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Three Silly Notions About Technology Transfer: And One That's Not
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Innovation: What are the roles of basic and applied research? What are the roles of industries and universities? Industries need innovation just to stay in business, let alone compete successfully in the global economy. But too many "solutions" to questions of innovation rest on some misconceptions of the relationship between science and technology, as well as between academia and industry.

Here are the most prevalent:

1) Basic science precedes and leads to applied technology.

2) The findings of academic science usually lead directly to marketable products.

3) Academic and industrial science have a natural collaborative relationship because the results of the former solve problems of the latter.

Superficially, these notions seem like common sense, but scrutiny shows that they are foolish. When well-meaning believers use these ideas as their basis for orchestrating relationships among university, government, and industry, all parties can suffer.

In fact, there is a sound basis for a relationship among these Players--but before we discuss a healthy R&D enterprise based on the realities and strengths of existing institutions, we must understand why these three notions are misleading.

Basic or Abstract?

The first belief--that the applied flows from the abstract--is not wrong so much as dangerously incomplete. Much of 20th century technology (radio, television, lasers) did indeed arise from the basic ideas of quantum mechanics and relativity, just as much of 19th century technology stemmed from the fundamental scientific discoveries of Faraday, Maxwell and others.

On the other hand, many basic theories have emerged in response to practical questions. Probably the most striking illustration of this "reverse flow" is thermodynamics, which evolved when scientists faced an utterly practical problem: What was the minimum coal required to pump water from underground mines?

What characterizes the motivations for productive "reverse flow?" Some well-intentioned, would-be reformers of the R&D enterprise suppose that by channeling funds to academic scientists--not to be used for basic or curiosity-driven research, but rather for goal-directed applied research--the academics, with their prior basic knowledge, will find solutions to well-posed, exogenous problems, on command. This notion has no foundation in reality. The genius of successful "reverse flow" scientists has been their capacity to respond to challenges of applied problems with the same spontaneity, curiosity, and originality that characterizes the quality of their work in basic science. One cannot legislate the unforeseen, even by manipulating funding allocations.

The greatest danger of believing the incomplete notion that the applied always flows from the basic is that inadequacies in technology and applied science will be blamed on the upstream partner's "failure" to do basic research that leads directly to marketable ideas.

What Good Are Universities?

This brings us to the second misconception: That the findings of academic science normally lead to marketable products. In the United States and elsewhere, basic science--one of the most innovative and productive of human enterprises--has become unattractive to legislators, government agencies, and industry. This has occurred despite the fact that basic science has been performing well in the United States, Europe and Japan in its primary function of generating fundamental ideas and producing scientists.

Basic science is a high-risk, high-return activity. Its costs are low and its return on investment, overall, seems to be somewhere between 25 and 40 percent, according to different economic analyses. There is no reason to suppose that the output of basic science in the 1990's is any less applicable than it was in the 1960's and '70's. Investors in basic science realize that a long-term research program is an investment portfolio, that the likelihood is small that any single project will bring a large return but the probability is high that from the overall portfolio, high-yield results will emerge. History has fully justified this concept and rewarded those investors.

Critics have argued that innovative applications of new science have not been forthcoming, because basic scientists have not solved our social and economic problems!

Clearly society has problems that basic science has not solved. Basic science may even be relevant to some of those problems.

The question is, what would facilitate more effective application of results of basic science to societal problems? Who has the incentive to make those innovative applications? Clearly not consumers--they’re at the end of the chain. The bottleneck, if it is real, lies somewhere between the basic scientists and the marketers. Marketable, innovative technologies--it seems to me--should spring more freely from the minds of people close to markets and manufacturing than from people close to advances in basic science.

Could there be a lack of incentive for creative people in industrial settings to advance innovative ideas? Could it be that industry is simply not very hospitable to innovation?

Those of us who train young scientists and engineers for industry answer that question with a loud, vigorous "YES." We watch firm after firm cut back its investment in R&D during a period of falling interest rates; this is deeply disturbing. All the doctrine of traditional economics argues that the value of investment in long-term research should go up when interest rates fall. Firms that do the opposite are bent on technological suicide. With bitterness, we watch managers sacrifice the long-term health of their firms to competitors who understand time horizons and the role of R&D in global markets.

Compatibility Problems

The third silly idea--that basic university science has a natural affinity for technology in industry--rests on two misconceptions. First, that the principal university product for industry is its steady flow of scientific results. Second, that the modes of work in business and academia are naturally compatible.

Both these notions are terribly wrong. The first, because universities' cardinal product for industry is manpower, well-trained, versatile scientists able to attack a succession of ever-changing problems.

New scientific information may be relevant, even useful, to industrial problems--but the reason industrial scientists use information generated in universities is that university scientists publish their results. If an industrial scientist notices something relevant in the literature, there is a reasonable possibility that the new information will be put to use. This is a matter of serendipity far more than a natural course of affairs.

The second misconception--that the modes of scientific work in industrial and academic settings are naturally compatible--is the result of naive wishful thinking. The best way a university scientist “markets” the primary “product,” a new graduate or postdoctoral fellow, is by showing off all the strong qualities of that young person in the standard scientific venues, journals and meetings. Credentials depend on the quality, novelty and impact of the person's work, so it must be published quickly.

An industrial R&D group, on the other hand, succeeds by translating its ideas into new, profitable products before competitors can produce better or cheaper products. Hence ideas developed in industry are secret until they have been exploited. Furthermore, once an idea has been published, industrial scientists have little motivation to build on that idea unless they can contribute enough to give them a competitive edge.

For all these reasons, it’s difficult for academic and industrial scientists to work together, except in the relatively uncommon situations in which publishable and proprietary parts of the problem can be separated. Furthermore, there are few incentives for either academic or industrial scientists to look hard for such opportunities.

The True Relationship?

What is the real relationship between basic science and applied technology? U.S. industrial history gives us a few hints. Although in some industries, such as auto manufacturing, fundamental science contributed little compared with the adaptation of known technologies; in other cases, such as solid state electronics, basic science provided the concept and first proof of principle. After that, inventiveness led to profitable devices.

The one hallmark of an effective relationship between basic and applied research is an easy flow of ideas. Human inventiveness itself, as well as an environment that encourages and rewards that inventiveness, are two factors that make ideas flow freely--and in both directions.

Basic science isn’t at fault in the current thrust toward technological suicide--rather, it’s the failure of industry, industrial managers and stockholders to care about the long-term health of their firms. The market system fails to encourage pension funds to invest in firms on the basis of their performance, or to make investors prefer long-term gains over short-term returns, or to motivate an oligarchical executive officer to care about the performance of a firm after retirement. These factors, in an irresponsible trading game whose players have no obligations to the future, have transformed many large industrial firms from self-restoring, self-strengthening enterprises into mere tokens.

To restore health to industry, we need incentives favoring long-term capital gains and high-risk, high-payoff portfolios of basic research investment. We need option and retirement plans that motivate business executives to care how their firms perform years after they have left their managerial positions. We need an incentive system that makes shareholders concerned about the performance and long-term sustainability of the firms in which they invest, and discourages "churning" of stocks.

We need to invent a bi-directional enterprise to scan the products of basic research and to inform basic researchers of the problems and opportunities that challenge industrial scientists. We would gain much from a system of allowing industrial scientists sabbaticals for working with their counterparts in basic research, and vice versa. And we need incentives to exploit the innovations that will result from such a productive interaction between basic and applied science.

We need not--nor cannot--know in advance what innovations are possibleÑbut we must have reasons to make those possibilities happen.