SUMMARY

The National Science Foundation (NSF) was created at the onset of the Cold War in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes."[1] Since then, there have been enormous changes in the international and domestic arenas, in the U.S. economy, and in the character of the national innovation system. Moreover, the nation will face substantial economic and social challenges in the future that differ in fundamental ways from those of the past.

The NSF created the Partnerships for Innovation (PFI) program in 2000 as part of an effort to build a new foundation for innovation in local communities that is responsive to these changes and emerging challenges. This effort is based on partnerships among universities, industry, and local and regional governments. The PFI program's goals are to:

- Catalyze Partnerships for Innovation that will enable the transformation of knowledge created by the national research and education enterprise into innovations that create new wealth; build strong local, regional, and national economies; and improve the national well-being;

[1] The NSF's continuing mission is set out in the preamble to the National Science Foundation Act of 1950 (Public Law 810507).

- Broaden the participation of all types of academic institutions and all citizens in NSF activities to more fully meet the broad workforce needs of the national innovation enterprise; and
- Catalyze creation of the enabling infrastructure necessary to foster and sustain long-term innovation.

This report summarizes the results of discussions that took place during a 1-1/2 day workshop that convened in June 2001 to consider the PFI program and the NSF's role in the larger national innovation enterprise.[2] These discussions can be summarized broadly in terms of what was said about innovation and how best to measure it, about partnerships and how they might be assessed, and about what the National Science Foundation might do to foster innovation generally, and more specifically, through partnerships.

INNOVATION

Although the NSF as yet has not embraced a single definition for innovation, workshop participants generally used the term in a way that focused on the processes and mechanisms for producing commercial applications of new knowledge rather than on the products or outputs from these processes. The workshop discussions implied the following sort of working definition:

> Innovation is the transformation of knowledge into products, processes, systems, and services, with the key elements of underlying innovation being: (1) knowledge; (2) a skilled workforce; and (3) infrastructure.[3]

There was broad support in the workshop for the proposition that innovation drives manufacturing and other productivity growth, which in turn drives economic growth and national well-being. The PFI program seeks to connect, at the project and programmatic level, knowledge creation to innovation, and innovation to wealth, economic development, and, ultimately, national well-being.

---

[2]The viewpoints reported here were those expressed by workshop participants and do not necessarily reflect the positions of the National Science Foundation or RAND.

[3]Definition suggested by John Hurt, PFI program officer.

Regarding the process of transforming new knowledge into innovation, a common view was that although there were few proven formulas for innovation, work at the seams—i.e., work that cuts across traditional disciplinary lines and across university-industry lines—was where the unexpected could be expected to happen, with the result being a more effective innovation process.

Most of the workshop discussions focused on the steps involved in establishing partnerships that can bring an invention into the commercial world. The commercial link in many respects was viewed as the most critical link. Characteristics of commercially useful research were seen to include uniqueness and responsiveness to industry and market needs. Simply identifying potential strategic partners was seen as perhaps the main challenge, largely because of imperfections in information markets: Potential customers for inventions (industry) and potential suppliers of inventions (universities) frequently know very little about one another or where they might find common cause.

Another potential challenge was ensuring the requisite level of compatibility of objectives between university and industry and mutual understanding of (and respect for) differences in objectives. Differences in institutional cultures, time horizons, and confidentiality needs, and the potential for disagreements over royalty shares from intellectual property, were seen to be particularly problematic. Access to a host of other resources—money, personnel, and infrastructure—also were seen as potential challenges. Attendees offered a number of suggestions to overcome these challenges, most of which aimed to improve communications in some fashion or change university policies that hindered the university's ability to contribute to innovation.

The final link in the innovation chain—the spread of benefits beyond the partnership and its immediate customers to the broader local, state, regional, and national economy—received less attention. Nevertheless, workshop participants suggested that localities, regions, states, or nations ultimately compete with one another, particularly in creating new technology clusters that could lead to high-quality jobs and other types of economic development, and that competitive advantages were an important consideration at this level. Neverthe-

less, it can be exceedingly difficult to establish direct connections between a specific innovation and larger economic or societal effects.

PARTNERSHIPS

More often than not, workshop participants described genuine partnerships as dynamic and growing relationships based upon shared interests, trust, and an evolving technical relationship. Participants saw these relationships as necessarily multifaceted, including senior researchers, students, business people, and others who could find common ground and purpose. Some argued that such partnerships were inherently long-term in nature, but a vocal minority argued that innovative partnerships typically lasted only until the original purpose (commercializing the innovation) was achieved, at which time the most innovative partners would move on to the next challenge.

Catalyzing partnerships with these characteristics was seen to be very challenging. Partnerships required a vision and performance goals and benchmarks, passionate and visionary leaders, and partners who were bound by an essential interdependency and shared commitment. Moreover, to achieve success these partners needed to identify their competitive advantages (and disadvantages), resolve potential intellectual property (IP) disputes, and develop and execute strategic business plans. Continued communication and conflict resolution also were needed once the commercial phase was under way. In short, workshop participants warned that many centrifugal forces can pull partnerships apart and only one—the shared commitment and interdependency of the partners—can hold them together.

The workshop also addressed the sorts of infrastructure that can sustain and nurture the spread of innovative activity over the long term. Workshop deliberations described infrastructure of three general kinds: for developing human capital, for developing networks, and for providing direct support for the innovation enterprise.

- To educate and train human capital for the research enterprise—and the entrepreneurial aspects of innovation—workshop participants saw the requirement for an innovative educational process whose most important goal was to serve the student, to

provide hands-on education, and then to recruit and retain the best young scientists and engineers.

- The intellectual capital and know-how embodied in young scientists and engineers, honed through advanced education and training, is embedded in social networks characterized by shared commitment and trust. Such networks can be built through extended interactions and problem-solving, and represent a form of social capital that, in some workshop participants' minds, seemed to be the most important type of infrastructure of all.
- Finally, a base of operational support is essential, because sustainable partnerships cannot exist without such support. Ultimately, this was viewed both as a resource issue—a diversified base of private investment—and as a physical place that can provide a context for incubation; technical, management, and administrative support; laboratory and other capacity; communications services; and reliable sources of capital. The importance of support for federal innovation programs from at least one key constituency—the Congress—also was seen as critical.

A final aim of the PFI program is to broaden the participation of all institutions and people in the innovation enterprise, including underrepresented and underserved institutions and individuals. Workshop participants seemed to agree that this can successfully be accomplished through a solicitation and selection process that rewards quality; none argued that by including such institutions technical standards would necessarily suffer.

IMPLICATIONS FOR THE NSF

Two major points affecting both the PFI program and NSF came out of the workshop.

First, there was nearly unanimous support for a formal evaluation of the PFI program by an independent, paid evaluator. Such an effort was viewed as being consistent both with the NSF's general commitment to evaluation as an aid to outcome-based management and with its specific obligations under the Government Performance and Results Act of 1993 (GPRA). According to participants, such an evaluation should focus on the most critical questions related to innova-

tion and the partnerships and should provide outcome and process measures for individual projects and the program as a whole.[4]

Second, the workshop endorsed both an expanded NSF role in promoting innovation and partnerships through the PFI program and continued efforts by the NSF to further diversify and better exploit synergisms in its support for innovation. The presentations and workshop discussions evidenced substantial enthusiasm for the PFI and other NSF programs that support innovation and university-industry collaborative efforts, without favoring any particular model (e.g., PFI) over any other (e.g., Industry/University Cooperative Research Centers, or I/UCRCs).

However, the workshop left unaddressed a number of critically important strategic-level questions that the NSF should consider in current and future planning: How can the NSF refine its understanding of the relative effectiveness of its innovation programs in promoting its objectives? Which of the available programs and models is the most appropriate tool for the NSF to use under which circumstances? In what ways can (or should) the NSF exploit synergies between programs (e.g., partnerships that are incubated in an engineering research center (ERC) or I/UCRC)? In what ways can (or should) this mosaic of programs be considered together as a larger whole to ensure that the NSF's enterprise-wide portfolio of innovation-catalyzing programs matches its strategic intent and its presumed desire to achieve an optimal program mix and level of diversification? What is the best balance or tradeoff among the various potentially conflicting imperatives (e.g., education and workforce development, academic research, innovation, and diversity)? What factors are associated with the success or failure of technology partnerships, networks, and clusters?

Insofar as these questions seems to be at the heart of the NSF's effort to build a new foundation for innovation in the new century while remaining true to its historical purpose, they are particularly deserving of further analysis, discussion, and debate.

---

[4]One reviewer of this report suggested that another way to categorize the metrics for evaluation would be in terms of input, output, outcome, and in-process metrics.