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Running The Marathon

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Abstract

Over the twentieth century universities in the industrialized world have evolved from being "universities of culture" to "universities of innovation." Policy makers and universities themselves see their one of their major roles as supporting industrial innovation and thus economic growth. We argue that this rests on a mis-cconception of the nature of innovation and the value of universities. We argue that a more appropriate function for this institution is as the "university of reflection" where scholarship and truth-seeking are the ultimate goals.

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Universities are delicate organizations, and can be destroyed. Elaine Scarry

Its all very well for you to say that: you have tenure. A junior colleague

I Introduction

Universities, private and public alike, indubitably compete, and in many ways. But over which spoils? There is general agreement that the markets in which they compete are not normal ones: almost no contemporary university pursues profit-maximization as it ultimate goal (Bok, 2003; Kirp, 2003). What, then, is the goal? It's easy to compile a long list of circumstances in which competition is observed: undergraduate and graduate student recruitment, professorial hiring, fund raising, gaining support for research, and so on.[1] In each case it is possible to identify a scarce resource, such as top students or prominent professors. Yet, the competition, usually against other universities, to gain the lion's share of the resource is clearly instrumental. Acquiring neither good students nor prominent professors nor ample funding is the goal of the university; they merely contribute to achieving a superordinate goal. What is that goal?

A standard justification for the public support of the university, or any other institution, is that it provides some public good. If the products of a university could be privately owned and were easily appropriable, it would be difficult to justify public funding. Industrial firms could fund the research output, internalizing the results in their own products. Equally they could fund training, benefiting from the increased human capital of their workers. For example, universities of the middle ages, creatures of the church, provided training that increased the human capital of church functionaries. Scholarly activities were concentrated on the production of goods consumed internally, such as copied and original manuscripts. Alternatively, students could fund the training themselves from higher future earnings, a model common in the professional schools of North America.[2] Consequently, one way to seek the superordinate goal of universities is to ask what public goods they can provide, which cannot be provided in other ways.

There are many possible answers to this question, which have received varying emphasis at different times. We follow the historical arguments of Readings (1996) and Cowan (2006) to see how the answer changed during the twentieth century, only to discover that misconceptions about the unique strengths of the university thrusts into types of competition that could easily be ruinous.

Universities in North America and Europe have, by and large, followed the model of the nineteenth century German university, the model which Bill Readings calls the *university of culture*. Readings argues that Humbolt and the German idealists, who shaped the university of culture, saw universities as primary repositories of a nation's culture. In the university of culture scholarly activity spread into new disciplines, such as literature, which studied, preserved, extended and even created the national culture.

In this model the university creates a unique public good. Fostering the nation's culture, it defines a national identity in which all citizens participate. Educated within the university of culture, future leaders of the nation acquire a common view of the nation, which makes it possible for them to work easily together. The graduates of the Grandes Ecoles in France embody this benefit at its apogee. Their common education creates a distinct social class, the members of which move effortlessly among the leading roles in political, business and intellectual culture. The value of a common culture in facilitating a cohesive nation cannot be overestimated. Specially able students from outlying provinces, where culture is more varied, are drawn toward Paris by the lure of the Grandes Ecoles so as to participate more fully in the common culture of the nation.[3]

The university of culture well describes most of the world's universities into the first half of the twentieth century, and provided a strong reason for central governments to fund them and to coordinate what they taught. Subsequently, however, universities themselves participated in, and sometimes initiated, changes that undercut the university of culture. The rapid growth of science and technology created within the university a large and influential group of scientists, the allegiances of which were, and continue to be, trans-national; graduates of newly founded professional schools of business spread corporations across national boundaries, weakening the monopoly governments had previously held over the culture of their citizens. Finally, the commercialization of culture made it no more or less than any other commodity, to be selected and consumed at will.[4]

Deprived of their role as the repository of a nation's culture, public universities cast about for a new one, and found the support of innovation as their new model, which we call the *university of innovation*. The foundation for this shift was an analysis of the incentives of scientists, which are to be open and to communicate findings publicly; and of the nature of scientists' output: fundamental, widely applicable, and inappropriable knowledge. These ideas combine to guarantee the under-provision of basic science by the private sector, in terms of both funding and outputs. In the middle of the twentieth century, basic research was to be the main activity of the university, and it would be funded to a great extent publicly. After several decades, however, governments seemed to have become disappointed with the results produced by this model: papers in scientific journals or conferences did not translate quickly into product innovation. Thus, a second stone was added to the foundation, which ushered in a more intense era for the university of innovation. This was the idea that laboratory benches of universities were littered with innovations, provided by public funding, which could invigorate innovation in the private sector. The policy problem now became how to get the knowledge or innovations more rapidly and directly out of the university and into industry.

In most cases the cure was seen to be more private participation in the funding of university research, which implied that the measure of university output should be broadened from 'scholarly publication' to include measures of ownable research, such as patents.[5] The result was a further shortening of the time span on which research was expected to produce concrete (aka pecuniary) results. Almost unnoticed in this process was a shift in the proposed mission. In the early years of the university of innovation, universities seem to have planned that they would evolve from repositories of a nation's *social* culture to respositories of the world's *scientific* culture. But as time passed the governments that fund them wished the product of the university, research and innovation, to be appropriable by the nation, and thus tried to tie them closer to the industrial innovation process of the nation.

We should note a certain irony, when this is seen in the European context. An ongoing concern of the European Union is "social cohesion", a target that is written into many of its research programmes. In order to submit applications to the Framework programmes for example, it is often an expicit requirement (and certainly an implicit one) that the consortium submitting should include partners from all regions of Europe. In the latter part of the twentieth century, when social cohesion was again a concern of policy makers, Europen universities could have been recruited to play a modern (European) version of the role that they had played historically at the national level. But partly in response to pressure from the EU itself, universities abandoned this role to take up their new role in innovation. And one is left to wonder where the European social cohesion will come from.

This paper argues that this unfortunate evolution of the university's role during the last half century is a result of misunderstanding the process of innovation, and of mistaking the purpose of research done within universities. This misunderstanding, shared between university administrations and the governments that fund them, induced universities to compete inappropriately both with vocational schools and with industrial laboratories, which engage in activities that occur on much shorter time scales than those of the university of culture. We argue that universities ought to be competing in a much different race than public policy now encourages. Our conclusion is not that competition is antithetical to universities – indeed, it is deeply rooted in university culture (Cornford, 1908) – but that the unique role universities should occupy is subverted when the university is expected to compete in the direct provision of industrial innovation or vocational education. The following anecdotal description of the reactions of universities to a recent survey of their relative standing well illustrates two important points about how universities compete most naturally.

Much of the day-to-day work of a university consists of marking and ranking. Thus, universities feel strongly when they themselves are marked and ranked with respect to one another. Their schizophrenic responses to these rankings tell us much about how universities see themselves.

The recent Shanghai survey (Liu and Cheng, 2005) shows typical university responses to being ranked. Most of the universities that ranked below their self-evaluations (or perhaps self-image) rejected the survey, at least in their explicit reactions, criticizing the metrics and the algorithm combining them into an overall ranking, sometimes even rejecting the possibility that ranking universities is possible, even in principle. Yet their actions belied their words: favourable interpretations of their rankings were placed prominently in their promotional literature, and the hunt was on for Nobel prize winners who would accept an additional position, since adding Nobel laureates to one's faculty was the easiest and fastest way to rise in rank. Thus, in their actions universities indicated a willingness to compete, even as they derided the competition as futile and not even in good taste, and when the rules of the competition were regarded as mistaken.

The critics of such surveys are wrong: competition is not, in itself, bad. Universities should desire to be better, and being judged better by one's peers in Shanghai is quite appropriate. But the process has perverse features. The source of the judgement should not, we all agree, be personal opinion: it should be formed from a collection of objective metrics, so that it has the coercive nature observed to be characteristic of scholarly argument by Nozick (1981, pp. 4–5). But, just as the ranking stands proxy for the quality of the university, the metrics stand proxy for the ranking. As Goodhart (1984) points out, once targets, which are proxies for actual objectives, are known, competitors immediately find ways of satisfying the targets without achieving the objectives.[6] The process is most invidious when the targets are rankings (Hirsch, 1976) because only one university can be number one. Currently, the stated goal of many universities in Europe is to be a 'top European institute', and as one waggish colleague pointed out: 'It is going to be pretty crowded up there at the top.' In a competition for ranking, because the rewards are not commensurate with the effort expended, universities overcommit resources to enhancing their rankings, to the detriment of other, more directly useful, activities.

An extreme reaction to the Shanghai survey occurred in France, where the Grandes Ecoles fared less well, compared to the public universities, than managers in the tertiary education system would have expected. The response was extreme. Because the metrics were objectively measured they could only be rejected as inappropriate. Surely enough, l'Ecole des Mines, one of the Grandes Ecoles, provided a new survey using metrics said to be more suited to French educational objectives (Ecole des Mines de Paris, 2007). Naturally, the Grandes Ecoles had pride of place, even on the world stage. Laughable, perhaps, if you are outside France, but it demonstrates something fundamental about the nature of competition among universities.

Suppose, for example, the Shanghai survey had ranked the University of Waterloo and l'Université Louis Pasteur in the top ten of the world, while ranking Stanford, Harvard, Oxford, and Cambridge below two hundred. Despite the objectivity of the metrics, the reaction of the academic world would not have been, 'What an interesting surprise!' And yet this was exactly the reaction of the financial world when the market capitalization of Google surpassed all firms except Exxon and General Electric. In contrast to the way this sort of news is received in the financial world, had the Shanghai survey reported such a sudden change in status, its results would have been ignored as obviously incorrect, and rightly so. This draws attention to one of the key differences between the world of industry and the world of the university.

Sudden drastic changes in the stature of economic entities, such as firms, is normal because the time constants of the tastes and technologies that determine economic success are short. But similar changes in the relative status of universities is not normal. To be sure, ill-advised policies can destroy the status of universities within as little time as a generation, such as occurred with the university system in Argentina after the 'glorious' era of the sixties. There, uncoordinated policies, political interference and under funding managed to seriously weaken a previously robust system.[7] But climbing the ladder takes several generations, so that the sudden appearance of an outsider at the top of a university ranking undercuts the authority of the ranking more than it elevates the status of the newcomer.

We take two lessons from this example. First, competition for status, the most natural way in which universities compete, easily goes wrong because the yardstick can be mistaken for the quality it imperfectly measures. Status is highly subjective, while the dominance of natural science within the modern public university demands the veneer of objectivity. Second, changes in status occur on a time scale of generations. In contrast to firms, universities are slow-moving institutions. This has to do, fundamentally, with differences in the ultimate motivation of the two institutions: in the first case it is profits, and the search for profitable activities; in the second it is truth, its discovery, elucidation and dissemination. By their very nature, profitable activities change rapidly (especially in a competitive economy) whereas what we believe to be true changes slowly. Institutions must be designed to operate and expected to compete on the same time-scale as their core activities, which for universities is very long.

II The University of Innovation

Readings (1996) suggests that the university of culture is succeeded by the university of excellence. He noticed both the vacuity of 'excellence' and its prominence in the 'zombielike rhetoric'[8] that fills university promotional literature. Readings was writing early in the evolution of the university's role. We suggest that, were he writing today, he would observe the frequency with which 'innovation' is paired with 'excellence' in describing the strengths of universities[9].

'Innovation' *tout court* is, of course, as vacuous as 'excellence', but increasingly it is used to describe the university as a player in the nation's system of innovation. This model of the university we call the 'university of innovation'. We argue that the role assigned the university in this system has two faults, that it misunderstands both the process of innovation and the strengths of the university, and that it thrusts the university into competition that undermines it as a public institution. The argument rests largely on the linear model of innovation and its reorganization by Cowan (2006).

Innovation has often been considered a linear process, summarized in 'the linear model'. In the linear model basic research creates the knowledge on which applied research is founded, and applied research is the basis for innovation in product development. Innovation is a good diffused to consumers in the form of improved products. The innovation process is linear and uni-directional, with one stage feeding the next.[10]

In this model, it is relatively easy to identify the actors: universities provide the basic research; development laboratories of industry supply the applied research; and industry manufactures the products. Proponents of this model identify the various products of basic research as public goods (Arrow, 1962; Nelson, 1959) that are insufficiently supplied by firms acting on their own owing to problems of appropriability. Thus, basic research, the most widely applicable of all types of knowledge, is severely under-supplied by the market, and must be provided publicly. Presumably it is supported by taxes on consumers who, after all, eventually benefit from better and cheaper products as a result of the innovations based on this research. Universities argue that they are uniquely suited to providing basic research: casting themselves as ultimate foundation on which innovation is based, and justifying public funding for their activities. Industry, by contrast, is further downstream in the innovation process: the benefits of its research are appropriable in the form of patents or trade secrecy, reducing the necessity for public subsidy.

The linear model provides a clear framework in which the university of innovation competes: to provide as much basic research input to the nation's innovation stream as possible. Getting basic research across the finishing line is the goal, and measures of success are easy to find, papers published and research prizes received, which are gratifyingly similar to the criteria that scholars freely use to evaluate one another. Equally, the reward for competing successfully is clear, increased public funds to support research.

All is not so smooth, however: many public agencies have been dissatisfied with the difficulty of documenting university-initiated innovation, and industry has complained about its slow pace. Together they have introduced additional goals for the competition, such as patents and explicit collaboration in applied research. In response, universities have encouraged researchers to work more closely with industry and to engage in more targeted research, complete with milestones and deliverables. As a result, university research has moved downstream in the innovation process, where the results of research are more appropriable. This movement coincided with funding shortages, and universities were expected to fund more of their activities by marketing the innovations created in their research laboratories, or by receiving contributions from industry collaborators with whom they share their results.[11] These pressures brought universities a new, and conflicted, collection of competitors, the applied research laboratories of innovative firms, with whom they were simultaneously expected to collaborate. The university of innovation has evolved from providing a foundation for downstream activities that take place in industry, to hosting downstream activities within the university itself.

These changes undermine the university's claim to special status. Research that is patentable is, by definition, appropriable and not a public good. If it is worth doing the value of the patent will certainly exceed the cost of doing it. If the university contribution to an applied research collaboration is worth what it costs, the firm, which appropriates the results, will surely be willing to cover fully the university's costs. Furthermore, there exists a host of consultants offering services very similar to the collaborative services supplied by the university, so that the market puts a clear value on what the university offers.

These arguments feel comfortable if we take the university for a firm: they appear because the university of innovation provides value as a supplier of wealth, justifies itself by claiming that the wealth it creates exceeds the public funds it consumes. Implicit in this claim is the ability to value the contribution of the university, which is done by allocating to it a share of the private good created by innovation in which it participates. But, if this allocation is possible in practice, then this share of the wealth can be provided directly to the university through the market by the consumers of the products to which it contributes. The argument for public funding vanishes, which is not surprising given that the university of innovation eschews any unique role, such as that possessed by the university of culture.

The university of innovation has, however, another output, its students, once they have graduated. Without them, neither applied research nor product development is possible. As supplier of cannon fodder for private innovation, the university competes with vocational colleges and trade schools. Is there an argument that justifies the higher cost of a university education? And is there an argument that explains why the full cost should not be paid by the students who receive the benefit, or possibly the firms that employ them, but should instead be covered by public funds? To answer such question we must look more closely at the university's contribution to innovation.

III The University of Reflection

Not surprisingly, the linear model and the early stages of the university of innovation go well together: basic research is the central activity of the university; the source of research ideas lies within the internal dynamics of the scientific disciplines; universities compete only with each other, on the familiar grounds of refereed papers, citations and scientific prizes; and the goals of competition are the reputations and the self-perpetuation of universities. This is a conservative model of the university, which would be instantly recognizable to Ernest Rutherford or G. H. Hardy. A single added feature makes it modern: consumers, in the form of applied research laboratories in industry, take the ideas created by basic research and turn them into product innovation. The happy result is an economic justification for public funding of the university, and the academic legitimacy of the professor-entrepreneur, who combines the life of the mind with the wealth of a successful businessman.

The previous section suggested one problem with this picture of academic life. As it meets the reality of the market for innovation and evolves towards the later stages of the university of innovation, it is corroded by profit seeking. This section pursues a second problem: the observation of Cowan (2006), Rosenberg, (1982), von Hippel (2005) and others that it simply doesn't fit the facts of innovation. First, the firm is not a passive recipient of ideas generated within the university: as a client in the market of ideas it attempts to pull the basic research it requires out of the university[12]. And second, while basic research may be determined on short time scales by the internal dynamics of its discipline, on long time scales it is determined by unexplained, but seemingly explicable phenomena. Sometimes these phenomena follow the picture book story of the scientist sitting on a hillside wondering why the sky is blue or why a rainbow is curved. More often the phenomena to be explained are the result of technology. That is, basic research is the result, not the cause of technology. For example, in ancient astronomy the observation that patterns in the sky provided reliable cues for agriculture or navigation seems to have come first, with the creation of models to explain the regularities later. Or, more recently, thermodynamics followed high pressure technology in order to, among other things, explain regularities observed in steam tables.

Cowan suggests that the linear model requires two amendments in order to fit these facts. It must be made circular, with the innovation activities of firms, and their customers (von Hippel, 2005), providing an important, even dominant, input to the basic research of universities. Also, the output from the university to the firm must be re-examined: it is not ideas encoded in papers, patents or prototypes, but ideas encoded as the human capital of its graduates. Within a round of innovation, users lead, industry follows, and basic research brings up the rear, systematizing, codifying and understanding what the others have been doing. But for the next round of innovation, universities lead: teaching the basic research of the last round's innovations to their students, who, on graduation, become the innovators of the next round. Thus, the university is indeed an essential component of any system of innovation, not by supplying the ideas on which applied research and then innovation is based, but by supplying an understanding of past innovations to the personnel in whose minds innovation occurs.

How large software systems are developed illustrates this point.[13] Software projects begin with what is known: knowledge that their designers gained through education or experience. On this basis a more or less predictable implementation plan is created. At the beginning the work done by implementers simply follows this plan and is routine. Inevitably, however, misconceptions in the plan are uncovered and parts of it are found to be unimplementable with existing techniques. In addition new or modified features, not easily accommodated in the original plan, are added. These problems are solved one by one, not by a complete reworking of the plan, but by *ad hoc* expedients.[14] This is true innovation and it occurs by trial and error, not by doing research[15]. The result of these innovations, which accommodate changes in the plan, is an increase in the complexity of the software, not matched by an increase in understanding on the part of the implementers because it accrued through one *ad hoc* change after another.

As complexity increases the difficulty of implementation increases, and at a certain point the project stops: an improvement in one place makes, by an interaction no one understands, a problem in another. Usually, features are subtracted from the plan until it is possible to declare that the product is complete, at which point it is released, often with the promise of an imminent upgrade or service pack that will fix outstanding problems. In the software industry there are many methodologies, such as frequent refactoring, that are supposed to remedy such problems. But the real solution is what universities do well, undirected rethinking, in other words, reflection.

That is, the best solution is to think deeply about the particular troublesome software, and software in general: examining existing *ad hoc* solutions to differentiate aspects that are fundamental to providing the functionality from those that are adventitious, discovering commonalities of function among modules, and creating a controlled incorporation of the functionality within a modified design. This is what university research, professor and graduate student working together under minimal pressure, does best. When the student graduates he or she has the understanding needed to proceed in a controlled way to the next version of the software, which will subsequently be pushed into a similar state of uncontrolled complexity, and require another passage through the university.

Unfortunately, this cycle is too slow for industry in the twentieth century. Cowan (2006) describes a senior manager responsible for university-firm interaction at a major North American computer firm. The manager was clear that he invited professors into his firm, not to solve his current technical problems, but to interest them in his firm's probable future problems. Most likely, he was looking for faster ways of pushing problems that his firm would need to understand into the university and receiving back graduated students with the expertise to solve them. He may, however, have been pushing on a string, because separating the enduring from the transient, which is an important goal of reflection, cannot be hurried.

Cowan's, seemingly minor, changes to the linear model have profound consequences for the superordinate goal of the university, for the time scales on which universities change, and for the markets in which universities can compete. To understand this let us look closely at how universities transform the input they receive from innovating firms. The relational database is a typical example. In the 1960s E. F. Codd, working for IBM, developed a new type of database, the relational database, which remedied many problems of earlier navigational, or codasyl, databases. This was the first database design sufficiently formal to draw significant interest from researchers in universities, which were then in the process of forming departments of computer science. Unwilling to cannibalize an existing, market-dominating product, IBM moved slowly in developing a relational DBMS[16], so that during the mid 1970s IBM and its rivals, including Oracle and Sybase, brought relational DBMSs to market. Academic research developed in parallel, the first regularly-scheduled database conferences starting in the mid to late seventies, a decade after Codd's work. University research did not, however, feed ideas to industry where programmers were struggling to implement DBMSs, which were arguably the biggest and most complex software artifacts of their time. Instead[17], professors made themselves familiar with the relational model, by proving theorems, generalizing algorithms, extending the relational model, teaching database courses and writing textbooks. By the mid 1980s database courses based on the relational model were in the final year of most computer science curricula.

The result was a flood of graduates. They provided the configuration and end-user programming expertise needed to configure DBMSs; they were the programmers implementing, and debugging, DBMS implementations, and they were the applied scientists adding novel features to DBMSs. These graduates are the primary input from universities to the innovation process, the critical input that universities provide to innovating industry and its customers. This is a typical example of universities supporting innovation, but not by creating innovations that are then pulled out into the world by industry (or pushed out by technology transfer offices), as the university of innovation would have it. Instead, universities *reflected* on an innovation produced elsewhere[18], understood it and pushed that understanding into the world in the human capital of their graduates.

Reflection covers many scholarly activities. It centres on understanding by rethinking: scholars create simple causal models through which they understand phenomena; they do experiments to test and refine their models; they create metaphors and analogies that allow them to communicate their understanding to others, first to colleagues through seminars, then to graduate students through research collaboration, and finally to undergraduate students through lectures.

It is possible to observe how the university of reflection interacts with industry to further innovation at different stages. An early stage example is reputation systems. Less than a decade ago e-Bay, in an attempt to induce cheating traders to leave its community, created an *ad hoc* online reputation system: participants in transactions were asked to rate other participants, and the aggregate ratings were publicly visible. Interested by the contrast between face-to-face and online communities, scholars became curious about online reputation, and began to ask themselves questions: What is reputation? How is reputation enhanced or spoiled? Can online interaction produce the complex interactions that subserve face-to-face reputation? Can we by experiment show that e-Bay's reputation system works?

Currently this research is embryonic: precious little understanding has so far been created from the dozen or so investigations by graduate students and professors. But two important lessons are clear. First, most of this research is truly basic. It is not competing with e-Bay to patent the killer reputation system, because its goal is understanding. And second, no one knows at present whether online reputation is a fundamental concept or a passing fad. The long view of universities, passing online reputation from research to graduate teaching to the undergraduate curriculum, takes time. It can be, and will be, aborted if its central concepts turn out to be neither fundamental nor fruitful.

A final example shows the innovation-understanding-innovation cycle occurring twice. A recent paper by Talbot (2003) argues that Renaissance artists probably discovered perspective by noticing the illusion of depth in patterns used to compose pictures on the image plane. This innovation in artistic practice, developed by trial and error, produced a revolution in realistic depiction. Alberti and Brunelleschi, reflecting on these practices, then found analogies that gave simple explanations of how they worked. These models were not for the benefit of their contemporaries who had already mastered drawing the illusion of depth. They were for teaching non-artists and future artists. And indeed, they are used in first year drawing classes. During four centuries the models were also formalized and elaborated by university mathematicians into a highly abstract subject: projective geometry (Coxeter, 1987).

Then, in the 1970s scientists, mostly in government and industry laboratories, put projective geometry to work as the mathematical foundation of the computational geometry required by three-dimensional computer graphics. The source of this innovation was the mathematics courses they had taken in university, which enabled them to create algorithms to do geometry. The algorithms have subsequently been reworked within the university and are now part of the undergraduate curriculum in computer science. Graduates of these programs are, mostly in industry laboratories, creating innovations that flow back into universities in the games played by incoming students.

Notice that competition occurred twice, when artists competed to acquire more prosperous patrons through innovation, and when firms competed to bring three-dimensional computer graphics to the market. Within the *reflective* component of this cycle market competition did not occur. To be sure, Alberti and Brunelleschi competed for readers and future reputation, just as professors compete for publication and recognition, but this competition bears little relationship to the competition in which the university of innovation gets stuck (Kirp, 2003, p. 2).

Considering this final example, we note that the second round of innovation was not initiated by professors of projective geometry. They did not feel any urge to push projective geometry out of the university into innovative products. Yet, without the algebra they created in their quest for understanding, and without the courses they taught, the quick development of three dimensional computer graphics would have been impossible. To be sure, once innovation had taken place professors of mathematics tried to jump on the bandwagon, offering software packages and textbooks taking advantage of the formal simplicity of their subject. However, the conceptual clarity sought in basic research turned out to be quite different than the efficiency and quick results necessary for innovation.

The above examples show that the university of reflection values basic research differently than the linear model and the university of innovation. In it basic research follows innovation and the domestication of innovation by basic research is essential not for the innovation of today, but for the innovation of tomorrow. Innovation is not the direct application of basic research, but the indirect result of graduates applying basic research stimulated by previous rounds of innovation.

With basic research a part of scholarship, which is subordinated to education, universities of reflection compete only with each other, and on the grounds of reputation, reputation for the quality of the environment they provide to professors and students and for the public goods they supply as they work together to increase understanding. This competition is highly subjective: its results are found in the collective opinions of professors and students. Attempts to make the competition objective are both self-defeating and distorting. Competition with entities that have different goals and different time scales, such as firms that create innovative products, simply makes no sense.

IV Scholarship as a Public Good

The sections above identify the modern university's superordinate objective as support of innovation, which is appropriate for a society that values economic growth highly[19] and that identifies innovation as the source of growth. They argue that the university of innovation, which is currently the most popular model of the university's role, and which has been used to justify expansion of the university's basic research during the last half century, is based on a misunderstanding of the nature of innovation, and of the university's role in it, and the university of reflection better describes the important role of the university in innovation. Probably the most important practical difference between the two models of the university is how they compete in the marketplace for innovation.

The university of innovation competes in a market of product-relevant ideas with other sources of innovation, most of which are private firms. The university's claim on society is determined by its success at producing marketable ideas. The success of this model creates pressure on the entire university to live within a market for ideas. Literature departments, for example, which were central in the university of culture, market courses in technical writing. And to justify their placement in a university, as opposed to a vocational school, technical writing must be a 'fast-moving field', taught by professors who have research programs in technical communication. These departments are, *ipso facto*, undermining their claim to any activity that has no immediate value in the market.

Similarly, philosophy departments offer courses on the ethics of business. These courses, which teach prospective businessmen how to reason about ethics, are an indubitable social good. But they force philosophers to compete in a market that includes management consultants and motivational speakers. The clients, executives and budding executives, choose whom they will patronize. All too often the clients' interest in ethics is purely instrumental: how ethics contributes to the success of their businesses.[20] When philosophers succeed in such a market they contradict the intuition that philosophers are a better source of ethical guidance because their advice is disinterested. Even worse, the necessity of competing successfully with management consultants corrupts philosophy itself. Why?

Truth is a core value of philosophy: statements uttered without regard to their truth or falsity do not belong to philosophy. In a market for ethical advice clients are the masters, they have market power to demand whatever advice they wish. Philosophers can compete successfully in this market only if they let the clients' demands take priority over other values, including truth. To be sure, what truth is, as opposed to what is true, can be a matter of contention. Many philosophers (e.g., Rorty, 1979) think it is more complex than the simple Platonism of most natural scientists. But all members of the university regard truth as an indispensable value: it is even worth arguing over the truth of theories of what truth is. In the university of reflection, 'It doesn't matter whether what I write and teach is true or untrue, as long as it gets me tenure,' is simply unacceptable, and rightly so.

Truth both trumps all, and is inappropriable. When firms fall into dispute with universities the appropriability of truth is usually the key issue, and when firms succeed in appropriating truth the result is unfortunate for the university. Cowan (2006) reviews two cases in which satisfying its clients in a highly competitive market brought universities into conflict with their own fundamental values. These cases are unique only in being unusually well documented. A host of editorials in biomedical journals testifies that the problem is widespread. It should not be a surprise to find universities subverting their own values in competing to supply ideas to industry: clients expect to dictate the nature of the product they receive.[21]

One might asks why it is important at all to have some institution worried about truth. Whether or not it is important in some objective sense, in any society it is possible to find some institution that sees "takingcare of truth" as its role. Astrologers, priests, withc-dogtors, gurus of various types, and scieintists, have all played that role in some time or place. If no institution is charged with this task, it does create a vacuum that will be filled in some way. In the west, the university has been given this role over the past several centuries, and one could argue that it has coincided with tremendous progress, not only in science, but also in humanism. One must ask in response, if the universities are denied this role, are we willing to live with the consequences of it being taken up by we know not whom? This is not an idle question.

It is the nature of teaching that causes the university to value truth. Universities and vocational schools offer different sides of the commitment each generation makes to the next, the university promising, 'We will teach you what is true,' and the vocational school promising, 'We will teach you what is useful.'[22] the university fulfils its promise by expecting every professor to pursue truth in scholarship, which is the traditional activity of the university. It is a more encompassing concept than research, including all the activities that integrate new truths with old, separate deep central truths from evanescent details, and make truth systematic and teachable.

How scholarship responds to revolutionary ideas in science, the most extreme form of innovation, demonstrates in sharp relief the moulding of innovation in the hands of scholarship. Episodes of true scientific revolution (Kuhn, 1980) occur rarely. The ideas they generate are, almost by definition, inaccessible to the community in which they arise. Yet within a few generations they spread within the research community and become the subject of normal science. How does this occur? Scientists teach the new ideas first to themselves, then to their research students. In doing so they rework formalisms, simplify models, add features and do experiments that test their work, all aspects of basic research within normal science. And the process does not stop there. In subsequent generations, the once revolutionary ideas continue to be reworked again and again, simplified as adventitious aspects are shed, systematized as commonalities are noticed with other ideas. This reworking tames the ideas as it makes them teachable: they move progressively earlier in the education of a student.

The differential calculus is probably the canonical example. What took Newton and Leibniz two lifetimes to 'learn' can now be taught in fewer than a hundred hours to many eighteen-year-olds. Three centuries of scholarship, including both basic research, which created simple proofs and notations and that extended greatly the original theory, and also pedagogy, which developed texts, curricula and teaching strategies, made this possible. Knowledge of calculus among scientists and engineers is now responsible for most of the technology that pervades all aspects of modern life. This extraordinary achievement is a triumph of the university as an institution: hundreds or thousands of researchers and teachers systematized knowledge, building in small increments on each others' work to make possible more effective pedagogical practices. It only occurs in the university of reflection. This is normal science, not well-rewarded in the university of innovation, but at home in the university of reflection and as essential as the initial discovery. Furthermore, the process is never complete.[23] Calculus is currently moving from early tertiary to advanced secondary curricula, and the search continues for better ways of codifying it. Throughout this activity the tension between simplicity and truth, which cannot be compromised, is typical, as in all scholarly activity.

Revolutionary science can occur anywhere: Newton, to be sure, was a professor, but Leibniz was a courtier. At the same time, Boyle worked in his country house, and Hooke in the Royal Society. And lest it be thought that this dispersion is obsolete, consider the twentieth century: relativity was discovered in a patent office, quantum mechanics in universities, the transistor in an industrial research laboratory, and the computer in government laboratories.[24] In all cases, however, it was scholarship within the university that took revolutionary concepts, available to few, and created from them simple causal models teachable to many. When considering the public contribution of the university systematizing the revolutionary outweighs all. The long time scales and the openness of science, where each scientist contributes a little, make these contributions inappropriable.

Systematizing calculus took several centuries. All time scales are not so long. The revolutionary ideas on which first year chemistry is based are only one or two centuries old, and even younger ideas, such as plate tectonics, are taught in other first year science courses. These time scales suggest that smaller and smaller innovations might enter the undergraduate curriculum after shorter and shorter delays. But there is a lower limit: university graduates are expected to benefit from their education for their half-century working lives. The specific skills with which they graduate are likely to become obsolete quickly, but their foundation knowledge and analytical skills should endure. This sets a lower limit on time scales for the university of reflection: patient reworking of innovation within the university should concentrate on concepts and principals that are likely still to be important half a century later, a time scale that is reinforced by the style of normal science: a host of small advances that eventually cumulate to a significant whole.

Essential to the continuation of scholarship is the requirement that every faculty member should perform research, as the handmaiden of teaching, and not as an end in itself, as it is in most contemporary universities. Normal scientific research[25] forces faculty to know current innovation well enough to shepherd its transition to the curricula of graduate courses. That is, we should not expect university scientists to do research because it provides ideas from which firms innovate, but because it contributes to teaching based on the essence of previous innovation.

The long time scale of this process makes it a public good, which will be supplied inadequately by the market. Furthermore, even if firms would pay for the creation of teachability, it is bad for society if the resulting understanding is appropriable. Presumably, the unpatentability of knowledge *per se* recognizes the undesirability of private appropriation of understanding.

Finally, remember that successful reworking of scientific truth produces expertise in differentiating the essence from the accidental. Firms must follow the tastes of their clients, which vary on a time scale of years, and must be nimble. But universities supply education to students who will use it for half a century. Neither individuals nor firms have discount rates low enough to consume the right amount of a good having such a long life-time: only nations do. Thus, nations must supply as a public good the university, which uses the long time scales of scholarship to select what is enduring. The providers of education, not the clients, have the knowledge necessary to judge what is in the best interest of those to be educated. This consideration, combined with the disinterestedness that makes philosophers better suppliers of ethical education, demonstrates that universities focussed on scholarship rather than research supply a genuine public good, one that is better for innovation as well as better for the long run interests of the nation.

V Universities Competing Naturally

Having established the superordinate goal of the university of reflection we are ready to think about competition. The product of the university is scholarship, an openly-conducted activity of normal science that works and reworks revolutionary science, which includes innovation[26], into systematic and simple models that are easily teachable. Teaching is, of course, part of scholarship, and for two reasons: first, success and failure can be judged only by teaching, and second, scholarship is the opposite of solipsistic: its very purpose is diffusion of knowledge. Scholarship is a unique human activity, depending on continuous growth over centuries: old ideas being revived and reworked.

Who benefits from scholarship? Directly, the students who receive it results; indirectly, firms that employ these students to create products that are ever more suffused with knowledge, and societies that benefit from long-term secular growth through innovation. Nation by nation we see a strong correlation between innovation-related productivity growth and scholarship-related growth in the productivity of teaching, which manifests itself not as an increase in students graduated per scholar-hour, but as an increase in depth of understanding, per student per scholar-hour.

Of course, such a claim is easier to make than to substantiate: how do we measure, for example, 'depth of understanding', when Goodheart's law tells us that any 'objective' proxy will be immediately subverted. The best answer we can give is discouraging: reputation. The superordinate goal of the university of reflection is scholarship, and scholars, who are by nature competitive (Cornford, 1908), continuously generate a collective reputational ranking. That is, universities provide scholarship as a public good, as doctors collectively provide public health. And just as doctors themselves judge the health they produce, scholars judge each other's scholarship, usually harshly.

A natural competitor to the university would seem to be the vocational school, but they serve qualitatively different constituencies. Universities try to provide their students with knowledge that will remain useful for half a century.[27] Expecting their graduates to inhabit a changing world, they stress principles over specific skills. Vocational schools also take the long view, but in a different way. Many goods and service are the product of technologies that are truly mature. Their processes and procedures evolve slowly over decades. Vocational schools equip their graduates with the skill to carry them out, which they expect to last a working lifetime. Thus, universities and vocational schools occupy not competing, but complementary, roles. They do, however, have one commonality: they both compete, not with each other but within themselves, on reputation.

It is rightly argued that reputation lags ten to twenty years behind the current state of a university. Fortunately, what reputation measures changes even more slowly: it takes forty years to turn over completely the faculty of a university and there is a strong correlation between the quality of new faculty hired and a university's reputation.[28] It is natural that universities compete, and the natural measure on which they compete is reputation, which changes slowly. In athletic terms, the university runs the marathon against other universities, with the end not in sight. But the athletic metaphor is surely too strenuous: the natural competition for universities is more like bird-watchers out for a stroll in the forest, competing to fill out their life lists.

Competition that is so slow and unintensive is exclusive to the university. Successful nations comprise a variety of institutions that operate on different time scales: firms producing fashion-oriented consumer goods are nimble, changing direction in weeks or months; firms producing basic materials make investments that pay off over a decade; firms supplying the base infrastructure that shapes settlement patterns must plan with a time horizon of several decades. Let us make two observations about this uncontroversial fact: first, that as the time scale increases, the coordinating authority moves to a higher political level, and second, that competition is only natural between institutions operating on similar time scales. The university of reflection competes on even longer time scales, as it works and reworks the core ideas of science. Here we see most clearly the failure of the university of innovation: requiring the university to enter the market for innovation pushes the university into a time scale, six months to three years, that is already over-populated, and in doing so it both undermines the unique role the university plays in society, vitiates its claim for public funding as the provider of a public good, and leaves unoccupied its important niche of retaining truths that change very slowly. Very few institutions take such a long view: we may think of political institutions, but only when they operate at their best, and religious ones. Society cannot afford to undermine the long-term foundation that supports the activities of faster changing institutions.

The position that the university vacates is one for which it is uniquely suited: preserver and arbiter of the enduring in a world that is increasingly changeable. The willingness to think once, and then think again, which is characteristic of scholarship, is a fatal weakness in the context of competition on short time scales: the intuition that the university plays against its own strengths when pushed into the rapidly changing market for innovation is certainly true.

Finally, the long time scale of the university makes it one of the few institutions that explicitly value reflection. Sometimes it is best to act without thinking, which society delegates to institutions that abjure history for nimbleness. Sometimes it is best to think without acting, where the right response is, 'Wait. Is it really true? Let's think about it.' We do this best in the university.

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Endnotes

1. All three authors have, on request, participated in these activities.
2. Beneath the surface professional schools also have an unexpected commonality with education in the Middle Ages, growing, as they did, from the apprenticeships that educated surgeons, solicitors and engineers. As then, the greatest pecuniary benefit of education seems to be membership in an exclusive guild, for which students are willing to pay dearly.
3. In this respect is tempting to view the displacement of ENA to Strasbourg as spreading the common culture of the French elite across the European Community. In another age and with similar goals, Great Britain brought the leading students of its colonies to Oxford and Cambridge via Rhodes scholarships in order to spread a common English national culture across its empire.
4. Toward the end of the twentieth century, the survivors of the university of culture in the English-speaking world struggled against these changes, most visibly in the 'culture wars': public, and commonly violent, arguments about which culture should be studied, or the cultural content of courses. Important contributors to these arguments were new departments of cultural studies, a sure signal that culture was no longer the glue holding together the university and the nation that funds it, but a discipline like any other. The culture wars, of course, were neither won nor lost, but merely faded into the background noise from other tables at the faculty club.
5. Indeed, in Denmark today, this is taken so seriously that the level of a university's funding depends in part on how many patents it owns. In France the Loi Organique relative aux Lois de Finance of 2001, states that patent applications and lisences are to be used as indicators for the success of public funding in higher education and researrch. And naturally, French patent statistics show the effects of Goodhart's law[6]. Innovation in the CNRS and Universities sky-rocketed starting after that law was fully implemented in 2006. Sky-rocketed that is, as measured by patent data!
6. This observation, profound enough to seem obvious, is sometimes called Goodhart's law.
7. Thanks to Ezequiel Tacsir for this comment.
8. We are indebted to David DeVidi for this evocative phrase.
9. A very recent example, (Anonymous, 2007) shows that excellence may be losing ground. In an advertising supplement describing research in German universities, 'excellent' and its cognates occur only 187 times in 57 pages.
10. Intuitively, there should be positive feedback through which some good potentially available by the consumer returns to fuel the early stages of this engine of innovation. This feedback, however natural it seems, is rarely included explicitly in the linear model.
11. As a concrete contribution governments provided universities with the intellectual property generated by government-funded research. How valuable is it? One university, UCBerkley, which would we expect to be well positioned to benefit financially, seems to have concluded that this property is more beneficially employed increasing reputation than earning money (Butler, 2007).
12. The last statement is a true oxymoron. Properly phrased it would say that the consumers of basic research don't want basic research at all, but something different, which they call 'research', probably because tax credits encourage them to do so. It is, in fact, not uncommon to hear university researchers say about the industrial collaborators, 'They don't even know what basic research is.' This is a serious problem, but not for the industrial collaborators.
13. The story told here is schematic, but in the abstract describes many specific cases. Brooks (1995) gives a well-known example.

14. Operating system kernels really do have in their code comments like, 'This seems to work, but I don't know why.'
15. Industry scientists often encourage management to solve such problems by research, but the time scales are wrong: research is too slow compared to trial and error. In an extreme case (Mack et al, 1983) the research was not completed until after the product had been introduced, marketed and discontinued.
16. DBMS – database management system. The relational model is formally clean, so databases are no longer custom-built each time they were needed. Instead, databases are created by configuring standard DBMSs to the business rules of a firm.
17. With one exception, the INGRES project at UCBerkley.
18. For which reason we call this model of the university the *university of reflection*.
19. Possibly even above all other values. So much the worse for society!
20. Google's slogan, 'Do no evil,' where 'evil' is defined situationally, is an example of this tendency.
21. In compromising their unswerving allegiance to truth universities are, as a marketing student would tell them, in danger of diluting their brand. Well-advertised adherence to 'truth above all' is the best reason for industry to collaborate with universities. Salable items as different as clinical trials and encryption algorithms have their value enhanced when given the imprimatur of a university known for its dedication to truth. Thus, universities, allying themselves with industry in the competition to innovate, require careful brand management to retain their value as partners. This discussion contradicts our intuition of what a university is. (But, see Kirp, 2003.)
22. This is not to say that everything taught in a university is true, any more than everything taught in a vocational school is useful, only that, as institutions they strive to fulfil these commitments to the best of their ability.
23. Ask any student studying calculus if today's pedagogy can be improved.
24. One could even argue that the main contribution of universities to revolutionary science is the provision of an undemanding jobs that allow ample time for undirected thought. However, as the examples in this paragraph show, there is stiff competition for this role, and there are few university presidents would seek government funding on the basis of providing undemanding jobs for professors.
25. It is important not to be misled by the claims of tenure and promotion statements or of grant applications, in which all research is revolutionary. Few scientific revolutions happen each century, so we can be certain that all the scientists in the world, except one or two, are doing normal science at any time. Like it or not we are all normal. We claim that this activity is justified because its result is that the truly revolutionary scientific developments are sufficiently reworked that many can learn and understand.
26. Why is innovation included with revolutionary science? They are end-points of a range of results that has in common unpredictability and unexpectedness. Furthermore when they occur almost no one understands them. For this reason both are inputs to the university of reflection, where socially distributed understanding is generated from new ideas.
27. Universities that promote life-long learning merely admit that they don't do the job properly in the first place.
28. Newly-hired faculty say that reputation and academic environment are the two most important factors determining which job offer they choose. Economic considerations, like salary, are less important, reinforcing the non-market aspects of most universities noted by Kirp (2003).

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