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# Thinking About Technology Policy: ‘Market Failures’ versus ‘Innovation systems’

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**Summary**

In this essay I compare two different theoretical frameworks in economics for orienting analysis of issues in technology policy. One is a neoclassical framework that sees appropriate policies as dealing with “market failures”. The other framework is provided by an evolutionary and institutional approach to economic analysis that sees appropriate policies as building or maintaining an effective “innovation system”. It should be no surprise that I believe the latter framework is the more useful one. I begin by laying out the key general differences between the two broad theoretical frameworks, and how they lead to different perspectives on technology policy. Then I turn to a particular case: technology policy regarding pharmaceuticals. Finally, I comment on the general question of the role of economic theories in framing policy analysis.

## I. Differences in the Perspectives

At the broadest level, and possibly the deepest, the difference between the neoclassical theory that has dominated microeconomic theorizing over the last half century, and the evolutionary economic theory that is taking shape, concerns their assumptions about the economic context for action. Neoclassical theory sees the economy as in an equilibrium configuration, at rest, or undergoing well anticipated change. Essentially, it is a situation where taking actions appropriate to the context is something decision makers have learned through relevant experience, or can calculate based on what they know securely. In contrast, evolutionary theory sees the economy as always in the process of change, with economic activity proceeding in a context that never is completely familiar to the actors, or perfectly understood by them.[1]

The difference here corresponds to the distinction Schumpeter drew in his *Theory of Economic Development* (1934), between the context for action set in a continuing circular flow of economic activity, and the context set by an economic environment where innovation is going on. We modern evolutionary economic theorists, like Schumpeter, believe that the latter context is a much better characterization than the former of conditions in modern capitalist economies.

This difference in the assumed context of action leads the two theories to very different conceptions of what is meant by "rational" behavior. Both theories assume that individual and organizational economic actors pursue objectives, sually in a reasonably intelligent way. Rational behavior in neoclassical theory means that economic actors can and do choose the course of action from all possible ones that, in fact, maximizes their expected

[1] For a discussion see Nelson and Winter, 1982

utility. In contrast, the "rationality" of actors in evolutionary theory is bounded, in the sense of Herbert Simon.[2] . There is no way they can understand fully the context in which they are operating, yet they have to cope, somehow. To a considerable extent the coping involves the use of routines that have in the past yielded satisfactory results. But the actors in evolutionary theory also have the capability to try something new, for example when they judge what they have been doing is inadequate in a changed context, or more generally where they think the see an opportunity to do better.

A related difference between the two theories is in how they conceive good economic performance. Neoclassical theory proposes that the performance of an economy should judged in terms of how close it is to a theoretical optimum. In evolutionary theory there is no theoretical optimum, since the range of possibilities for economic action is always changing, generally growing, but in a way that cannot be predicted or specified in detail. Economic performance is seen in terms of the rate and nature of progress. Enhancing these is what technology policy is all about.

I want to highlight that most of what is valuable in the standard contemporary tool kit of concepts and understandings is not tied to the assumptions of neoclassical theory. I include here such concepts as "public goods" and "externalities". These concepts surely are extremely valuable in organizing thinking about issues of technology policy. So also is the proposition that for the most part competition is an important vehicle for advancing the public interest, and monopoly or collusion something to be avoided if possible. The argument that "incentives matter" and that, in many cases, designing policies to shape incentives appropriately is a more effective strategy than trying directly to mandate

[2] see for example his Models of Man, 1957

behavior, is built deep within the traditions of today's standard economics, and almost surely generally provides good guidance.

But these concepts and maxims are not logically tied to a structure of modern neoclassical economic theory. They are perfectly at home within an economic analysis structured by evolutionary theory, although in some cases they are seen then in a somewhat different light.

*Problems with the 'market failure' orientation*

I want to turn now to another important difference between neoclassical economics and the evolutionary-institutional approach that I espouse. It is regarding how one should look at the institutional complexity of modern capitalist economies.

I believe that the deep incorporation in modern neoclassical economics of the theory that, under particular conditions, the operation of a pure market yields outcomes that are Pareto optimal, leads to a way of recognizing actual institutional complexity that is awkward and potentially biased. In particular, non-market elements in an economy, for example elements of an active technology policy, tend to be analyzed and rationalized as possible responses to "market failures". From my point of view, there are three different (but related) major problems with this orientation.

First of all, it gives pure market organization a privileged standing, as the default structure. The implicit presumption is that one should go with market organization, and leave market organization strictly alone, unless one can develop a case that there is something wrong with doing that. Supplements to market organization, or quite different

forms of finance and organization of an activity, are placed in a position of being a "second best" solution, justified only because markets "fail" in some sense.

But it seems to me intellectually strained to rationalize that government agencies are in charge of managing the air traffic control system, or matters relating to public health, or (to get to technology policy) for funding a good portion of a nation's basic research, with universities doing much of that work, because of "market failures". It is much more balanced, much less biased, to see different types of funding and organization as being good for different kinds of things, than to see markets as the preferred general-purpose mode of operation, except when they "fail." This certainly seems a better way of thinking about a variety of possible technology policies, from the general accepted one of funding basic research, to more controversial ones like supporting certain kinds of industrial applied research.[3]

An important reason, and the second problem with the market-failure theory point of view, is that pure market organization always fails, at least to some extent. The conditions for a pure market organization to result in a "Pareto optimal" equilibrium never are fully met. This is recognized, implicitly, in serious policy discussion, where the argument about policy almost never is about whether the situation actually is "optimal", but rather about whether the problems with the existing regime are sufficiently severe to warrant active new policy measures. That is, analysis of active government policies, like technology policies, inevitably involves a comparison of different ways of doing things. My argument is that the "comparative" mode of analysis should be theoretically explicit, and that the analysis of different ways of organizing, governing, and funding an activity proceed without bias.

[3] For a more extended argument, see Nelson 2002

Thus it is clear that virtually all R and D yields externalities, in the sense that some parties not involved in R and D decision making will be able to learn something useful from the results. It also is true that the understandings won from any R and D effort have public good properties, at least in the sense that use by one party does not reduce the stock of understanding that might be used by another.

But there are good reasons for leaving decisions and investments in R and D aimed at advancing commercial product lines and process technologies mostly to commercial firms. Among other things, that is where the relevant expertise resides. And various special institutional "devices", like a patent system, can help support incentives of firms to do this kind of R and D, even though allowing patents generates economic inefficiencies (market failures under a neoclassical perspective ) of its own. The institutional "call" here, that is endorsed by most knowledgeable economists, is that balancing the plusses and minuses of different ways of getting commercial product and process development done, society is better off leaving it mostly to business firms and paying the price of allowing patent protection of new product and process technology. However, as I will consider in a moment, in some areas the consensus here is not sharp, for example regarding certain classes of pharmaceuticals.

Regarding basic research, the results of which are likely to be far upstream from something commercial, the situation is different. Here university researchers often have a better knowledge of what is going on in a field than do most researchers in commercial firms. While if one allows patents on research outputs far upstream from direct practical application one can provide firms with a profit incentive to do such work, as in fact we have done in biotech, the economic costs of allowing basic scientific discoveries to

become private property can be very considerable. The comparative institutional call here is widely agreed to support funding basic research with public monies, and having it undertaken in institutions that have an interest in open science.

My argument is that in both of these cases, the important analysis is not so much whether markets "fail" to some degree or not. Rather, the issue is how best to get the work done.

The third problem with the market-failure orientation to questions of public policy is that, as the examples above indicate, just as there isn't any such thing as a perfect market, there is no such thing as a pure market, or from another point of view, markets always are supported and complemented by a wide range of non-market apparatus. A patent system is a complex and expensive legal structure put in place (among other reasons) to enhance the expectations of potential private inventors that they can profit from their market oriented work. The R and D of for-profit pharmaceutical companies aimed at developing new drugs draws from public funding of biomedical research and training at universities.

*The innovation system*

This brings me to the concept of an innovation system. The broad concept emerged from the work of a number of scholars who had been studying how innovation occurred in different countries and different economic sectors, and the key institutional actors involved. Their research and writing highlighted both the importance of different kinds of actors – a lot more than firms and private inventors were involved – and the differences between countries and sectors. During the 1980s and 1990s the term "innovation

system" cameo be used widely to describe these structures and differences.[4]. By the mid 1990s the term and the concept were well established within the community concerned with technology policy.[5]

Most of the early use of the term was in analysis concerned with illuminating broad national differences, that is differences in National Innovation Systems. But the major differences across sectors and technologies gained increasing attention, and the concept of Sectoral systems gained increasing currency.[6]. The advantage of the innovation system concept, at least in my view, is that it focuses attention on the variety of institutions and institutional actors that are involved in innovation in a field, and it does so without invoking the notion of "market failure" to rationalize the non-market parts of the system.

From this point of view, government programs, policies, special legal structures, are part of the system. This does not mean that technology policies do not require careful scrutiny, evaluation, continuing efforts to adjust them to changing circumstances, to make them better. But policies to support, for example, biomedical research at universities, and proposals to modify those policies, are considered in their own right. Thus the question of whether to provide more public money for research at universities and public labs for the purpose of developing drugs for diseases that mainly plague poor countries clearly is a difficult one. But within a perspective that sees an "innovation system" as a natural concept, it can be addressed without a background notion that the market obviously could do the whole job in the best possible way, if it weren't for that darned market failure problem.

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[4] The most widely cited referenced are Freeman, 1987, Lundvall, 1992, and Nelson, 1993
[5] Freeman, 1995, and OECD, 1997, provide broad reviews of the subject.
[6] See Malerba 2004

My brand of evolutionary economics sees institutional evolution as a central part of the dynamic processes of economic change.[7]. Institutions evolve, along with technologies. The institutions, and the way they evolve, involve both private and public actors. An important consequence of this point of view is that policymaking is seen as a continuing process. Existing institutional structures, including bodies of relevant law, and particular government policies and programs, never can be regarded as optimal. They are, and should be, always subject to scrutiny. While the intensity of political debate about whether reforms are needed in a particular sector or industry, and if so, the appropriate reforms, tends to wax and wane, the policy process is a continuing one.

In some cases the policy dialogue cuts across a wide swath of economic sectors, as the current discussion regarding whether patent reform is necessary. But much of the discussion, as well as the policies are technology or sectoral specific. Below I have chosen to do a relatively extensive discussion of present policy issues regarding the pharmaceuticals, rather than touching more lightly on several cases.

## II. Technology Policy and Pharmaceuticals

A major advantage of the innovation systems orientation to technology policy, at least in my view, is that it induces a broad view of the various forces and actors whose actions determine the pace and character of technological advance in a field. This wards off the tendency to analyze a particular policy issue as if it were the only game in town. In many sectors, and broad technologies, a number of policy debates are going on at once.

[7] See Nelson 2008, and also part II of Freeman and Louca, 2001

Pharmaceuticals is a fine case in point. I focus below on the US, but much of the policy debate I describe also is going on in other countries.

The innovation system in pharmaceuticals contains many actors and many aspects. The discovery or creation of new pharmaceuticals, their production, and their marketing, is largely today the business of for-profit private enterprise. However, since the 1950s the introduction of new pharmaceuticals to the market, and modes of production of pharmaceuticals, have been under tight regulatory restraints in the United States and in most other advanced industrial nations. While pharmaceutical companies do the lion's share of the work on the development and testing of new pharmaceuticals, since shortly after World War II, the National Institutes of Health have taken broad responsibility for the funding of basic biomedical research in the United States. Most of that research goes on at universities. An important portion of the testing of new pharmaceuticals, while funded by industry, goes on at university-affiliated medical centers. In some cases a government agency has funded and guided aspects of the testing of a new pharmaceutical.

While to a lesser degree than in most high income countries, a large portion of the purchases of pharmaceuticals in the United States is covered by insurance. A growing portion of that insurance is public. While in other countries particularly the public part of the health insurance system has negotiated pharmaceuticals prices with companies, this is happening to a lesser degree in the United States.

Patent protection is particular important for pharmaceutical companies. And pharmaceutical companies have a strong influence on the shape of patent policy in the United States.

None of these features stays constant for very long. The whole structure is almost always changing in one way or another, and the appropriate direction of change is a continuing matter of public policy debate. Let me parse various aspects of the current policy debates regarding pharmaceuticals going on in the US. Some of these do not relate directly to matters bearing on technological innovation, but all of them set the context for the technology policy debates

In the US the most visible and probably most important policy debate concerns proposals for public policies to extend the range of people covered by health insurance. This debate has been strongly influenced by technological advances in pharmaceuticals. Today the accepted medical treatments for a wide range of diseases involves the use of pharmaceuticals that were not available ten or twenty years ago. These drugs are expensive. The rising price of medical care is a major factor behind the growing pressures for widening insurance coverage. And how the issue gets resolved will have strong influences on pharmaceutical development. Almost surely there will be a significant expansion in publicly supported health insurance coverage, and with that new pressures and mechanisms to put ceilings on or bargain down the price of pharmaceuticals. This will affect both the profits of pharmaceutical companies, and their incentives as well as their funding for new drug development.

The concern in the US about high prices of pharmaceuticals also is behind a continuing debate about whether current patent law overly curtails competition. Here an important part of the argument is about whether companies with patents are extending their monopoly, holding off the rise of generic competition, through a set of mechanisms that have been given the name “evergreening”.

The issue of pharmaceutical prices also impinges on the growing political pressures in the US to try to address the high prices of pharmaceuticals in poor countries. This issue is tangled up with whether poor countries are justified in buying, or encouraging the production of, generic versions of those pharmaceuticals under the terms of TRIPs (Trade Related Intellectual Property). It would appear that a major diplomatic battle is pending between some of the larger and more powerful developing countries, and the United States.

The pharmaceutical companies have expressed their concern, and with good reason, that the advent of price controls, or stronger downward pressure on prices, in the US, and a reduction in the strength of patent protection, will erode their revenues and hence their capacity do to research and development. They have made similar arguments against polices aimed to reduce prices in less developed countries, although the stakes for them there are less.

Countering this view, a number of voices have been arguing that most of the R and D done by pharmaceutical companies either is oriented to developing “me too” drugs that add little of therapeutic value to what already is available, or involves picking up embryonic new drugs that that have come out of publicly funded university research, and establishing a patent based monopoly on what the public has largely paid for. While still

vague, there clearly are some arguments afoot that a significant change in the way pharmaceutical R and D is done is in order; and that Government support should move beyond the funding of basic research, and start to encompass drug development.

In particular, there is advocacy for public support of pharmaceuticals development in contexts where it can be argued that company expectations of profit potential are low, while the social, and even the broad economic, benefits of the development of new medication would be high. Here there are separate discussions about three different areas: the development of drugs for diseases prevalent in poor countries but not rich; so-called "orphan" drugs for life-threatening or debilitating diseases where the affected group is relatively small; and vaccines. Proposals for programs in these areas face the challenge of designating appropriately the kind of organization that would do the publicly financed work, what would be done about any resulting intellectual property rights, whether the inducement should be in the form of a guaranteed market, or prize, or whether the program should work through contracts and grants, etc.

And then there are a variety of issues relating to possible reform of the intellectual property right system bearing on pharmaceuticals. A number of studies has shown that, compared with most other industries, the ability of a company in the pharmaceuticals industry to profit from its innovations is strongly dependent on patent protection. At the same time, it is clear that pharmaceutical companies are able to use their patent protection to support very large margins between production costs and the prices they charge. This fact is prominent in many of the debates about high pharmaceuticals prices, and what to do about that problem.

As mentioned earlier, one contentious matter is whether, and if so how, to reign in the current proclivity of pharmaceutical firms holding patents on a particular drug to delay generic competition on the expiration of the original patent through practices called "evergreening". The issue of whether governments of low-income countries should have the right to purchase pharmaceuticals from generic producers, in effect voiding the legal power of the patent in such cases, also has been mentioned above. One of the arguments for government funding of pharmaceuticals development as well as research is that then the patent rights could be controlled by government, and licensed on terms that would encourage competitive pricing.

But there also are issues relating to what should be patentable in the broad area of pharmaceutical research, including the upstream science. For example, should genes, or gene fragments, or receptors, be patentable? A related issue stems from the fact that, in the period since 1980, when the Bayh-Dole Act was passed, universities have been active participants in patenting. Should Bayh-Dole be amended, and should there be some restrictions placed on university patenting and licensing?

There are a number of other issues under discussion that I could mention here. However, I think I have laid enough out on the table so that it is clear that the various technology policy issues relating to pharmaceuticals need to be seen in the contest of the overall "innovation system" – the wide variety of forces and actors that influence technological innovation in this area. And the context needs to be seen in the light of evolutionary theory. It is change that is driving the policy discussion. Analysis based on the assumption that the problem is to move from one unhappy neoclassical equilibrium position to another better one, and that the key to getting to a better equilibrium is

understanding of present market failures and the design of policies to fix or cope with them, is at best not very helpful, and in my view misses much of what is going on.

**III. How Does Economic Theory Influence Policy Analysis?**

But shouldn't understanding of such things as that externalities are almost always generated by R and D, that scientific and technological knowledge is non rivalrous in use, and that monopoly tends to lead to and support large gaps between price and costs, play a role in thinking about the kinds of technology policy issues I sketched above? Obviously yes. But as I argued earlier, working with these kinds of concepts and maxims does not require accepting the whole baggage of neoclassical theory. We evolutionary economists feel perfectly at home working with them when considering how to make innovation systems work better. In the particular case being considered, these understandings certainly weigh against allowing broad patents on research results that have a wide range of potential applications and, more generally against relying heavily on for-profit enterprise to fund and undertake this kind of research. But they equally warn against encouraging, or allowing, universities to patent these kinds of things. The nature and relevance of these kinds of understandings extends well beyond their signaling of "market failure".

I think it useful to reflect a bit on the question "what kind of policy guidance can be drawn from any kind of a broad economic framework?". Certainly not the kind of guidance that basic knowledge of constants and relationships that physics, or aeronautical engineering, gives to designers of a wing of a new aircraft. The guidance there is to a considerable extent in the form of established quantitative knowledge that enables reasonably reliable calculation of the relationships between wing shape and drag, the

ability of different materials to withstand pressure and heat, etc. While understanding of physics, aeronautical engineering, and material science, provides a lot more to designers of an aircraft wing than quantitative relationships and constraints, it does provide these, and these are extremely valuable.

Econometricians sometimes propose that estimated econometric models provide quantitative relationships and constraints to guide the development of economic policy, but this proposal should be taken with a grain of salt. While econometric models can provide some "ballpark" numbers to help locate the policy analysis, no economic policymaker that I know treats these numbers with anything like the respect that aeronautical engineers treat numbers regarding the strength of materials. Also, the econometrician's argument should not be taken as a case for neoclassical theory. As I suggested earlier, most of the (reduced form) equations fit by econometricians are as compatible with an evolutionary theoretic rationale as with a neoclassical theoretic rationale.

Rather, what an economic theory provides for policy analysis is a framework for interpretation. My argument in this essay is that the most useful framework for analysis of issues of technology policy that economists now have is an evolutionary theory of economic change. This recognizes the complex institutional structures supporting and molding innovation that is signaled by the concept of an "innovation system".

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