2010 2nd Year Exam – Answer: A1 Nanotech Policy

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What are the implications of university patenting of "basic building blocks" in nanotechnology for the future pace of and pattern of innovation in this field?

This question draws a distinction between basic and applied science, where applied science is more use oriented. According to Nelson (1959), the goal of any applied research is closely constrained, whereas the goal of basic research is adaptive. This suggests that universities, who are do not have closely controlled goals, are better suited to basic research. However, post the Bayh-Dole act, and other changes in the patenting environment in the early 1980's we have seen a rise in university patenting and universities conducting applied research. Note also that reductions in the cost of university patenting with the growth of TTOs. This rise in university patenting might be attributed to the fact that post Bayh-Dole government funded university research can be patented and held by universities who can license it as they see fit, including making exclusive licenses, though Mowery (1999) argues that there are a plethora of other causes and the effect of Bayh-Dole alone is probably small. Furthermore, universities have a comparative advantage at want the Stokes' Model labels as Use Inspired research. This is applied research that was created without an ex-ante specific goal in mind.

However, there is a danger of shifting universities towards applied research. This would be a move from the open science institution to a private property regime (Murray and Stern, 2005) and could lead to an Anti-Commons effect. That is "IPR may inhibit the free flow and diffusion of scientific knowledge and the ability of researchers to build cumulatively on each other's discoveries". By privatizing the scientific commons we may limit scientific progress. Privatization may act as a tax on innovation resulting in a lower equilibrium level of follow on research. This would have negative implications for the future pace and patterns of follow on research, particular if research is very path dependendent. On the other hand, this problem may not emerge for a number of reasons. First and foremost, we appear to be in a pre-paradigmatic phase of development in nanotech. Technological evolution is characterized by periods of experimentation, followed by the emergence of a dominant design. A dominant design is characterized by a set of core design concepts that correspond to major functions performed by the product (Henderson Clark, 1990), thus the patents that results from university research may end up as 'failed experiments that are not built upon'. Second, patents have 20 year life spans, and even successful patents may be close to expiration once a dominant design is achieved. Third, anticipating the downside of such an effect, firms have an incentive to form institutions such as patent pools, cross-licensing agreements, and collective rights organizations to mitigate transaction cost problems (explored further below). Fourth, some patents can be invented around.

How will high level of patenting form the inception of development affect entry by new firms and the evolution of industry structure?

To begin I note that there is a requirement to demonstrate that a patent is novel, non-obvious and useful. The third requirement may be more problematic for very nascent technologies that are far from development. That their is patenting activity suggests that we are already seeing inventions that will be useful within 20 years. Thus nanotech, like biotech in the 1980's might now be characterized as a growing field with expanding promise where the results are directly applicable commercially. Given that the scope and strength of IPR has grown since the 1980's and that if anything the appropriability regime (a concept due to Teece, 1986, which measures the strength of IPR) has got considerably stronger, we might expect nanotech to resemble and even more IP oriented version of biotech. The parallels between the two industries go further - in biotech there has been a trend towards vertical specialization, thought the displacement of incumbents has been minimal (see Mowery, 1999). In nanotech it is possible that some of the large semiconducter firms of today, such as advanced materials will be the incumbents of tomorrow.

In the basic science phase large firms have an advantage over small firms. As Nelson (1959) points out, in the activity of invention there are many paths to choose from - the greater a researcher's relevant knowledge the more likely he will eventually find a satisfactory path; so the degree to which a firm can capture the benefits of more basic science depends on how broad or narrow its technological base is. Large firms have inherently broader bases. Furthermore, the long lag between initiation of a project and commercial value realization might be prohibitive for firms that value short term survival and profits over longer term objectives. It is likely that monopolists have lower discount factors, and almost certainly governments should (again c.f. Arrow), suggesting that they should both be funding this type of research. Likewise, firms (and individuals) are risk averse and projects are risky. Firms without the economic resources to spread risk (by diversification across projects) will value projects less than its social value, even without externalities, again suggesting large firms will be dominant. While venture capital firms can diversify risk, the venture capital model can tolerate inventions that are at most ten years from full commercialization, realistically five years. Thus, we should might measure the closeness to first commercialization by the first round of venture capital financings in nanotech.

In the post-paradigmatic phase, commercialization and ultimate profits may well depend on complementary assets. These could include generic assets like the ability to access capital (where again VC will help), as the industry gains in maturity they are more likely to be co-specialized assets, and this would favor incumbents. A patent is a right to exclude and in this phase concentrated rights, that is rights held by only one or a small number of holders, are less problematic with respect to hold-up. Fragmented rights, (Ziedonis, 2004) are much more problematic, as underlying rights to development are more difficult to identify, accidental infringement is more likely, each underlying right must be valued seperately, and the number firms a developed must negotiate with is larger, leading to larger transaction costs. This is called the diffuse entitlements problem. If a small number of large players, such as universities and incumbents end up holding the key patents in the post-paradigmatic phase, this could be good. However, if in the transistion from the paradigmatic to the post-paradigmatic phase either a large number of broadly held patents remain valuable, or if a new wave of broadly held patents become key, then we can anticipate hold up problems and that the patents will become used to prevent rivals from patenting, to use patents in negotiations with owners of outside technologies, or to deter infringement lawsuits as in Ziedonis (2004).

However, we have also seen a trend for Open Innovation. This, as defined by Chesbrough, is "The purposive use of inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation". We can expect this to continue in nanotech as well. Firms will leverage outside knowledge, particular from universities during both the paradigmatic and post-paradigmatic phases.

A research design to assess the efficiency and effects on innovative performance of the high levels of patenting.

Within nanotechnology I would advocate the following empirical tests:

To establish whether there is an anti-commons effect, I would examinw patent-paper pairs by university researchers, using citations as a measure of quality of publications, and raw numbers of publications as a measure of basic research output, much as in Murray and Stern (2005). The control group would be a set of papers which did not recieve patents but where eligible to do so (i.e. at risk papers).

To establish whether there was a later hold-up problem from diffuse entanglements I would broadly follow Ziedonis (2004), using a measure of fragmentation of patent citations for whether a patent has diffuse rights, citations as measure of patent quality, and capital intensity of the firms as a proxy for their degree of cospecialized assets.

I would also consider comparing nanotechnology patents to biotechnology patents, perhaps adjusting the time periods to put the development of the biotechnology and nanotechnology industries side by side. Measures of stages of development could be developed as above (i.e. first patent, first VC funding, first dedicated IPO, etc).