between Mode-1 and Mode-2 knowledge production. The basic problem of "The New Knowledge Production" is that it is not interested in the *content* of science, focusing single-mindedly on the organization of research, thus losing sight of the Mode-2 features in traditional, "basic" research. Even the theoretical practices of science are problem-oriented, interventive, and material—carrying also within them the sediments of their transdisciplinary histories. On the other hand, the case of language technology shows that even in research seemingly undertaken in "the context of application," scientists make a distinction between those more difficult problems that are considered more scientific, and those that are already considered solved on a theoretical level (although their further development comes with its own challenges).[14] Thus although the organizational environment of science has undoubtedly changed, no fundamental *transition* seems to have happened, as yet, within scientific practices regarding their goals, scientific methodologies, and epistemic criteria.

From the philosophical perspective, then, in using the concepts Mode-1 and Mode-2, one should not commit the empirical fallacy of interpreting them as empirically identifiable modes of actual scientific research, which could form the basis of grandiose historical pronouncements concerning the transformations taking place. A more apt reaction would be to interpret the Mode-1/Mode-2 divide as a conceptual distinction that could cast some light on the various processes taking place in contemporary scientific research and its organization. The question, then, is to which extent this conceptual distinction really provides a fruitful analytical tool. On the basis of the combined philosophical-empirical study presented in this article, the Mode-1/Mode-2 distinction is not very helpful in understanding the challenges of contemporary scientific activity. Mode-1 is nothing but a straw man—a science policy construct whose function seems to be that of justifying the vision of science transforming into a more "hybrid" and problem-

[14] Perhaps the term "use-inspired basic research" (Stokes 1997) is appropriate in this context; yet, I wish to take distance from any "essential definitions of 'basic research'" (Calvert 2006, 218) that have become so unfashionable in STS discussion these days. However, the difficulties of defining precisely "basic research" need not lead to the conclusion that the uses of this concept are predominantly molded by extra-epistemic interests, like the quest for authority, or for social and economic benefits.

oriented regime. The idea of Mode-2 knowledge production, in turn, grossly *underestimates* the importance of theoretical understanding even for the application-oriented research. On the other hand, it simultaneously *overestimates* what scientists can do in the short term, and to which extent innovative scientific research can be tightly linked to solving some present practical problems. Thus it is questionable whether the Mode-2 policies based on such a simplified (or simply lacking) analysis of scientific practice can lead to the goals sought after.

This is not to say that Mode-2 policies do not influence academic research—quite the contrary. Mode-2 and related policies have offered governmental and business sectors as well as university administration and various funders a good justification for exerting more pressure on academic research in terms of (short-term) accountability and commodification. On the other hand, universities have also embraced the Mode-2 message in general, and commodification in particular, in their effort to fashion themselves as socially responsible institutions and to renew their financial base. Mode-2 and related discourses launder the status quo by legitimizing the organizational and other changes that are taking place in the name of more "socially relevant" or "robust" research. Time will tell whether this development may eventually lead to the deterioration of the quality and status of scientific research—some signs of it are already in the air.[15]

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[15] Cf. Elzinga 1997; Krimsky 2003.

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