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REPORT

Sustaining the Qatar National Research Fund

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Preface

Established in 2006, the Qatar National Research Fund (QNRF) is now five years old. It launched two successful grant programs almost immediately, the Undergraduate Research Experience Program (UREP) and the National Priorities Research Program (NPRP). By 2011, QNRF had awarded \$345 million through these programs, with the total number of recipients hailing from no fewer than 60 countries. The UREP alone had awarded over \$16 million to support student participation in more than 500 research projects. Other successful QNRF programs now include the Secondary School Research Experience Program, the Young Scientists Research Experience Program, and the Conference and Workshop Sponsorship Program.

By 2008, as QNRF's future began to unfold, the need for further study of its evolving responsibilities and potential challenges, as well as the conditions for its continuing success, became apparent to the leadership of Qatar Foundation for Education, Science, and Community Development (QF) and QNRF senior management. They wanted a careful analysis of what would be needed to sustain the fund well into the future, so they turned to the RAND-Qatar Policy Institute (RQPI), which had played a formative analytical and implementation role in the establishment of QNRF, for an answer to the question of sustainability, as well as for recommendations on how to secure that outcome. To address this question, RQPI assembled a multidisciplinary team: scientists, policy analysts, cultural anthropologists, and other professionals who had participated either in establishing QNRF or in helping similar organizations analyze and improve their research-granting efforts. Since 2006, RQPI has also helped QF carry out the business and implementation plans that it drafted for QNRF and that QF's board of directors approved in 2004, and it has contributed to QF-led efforts to develop procedures and structures for governance of QNRF.

During QNRF's first half-decade, new circumstances arose—most notably, the passage of Decree-Law No. (24) of 2008, which expanded QNRF's mandate dramatically. As of 2011, however, the legislation embodied in Decree-Law No. (24) of 2008 had not been implemented. At the outset, therefore, it should be acknowledged that this report was written with the 2008 legislation very much in mind, in part because most of the research and writing took place when that legislation still seemed to be in play—and even seemed on the verge of being implemented. Although that no longer appeared to be the case by 2011, references to Decree-Law No. (24) of 2008 remain in this report, in part because that legislation set higher standards for QNRF, particularly regarding governance issues, but also because these standards relate to the prospect, which seems likely, of QNRF eventually having to develop and manage sources of funding for research that are external to itself or QF. Meeting such standards—setting the “achievement bar” higher than before—is itself a worthy goal, regardless of the standards' legislative origins or prospects; it is also a good strategy and recommendation for sustaining QNRF well into the future.

This report will be of interest to officials of QF, QNRF, and the government of Qatar who are involved in making decisions on research issues related to the country's overarching vision for its future. It should also interest the broader research community in Qatar and elsewhere that has followed QNRF's development to date.

This research was conducted under the auspices of RQPI and the Transportation, Space, and Technology Program (TST) within RAND Infrastructure, Safety, and Environment (ISE).

The RAND-Qatar Policy Institute

To study some of the most important issues facing the Middle East, RAND and the Qatar Foundation for Education, Science and Community Development formed a partnership that in 2003 established RQPI in Doha, Qatar. RQPI is an integral part of Education City, which is being developed by QF under the leadership of Her Highness Sheikha Moza Bint Nasser. Education City is a community of institutions—both K–12 and universities—contributing to education and research in Qatar and the Gulf region. RQPI is a regional office that facilitates delivery of the full range of RAND's capabilities to clients in North Africa, the Middle East, and South Asia—roughly, from Mauritania to Bangladesh.

Further information

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Summary

In the half-decade since its launch in 2006, the Qatar National Research Fund (QNRF) has become a vital part of a national vision that sees research as a means of securing economic and educational gains—of generally creating positive change—both in Qatar and in the Gulf region. Established by the Qatar Foundation for Education, Science and Community Development (QF), QNRF awards research grants to recipients at all levels, from undergraduate to professional, in a wide range of disciplines in Qatar and abroad. Its flagship program is the National Priorities Research Program (NPRP), which has distributed \$345 million in grants thus far to professional research teams. The smaller Undergraduate Research Experience Program (UREP) is also a multimillion-dollar endeavor, having enabled more than 1,100 undergraduates in Qatar’s universities to participate in faculty-led research projects. These and future efforts seek to build domestic research capability and cultivate what the QF leadership refers to as a Qatari “research culture”—a concept with an illustrious precedent in the Golden Age of Arab-Islamic science during the 9th and 10th centuries.

The first five years of QNRF’s existence have also brought changes that have significantly expanded, at least in principle, its original mandate. In 2008, the Amir of Qatar, His Highness Sheikh Hamad bin Khalifa Al-Thani, issued Decree-Law No. (24) of 2008, which raised Qatar’s annual investment in research and development (R&D) to 2.8 percent of total annual government revenue and announced at the same time a new institution: the Qatar Foundation for the Support of Scientific Research (QFSSR), which was tasked with setting national priorities for spending this investment over time. The new law made QNRF the QFSSR’s implementation arm, responsible for carrying out the decisions of the QFSSR’s board of directors and administering funding for board-approved R&D projects.

This legislation has not yet been implemented, but the relationship it envisions between the QFSSR and QNRF, as well as the future role it suggests QNRF will have to play in developing and managing external sources of funding for research, raises QNRF’s profile appreciably, potentially requiring it to operate at the highest levels of the Qatari government and giving it unprecedented visibility. In addition, the total amounts of funding QNRF could conceivably be managing are an order of magnitude larger than its original funding. Thus, QNRF not only will need to continue performing all of its previous tasks but also may need, at some point in the future, to take on numerous new tasks, many outside the scope of its previous experience. These are demands that QNRF’s early planners did not anticipate.

In view of the fund’s potentially changing role, QF wanted to determine what might be needed to ensure its sustainability in the decades to come, and QF’s leadership engaged the RAND-Qatar Policy Institute (RQPI) to investigate this issue. Following systematic analysis of the issue, RQPI provided a twofold response: QNRF will need to (1) make measurable progress toward achieving its core mission of fostering a research culture in Qatar and (2) evolve its governance structure and related infrastructure to accommodate potential new responsibilities.

Pursuing a multi-method approach, RQPI assessed how well QNRF has done to date on both counts.¹ This report presents RQPI's recommendations for how best to continue pursuing these parallel objectives well into the future.

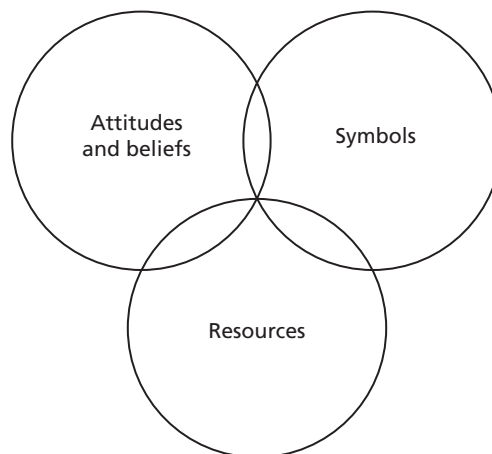
The Need for QNRF to Make Measurable Progress Toward Fostering a Research Culture in Qatar

In RQPI's assessment, *measurement* is the essential requirement for QNRF sustainability in making progress toward establishing a Qatari research culture. The key to constructive measurement is informative metrics directly linked to QNRF's goals. QF's concept of a contemporary research culture in Qatar is novel—there is no widely agreed-upon definition of this notion (as opposed to “culture” more broadly) either among researchers or in the available literature. RQPI's first task, then, was to define the concept. The definition offered is a working one that lays a solid foundation at this early stage in QNRF's development and points directly to metrics. QNRF is young, and building a research culture is an ambitious, long-term endeavor; consequently, this definition will inevitably need to be refined over time.

A Working Definition of a Qatari Research Culture

RQPI's working definition of a Qatari research culture encompasses three sets of characteristics of a shared community of researchers: attitudes and beliefs, symbols, and resources (Figure S.1). The first two of these are considered by many cultural anthropologists to be core elements of any culture. The Qatari *research* culture will have attitudes, beliefs, and symbols particular to research and to Qatar. Resources are not a part of cultural anthropological discourse, but they are essential to a research culture.

Figure S.1
Characteristics of a Research Culture



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¹ Methods included interviews, surveys of international best practices, benchmarking, literature reviews, and analysis of existing data from QNRF programs. The RQPI team also drew on the deep firsthand knowledge of QNRF's structure, organization, and administration it has gained over five years of working closely with QF and QNRF.

This working definition applies primarily to the research community centered in Qatar University and Education City, the community in which the fledgling QNRF can produce measurable accomplishments and in which a Qatari research culture will begin to thrive. If, after this initial research culture is well established, there is a desire to foster a broader national Qatari research culture, this community will form its core.

There are many specific examples of each of the sets of characteristics in the working definition. These examples will become evident as the Qatari research culture takes shape. When the culture is thriving, all will be present. The overarching goal is to be able to measure each characteristic to be able to develop it further.

Attitudes and Beliefs. This set of characteristics relates to how and what members of the research community think, what they value, and how they behave as part of a collective society. A flourishing research culture in Qatar will encompass the following attitudes and beliefs:

- Researchers emphasizing common priorities
- Researchers agreeing on the need for quality-assurance processes to ensure the highest-quality research
- Participants in the research culture in Qatar gaining a sense of esteem from being a part of the research community
- High levels of job satisfaction unique to participants' experience in Qatar
- Commitment to the Qatari research culture and community.

Symbols. The set of symbols includes items and markers that members of the Qatari research community use and value equally. Symbols are *evidence* of the research culture's attitudes and beliefs. A thriving research culture in Qatar will contain the following symbols:

- Research being funded and carried out and innovations created that directly address problems of interest to Qatar, the region, or the world, enhancing life and the environment
- QNRF grant programs attracting substantial numbers of applications, as many as possible led by Qatari principal investigators (PIs)
- Research teams publishing completed research
- Qatar's international research profile rising
- Human capital being built within the research community
- Students engaged in research receiving good mentoring and participating in research-related activities.

Resources. The resources of a research culture include the material and physical assets that make the culture operational. A thriving research culture in Qatar will have the following resources:

- Committed local institutions
- Financial stability and sustainability
- Professional researchers
- Research infrastructure (e.g., equipment, facilities).

Metrics for Assessing QNRF's Progress Toward Developing a Qatari Research Culture

The metrics QNRF should use to measure its progress in building a Qatari research culture should stem directly from the sets of characteristics. QNRF has already begun to take some measurements, and it should start taking others as soon as possible. Not every characteristic of a Qatari research culture has clear metrics at this time, but by measuring those that do, QNRF can gain insights to increase its ability to measure progress.

Metrics to Measure Attitudes and Beliefs. To measure *the sense of esteem that participants gain from being a part of Qatar's collaborative research community*, QNRF can use "referent identification," that is, the researchers to whom the members of the community compare themselves. Perception surveys that indicate that Qatari respondents perceive themselves to be the equals of members of other esteemed research communities would indicate that Qatar's research culture is taking hold. QNRF could add questions to its online surveys to measure the sense of esteem mentors, students, and others gain from being part of the UREP, NPRP, and the larger Qatari research community. Similar surveys could be administered to other key groups.

Metrics to Measure Symbols. To measure the degree to which QNRF is *funding successful research that directly addresses problems of interest to Qatar, the region, or the world*, QNRF can

- Conduct regular surveys of the research being done in Qatar (e.g., QNRF's current Biennial National Research Survey [BNRS])
- Use existing reporting requirements for QNRF-funded research projects to make in-progress assessments
- Require deliverables from QNRF-funded research projects.

To measure QNRF's progress in *attracting substantial numbers of high-quality applications for QNRF grant programs*, QNRF can

- Gather information on the numbers of applicants and grants awarded for each program and periodically examine participation and award rates across institutions
- Examine the distribution of scores given during the peer-review processes of both the UREP and the NPRP
- Collect and analyze data on proposals.

To measure the extent to which *research teams are publishing the results of completed research*, QNRF will need to establish core metrics for publications in peer-reviewed journals. While QNRF does not yet take such measurements, it plans to tally the numbers of publications by QNRF-funded research teams, publications in "influential" journals, and citations of QNRF-funded publications.

QNRF can use media surveys to measure the *rising international profile for Qatar as a research leader*. QNRF already gathers information on the press and news-media coverage it receives. Formal analysis of these data can indicate Qatar's status within the international research community and the influence of QNRF-funded projects.

Metrics to Measure Resources. To measure the extent to which *a local network of high-quality research institutions and facilities involved in QNRF-sponsored research* has been established, QNRF can tally the number of institutions and the amount of research facilities and equipment they have. It can benchmark the quality of the facilities and equipment against

that of other international research institutions and can survey funded researchers and grant applicants to assess whether Qatar's research infrastructure is attractive enough to draw good researchers to QNRF-funded projects.

QNRF's Progress to Date in Fostering a Research Culture

The data available from metrics QNRF is already using indicate that the fund has generally done well in laying the foundation for a research culture. These metrics include assessments of the application and award processes of the NPRP and UREP, peer-review scores, and demographic information on grant applicants.

The number of students and mentors participating in the UREP has risen during each funding cycle, and more Qatari students have taken part in each successive cycle. This and the general improvement in the quality of proposals being received are solid evidence that the characteristics of a research culture have begun to take root in Qatar.

A number of Qatari PIs have submitted grant proposals to the NPRP. In the first funding cycle, however, the number was a small fraction of the total and the proposals were relatively less successful. In a flourishing Qatari research culture, QNRF will receive many high-quality applications from Qatari PIs. While QNRF has made some headway on this front, improvement is needed. QNRF should take further steps to encourage Qatari PIs to participate in the program and should help them gain experience in formulating competitive proposals.

Future QNRF Actions to Ensure Continuing Measurable Progress

QNRF should build on the current characteristics of a Qatari research culture, further developing them and putting other, new characteristics in place. Metrics, again, are key. QNRF already uses a number of metrics to appraise symbols and resources. The goal should be to make every characteristic measurable. Metrics to measure attitudes and beliefs should be a special focus.

Specific recommendations include the following:

- Increase measurement of research outcomes
- Base future QNRF metrics on the working definition of a Qatari research culture
- Use surveys to determine job satisfaction and commitment among researchers
- Continue to promote a social research community.

QNRF should also *balance extrinsic and intrinsic motivations for researchers to participate in the Qatari research culture*. Extrinsic motivations include ample available funding and salary levels. Intrinsic motivations include the sense of esteem gained from being part of the Qatari research community. When these are balanced, QNRF will attract researchers not simply because they are *paid to participate* in the community, but because they also *want to belong to it*. QNRF should create initiatives to achieve the latter, while keeping grant award levels in line with those of other organizations.

Evolving QNRF's Infrastructure to Accommodate New Responsibilities

The original 2004 QNRF business plan recommended a board-based governance structure, with a start-up manager in its early stages. A permanent director was to replace the start-up

manager after the fund was established. But senior QF management modified these recommendations, deciding that an ad hoc steering committee offered advantages over a board of governors for the start-up phase. Senior management also decided to postpone appointing a permanent director and to name a director pro tem or start-up director instead, giving that person the title of Director until a full search was undertaken to fill the position.

In late 2008, after QNRF had successfully administered at least one round of both the NPRP and the UREP, senior QF management decided to move forward with the original governance model. But that same year, the Amir issued Decree-Law No. (24) of 2008. The projected expansion of QNRF's roles and responsibilities called for in this new legislation suggested that not only the governance plan but also QNRF's funding model, organizational structure, and staffing levels might need to be modified.

The Original Model for QNRF's Governance

Board of Governors. The board-led governance model envisioned by QF was similar to that of the National Science Foundation (NSF) in the United States. The governing board was to establish QNRF's overall direction, set policy, approve selection criteria for grant programs, and provide institutional oversight, ensuring the sound and timely implementation of QNRF's mission and goals. QF would hold the board ultimately accountable for the performance of the NPRP, the UREP, and the BNRS. The board would also select the permanent director of QNRF, giving him or her the authority to run the fund on a day-to-day basis. The board would participate in evaluations of both its own performance and that of the fund, but it would avoid micromanagement. Typically, board members were to serve four-year terms. Members of the board were to represent the diverse subject areas that receive QNRF funding. The majority were to be Qatari nationals to help ensure that QNRF programs serve long-term national interests. Some members were to be international to encourage cross-border research collaborations and provide knowledge of international best practices. One board member was to be a QF representative, given QF's role as QNRF's founder and funding source. The board was to have either eight members (one for each main QNRF subject area and one to represent QF) or nine (if a chairperson was appointed). The permanent director was to be an ex officio, non-voting member who would work with the board to execute QNRF policy and planning.

Five criteria were to guide the selection of board members:

- Established reputation
- Experience in decisionmaking
- Expertise in governance and management
- Subject-matter expertise in one or more of the areas supported by QNRF programs
- Lack of apparent or perceived conflict of interest.

These criteria were intended to build confidence in the objectivity and trustworthiness of the board's guidance.

Permanent Director. The QNRF director was originally intended to be responsible for both giving the fund long-term direction and managing it on a daily basis. Programmatic leadership was to be a key responsibility. The director was to implement QF's vision for QNRF, crafting funding activities and operational plans and serving on the governing board. The director was also expected to ensure that the fund was able to fulfill its mission effectively by,

for example, hiring and supervising staff, reviewing performance and compensation, preparing periodic reports, and certifying financial statements.

Finally, the director was to be responsible for outreach, relationship building, and communications. Building bridges between various interested groups in Qatar and abroad, managing QNRF's formal relationships with key stakeholders, and seeking and cementing funding opportunities beneficial to Qatar all fell within this area of responsibility. Communicating the fund's research priorities and results to diverse audiences was yet another important duty.

The first permanent director was to be appointed by the QF board, and QNRF's governing board would appoint subsequent directors. Candidates could be either Qatari or non-Qatari. The chosen candidate was to complement technical excellence with proven management, leadership, and interpersonal skills. Selection criteria were laid out in the job description. The director was to hold a Ph.D. in the sciences, engineering, the arts, or the humanities. He or she was expected to possess knowledge and experience across academic and professional disciplines and to have a strong grasp of research management. The ability to quickly understand Qatar's research environment, society, and economy was fundamental, as were excellent ties with the international research community and strong skills in relationship building.

Evolving the Original Governance Model and Related Infrastructure to Accommodate QNRF's Potential New Role and Responsibilities

The changes needed to ensure QNRF's sustainability in light of Decree-Law No. (24) of 2008, as well as the likelihood that QNRF would ultimately have to develop and manage external funding of its research agenda, involve both the original governance model and the original funding model, organizational structure, and staffing plan.

Governance Structure. RQPI recommends that QF make two modifications to the original model for QNRF's board of governors: The selection criteria should be revised, and individual board members should be of higher caliber than originally envisaged.

The modified criteria should specify that to avoid any conflict of interest, board members must not be potential recipients of QFSSR or other research funding external to QNRF. In addition, the subject areas in which board members have expertise should be expanded to include not just areas supported by QNRF programs but also those of programs QNRF may manage on behalf of the QFSSR or other external funders of research.

Increasing the caliber of QNRF board members will be necessary to enable the board to maintain a commensurate relationship with the QFSSR board, as well as the governing boards or other sources responsible for providing external funding for research, thus protecting QNRF's interests and making effective negotiating efforts more likely.

As QNRF evolves, the director may have a much higher profile than was originally envisioned and considerably expanded responsibilities. Accordingly, he or she will likely need to combine two very different sets of qualifications—the ability to run a growing grant institution and the stature and experience in Qatar and abroad to manage high-level board relationships. RQPI recommends a two-person, two-position approach to this situation, if and when it arises. One director—a managing director or chief operations officer (COO)—would continue to run QNRF, while another, higher-level executive director or chief executive officer (CEO) would manage the expanded relationships of a future QNRF and interface directly with the QFSSR and other external funders of QNRF research.

Funding Model. To manage a total amount of funding an order of magnitude larger than the original amount, QNRF will need to consider alternative, and probably multiple, funding models. Alternatives include

- Establishing a National Research Council similar to the U.S. NRC
- Establishing national laboratories
- Funding branches of international research centers
- Partnering with private sector firms in R&D
- Building new research centers at universities
- Partnering with government ministries.

Some of these options, particularly those in which funding is solely within Qatar, would be able to absorb productively only a limited amount of funding. This makes the need for multiple models more likely.

Organizational Structure. The potential magnitude of new research budgets in the future and the alternative funding models listed above suggest that QNRF will need to modify its current organizational structure. Setting up a national laboratory, for example, is very different from distributing awards for investigator-led research. There are many possibilities, and the right choice will depend on how much funding QNRF receives from the QFSSR or other external sources and the kinds of programs it is called on to implement—neither of which is yet clear. Given this uncertainty, *any* potential QNRF organizational structure should be highly flexible, with adaptive budgeting mechanisms, and should emphasize positions certain to be needed under nearly any scenario.

Staffing Levels. The number of QNRF staff needed will also be dictated by potentially larger budgets in the future and any new funding models adopted. An increase of QFSSR funding to approximately \$0.5 billion a year, for instance, would require QNRF to at least double its staff. New QNRF staff levels, therefore, should align with the full range of the organization's tasks: those it has undertaken in the past, those directly mandated by Decree-Law No. (24) of 2008, and those that stem indirectly from the new legislation or from other prospects for external funding.

QNRF Progress to Date in Developing Its Infrastructure

As of early 2011, Decree-Law No. (24) of 2008 had not been implemented. Most likely, this situation directly influenced the decisions of senior QF and QNRF management about whether to proceed with recommended changes to QNRF's infrastructure. But other changes had been envisioned well before the legislation was enacted. Movement on those fronts will also be needed to ensure QNRF's long-term sustainability.

In that regard, QNRF has made some progress in evolving its infrastructure as originally envisioned, but challenges remain. QF leadership has selected the former QNRF start-up director as the permanent director, but it has not yet established a governing board. In addition, QNRF's funding model, organizational structure, and staffing levels remain unchanged, still geared toward investigator-driven research in clearly defined fields.

Recommendations

RQPI recommends that QF and QNRF move forward as if the 2008 legislation could become operational at any time, with all of the changes that would bring. Nine members of a new

governing board for QNRF, for example, should be required to be more highly qualified than originally envisioned. Until and unless a tangible QFSSR-QNRF relationship takes shape, the board should remain accountable to QF for program performance, and there should always be a QF representative on the board. The next steps at this point are to have QF leaders generate a candidate list and forward it to QF's executive board of directors for final selection. QF leadership should also develop contingency plans for a two-person, two-position approach to the position of permanent director.

As long as answers to basic questions about QNRF's (and the QFSSR's) potential future roles remain pending, RQPI cannot recommend a particular organizational structure among the possible candidates. But simply expanding QNRF's legacy structure indefinitely will likely prove to be an inadequate way to sustain QNRF well into the future. Therefore, in the interim, QNRF should ensure that any proposed organizational structure is highly flexible and emphasizes positions certain to be needed under nearly any scenario.

By proceeding as described above, QNRF will be well prepared, when the time arrives, to function successfully in the new operating environment implied by its statutory relationship with the QFSSR, as well as with other potential sources of research funding that are external to QNRF itself. This, along with making measurable progress toward building a Qatari research culture, should secure the fund's sustainability for many years to come.

Acknowledgments

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Abbreviations

AC/GPA	Advisory Committee for the GPRA [Government Performance and Results Act] Performance Assessment
BNRS	Biennial National Research Survey
CEO	Chief Executive Officer
COO	Chief Operations Officer
EPO	European Patent Office
EU	European Union
GDP	gross domestic product
GPRA	Government Performance and Results Act
GSDP	General Secretariat for Development Planning
ICT	information and communications technology
IOM	Institute of Medicine
MNC	multinational corporations
NAE	National Academy of Engineering
NAICS	North American Industry Classification System
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NPRP	National Priorities Research Program
NRC	National Research Council
NSB	National Science Board
NSF	National Science Foundation
OECD	Organisation for Economic Co-operation and Development
PART	Program Assessment Rating Tool

PI	principal investigator
QF	Qatar Foundation for Education, Science and Community Development
QFSSR	Qatar Foundation for the Support of Scientific Research
QNRF	Qatar National Research Fund
QSTP	Qatar Science and Technology Park
R&D	research and development
RFP	request for proposals
RQPI	RAND-Qatar Policy Institute
S&E	science and engineering
SBES	social, behavioral, and economic sciences
SBIR	Small Business Innovation Research
STEM	science, technology, engineering, and mathematics
UREP	Undergraduate Research Experience Program
USPTO	United States Patent and Trademark Office
USRA	Universities Space Research Association

Introduction

In 2004, the seed of an ambitious idea took root in Qatar. The leadership of the Qatar Foundation for Education, Science and Community Development (QF)¹ decided to establish a national institution to fund research in a wide range of disciplines. The QF leadership believed strongly that research could serve as a catalyst for expanding and diversifying Qatar's economy, better educating its citizens and training its workforce, and generally creating positive change in both Qatar and the region. It saw the new funding body as a vital part of this vision: The institution was to develop and administer grant programs, workshops, conferences, and visiting-fellows programs to foster what the QF leadership referred to as a "research culture" in the country and build domestic research capability. The Qatar National Research Fund (QNRF), launched in 2006, was the result of this vision.

QF's leaders had been inspired by the celebrated scientific achievements and flourishing culture of scholarship and research that flowered in the Arab world many centuries earlier. The legendary Library of Alexandria in Egypt, established during the Ptolemaic Dynasty, amassed a collection of the world's knowledge that attracted the most accomplished scholars of the day. More scientific discoveries were made during the Golden Age of Arab-Islamic science in the 9th and 10th centuries than in any prior period of history (Armstrong, 2003, p. 170).

With reestablishing such a research culture in today's Middle East as its goal, QNRF seeks to advance knowledge and education in Qatar and abroad by supporting original, competitively selected research in the physical, life, and social sciences; engineering and technology; the arts; and the humanities. It provides opportunities for researchers at all levels—from students to professionals—in the private, public, and academic sectors. Today, QNRF is running two fully operational, multimillion-dollar grant programs. The National Priorities Research Program (NPRP) is QNRF's flagship program for professional researchers. To date, it has awarded \$230 million to multinational research teams in Qatar and more than 30 other countries.² The Undergraduate Research Experience Program (UREP) supports students in faculty-led research projects and has provided \$11.5 million in multiple grants to all of the universities in Qatar, funding more than 1,100 undergraduate students in more than 400 projects. With these accomplishments, the dynamic new QNRF has gained a firm foothold in the international research community and has laid the groundwork for a Qatari research infrastructure.

¹ Founded in 1995 by His Highness the Amir of Qatar, Sheikh Hamad bin Khalifa Al-Thani, QF is an independent, nonprofit organization with a dual mission: to prepare the people of Qatar and the region to meet the challenges of an ever-changing world and to make Qatar a leader in innovative education and research. To work toward these goals, QF has invested substantially in research and education, providing funding for Education City and the Qatar Science and Technology Park (QSTP) in Doha.

² http://www.qnrf.org/nl/director_message/, accessed February 12, 2011.

Ensuring QNRF's Sustainability

Having established its viability as a funding vehicle and won credibility both in Qatar and abroad, QNRF arrived in 2008 at a critical juncture in its development. As the QF leadership and QNRF senior management took stock of QNRF's achievements to 2008 and reflected on how to build on them in the years to come, a key question arose: What would it take to sustain QNRF well into the future?

A vision for QNRF's long-term development was sketched out in early plans for the fund. The goal of establishing a "research culture" still remains at the heart of this vision, but a host of new circumstances have emerged, calling for fresh consideration of what should be done to realize QNRF's ambitions. In perhaps the most challenging of these developments, the Amir of Qatar, His Highness Sheikh Hamad bin Khalifa Al-Thani, issued Decree-Law No. (24) of 2008. This law increased Qatar's national annual investment in research and development (R&D) to 2.8 percent of the Qatari government's total annual revenue. It also created the Qatar Foundation for the Support of Scientific Research (QFSSR) to set priorities for spending this investment over time and to reevaluate them periodically. These developments also brought changes for QNRF, which the law made responsible for implementing decisions made by the QFSSR's board of directors and administering the funding for R&D projects approved by the board.

The new relationship envisaged between QNRF and the QFSSR creates potential demands that were not anticipated by QNRF's early planners:

- QNRF would have a higher profile, operating at the top levels of government and assuming new visibility and prominence.
- It would continue to perform a number of its original tasks, but it would be expected to perform significantly more tasks, many of which are new and different. It would also have to manage new reporting requirements, heavier workloads, a broader scope of work, new programs, and more funding (by an order of magnitude) than before.

These potential new demands add complexity to what will be required to ensure QNRF's sustainability well into the future.

QNRF's Past Progress Toward Sustainability and Recommended Future Steps

The RAND-Qatar Policy Institute (RQPI), based in Qatar's capital, Doha, has served as an advisor and partner to QNRF since its beginning. QF originally approached RQPI in 2004 to develop business and implementation plans for QNRF. Since that time, RQPI has stayed closely involved in the fund's launch and operations.³ When the question of sustaining QNRF well into the future arose in 2008, QF asked RQPI to perform a strategic assessment of how well QNRF has thus far met its original intent and vision and what it will need to do in the years to come to continue to advance toward its goals.

³ In addition to designing and launching the NPRP and the UREP, a QNRF-RQPI team created an initial governance and organizational infrastructure for ongoing operations, established principles to guide program design, and developed a policy for intellectual property rights. See Greenfield et al., 2008, for detailed information about the early period of QNRF's existence.

RQPI drew insights from its firsthand experience working with QNRF to launch the fund's initial programs, reviewed the current status of those programs, and carefully analyzed the implications for QNRF of a host of external developments, including Decree-Law No. (24) of 2008. This work led RQPI to make two recommendations that will likely be crucial to ensuring QNRF's sustainability:

- QNRF should make measurable progress toward its core mission of fostering a research culture in Qatar.
- QNRF's infrastructure for governance, funding, organization, and staffing should evolve to accommodate its potential new responsibilities.

QNRF's Progress in Fostering a Research Culture

To assess QNRF's progress in fostering a Qatari research culture and to identify what it will need to do to continue its pursuit of this goal, RQPI first established a clear working definition of the concept. Consultations with anthropology experts⁴ and a literature review revealed that while "culture" is a term long used by anthropologists, "research culture" is not well defined in the literature, and its meaning is not widely agreed upon. Consequently, RQPI attempted to make the concept concrete, specifically for Qatar. This involved several research tasks:

- Interviews with researchers and leaders in Education City,⁵ Qatar University, QF, and QNRF⁶
- Interviews with QNRF staff
- Careful review of QNRF materials, such as program descriptions and requests for proposals (RFPs).

Using these sources, RQPI identified a set of characteristics that will be present when a healthy research culture is realized in Qatar. It next developed metrics to enable it to assess the degree to which each of the characteristics is currently in place in the country and to make recommendations for the future. The metrics were based largely on extensive benchmarking of well-established research-granting organizations in other nations. QNRF can use the metrics as a baseline for evaluating elements of a Qatari research culture they have successfully established, setting future goals, and continually measuring progress.

Given the complexity—and novelty—of the research-culture concept, it is clear that it will take time for QNRF to realize this goal. The working definition and metrics the RQPI team suggests are a starting point. They will need to be revisited and modified as ongoing assessments of progress are made.

QNRF's Progress in Setting Up and Evolving an Infrastructure

Part of RQPI's original mandate from the QF board of directors was to make recommendations about QNRF's infrastructure, i.e., its governance, funding, organization, and staffing. When QF asked RQPI to analyze how QNRF could best be sustained, RQPI was helping QF

⁴ One of the authors of this report, Margaret Harrell, is a cultural anthropologist; we also spoke to Frederick H. Damon, a professor of cultural anthropology at the University of Virginia.

⁵ Education City is a community of educational and research institutions with campuses in Doha.

⁶ RQPI conducted 15 structured discussions in April and May 2008.

with its recruiting of a permanent QNRF director and board of governors. RQPI was also analyzing whether QNRF should become independent of QF. Once RQPI had determined that, in view of QNRF's potential new QFSSR responsibilities, the original vision of its infrastructure might need to be modified, RQPI conducted a fresh analysis.

RQPI's evaluation of past progress relating to QNRF's infrastructure and its recommendations for the future stem from a set of formal and informal sources. Through ongoing contact with QF officials responsible for QNRF since its inception, as well as continuous participation in the QF's steering committee for QNRF, RQPI had gained extensive firsthand knowledge of QNRF's structure, organization, and administration; hence, it was able to evaluate how well positioned various facets of QNRF's infrastructure are to accommodate changes in the fund's roster of responsibilities. In addition, RQPI analysts spoke regularly with key officials involved in developing potential relationships between the QFSSR and QNRF. They also relied on two key reports (The Center for Effective Philanthropy, 2002, 2004) and on foundation and program reviews in RQPI's original study for the design of QNRF (Greenfield et al., 2008, Appendix A).

Organization of the Report

Chapter Two looks in detail at RQPI's first core recommendation for ensuring QNRF's long-term sustainability: The fund should make measurable progress toward fostering a research culture in Qatar. A working definition of the concept is presented, as is RQPI's assessment of QNRF progress to date and its recommendations for future actions to continue putting the elements of a Qatari research culture in place.

Chapter Three turns to RQPI's second core recommendation: The infrastructure for QNRF's governance, funding, organization, and staffing should evolve in the coming years to accommodate the likelihood of expanded responsibilities. Specific components of the original vision for a governance structure are reviewed, and Decree-Law No. (24) of 2008 is explained in detail. RQPI's recommendations for how QNRF's infrastructure should evolve are then discussed. This chapter also evaluates how QNRF has evolved to date, taking into account both the failure thus far to implement Decree-Law No. (24) of 2008 and the likelihood, regardless of this legislation's ultimate fate, that QNRF itself will have to develop and manage sources of external funding for research. Finally, RQPI's recommendations are presented—with the caveat that QNRF's responsibilities could expand at any time. Chapter Four offers several concluding observations.

Benchmarking is discussed in Appendix A. Appendix B presents lists of measurements used by the U.S. National Science Board (NSB). Appendix C presents a selected bibliography on measuring R&D. Appendix D summarizes the literature on balancing intrinsic and extrinsic motivations. Finally, Decree Law No. (24) of 2008 is reproduced in Appendix E.

Ensuring Long-Term Sustainability: Making Measurable Progress Toward Fostering a Research Culture in Qatar

QNRF's vision of fostering a Qatari research culture—including defining such a culture and being able to measure it—is novel among funding organizations. The analysis and recommendations presented here are only a starting point; fostering a research culture is an ambitious undertaking that will take time. Some of the culture's characteristics will be easier to measure than others, and some metrics will be available sooner than others. The ultimate goal is to be able to measure all of the characteristics and thus be able to improve them and to move steadily toward a fully realized research culture. We used the currently available metrics to assess progress to date; for some of those for which data are not yet available, we describe what QNRF could do to collect appropriate data in the future.

A Working Definition of a Qatari Research Culture

Our working definition of a Qatari research culture¹ encompasses three sets of characteristics of a shared community of researchers: attitudes and beliefs, symbols, and resources (Figure 2.1). This definition is grounded in the cultural anthropological premise that shared attitudes, beliefs, and symbols are generally core elements of a culture.² But a *research* culture also needs facilities, equipment, and funding, so we added a third characteristic: resources.³

Our working definition applies primarily to the Qatari research community that is centered, for the most part, in Education City and Qatar University. We have intentionally limited the scope of the definition to this community, because it is there that QNRF can have a direct and measurable effect. Focusing on this community is also a manageable starting point for such a large endeavor. Over time, as indications appear that the fledgling research culture is flourishing within that community, QF may choose to broaden the definition and its characteristics to encompass the national level.

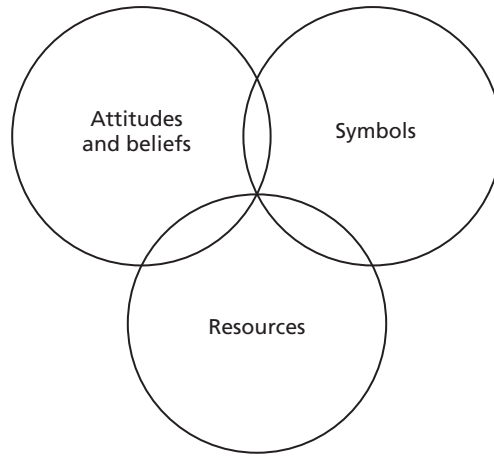
As part of our working definition, we identified the characteristics that will be present when a thriving research culture exists in Qatar. These characteristics can be used to determine the stage of development of the Qatari research culture.

¹ As described in Chapter One, the term *research culture* is not defined in the literature, and there is no widely agreed-upon definition among researchers. Thus, the first step in our research was to create a working definition.

² In 1952, Alfred Kroeber and Clyde Kluckhohn, two American anthropologists, published a work detailing 160 different definitions of culture (Kroeber and Kluckhohn, 1952). Debate over a precise definition of culture continues today.

³ Resources are not normally a part of cultural anthropologists' basic notion of culture.

Figure 2.1
Characteristics of a Research Culture



RAND TR1125-2.1

Attitudes and Beliefs

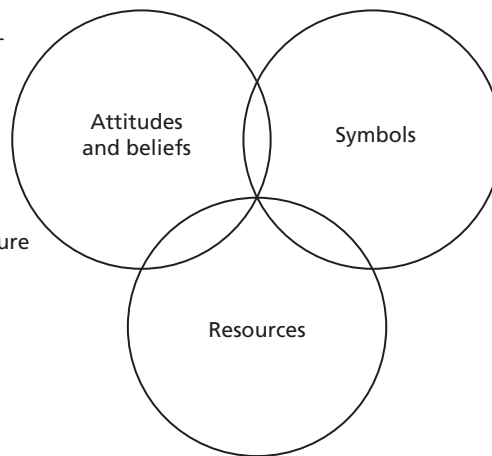
Attitudes and beliefs relate to how and what people think, what they value, and how they behave as part of a collective society. Attitudes and beliefs are cornerstones of a research culture in which many individuals share a common vision and goals and support the culture as a whole (Figure 2.2).

The following attitudes and beliefs are present in a thriving research culture:

- **Emphasis on common priorities.** In Qatar, such priorities include the advancement of knowledge and attainment of the nation’s vision for QNRF.

Figure 2.2
Attitudes and Beliefs That Will Signal a Flourishing Research Culture in Qatar

- Common priorities
- Belief in the quality-assurance process
- Sense of esteem
- High levels of job satisfaction specific to Qatar
- Commitment to the Qatari research culture and community



RAND TR1125-2.2

- **Agreement on the need for quality-assurance processes to ensure the highest-quality research.** Consistently high standards for research promote a sense of identity among researchers as members of an elite research community and reinforce their belief in that community.
- **A sense of esteem gained from being part of a collaborative research community.**
- **High levels of job satisfaction among participants unique to their experience.** Individuals in Qatar’s research community will be highly satisfied with their professional experience there. Researchers will feel job satisfaction unique to their experience in Qatar, in contrast to it being based solely on their profession, regardless of where they are located. Job satisfaction will in turn lead to commitment.
- **Commitment to the research culture and community.** Known by anthropologists as *affective commitment*, this characteristic can be defined as “the strength of an individual’s identification with and involvement in a particular organization” (Porter et al., 1976). Qatar’s research community is unique in that most participants are affiliated with independent organizations (for example, autonomous universities). When Qatar’s research culture is fully realized, its researchers will exhibit affective commitment to the Qatari research community itself rather than to their immediate employers.

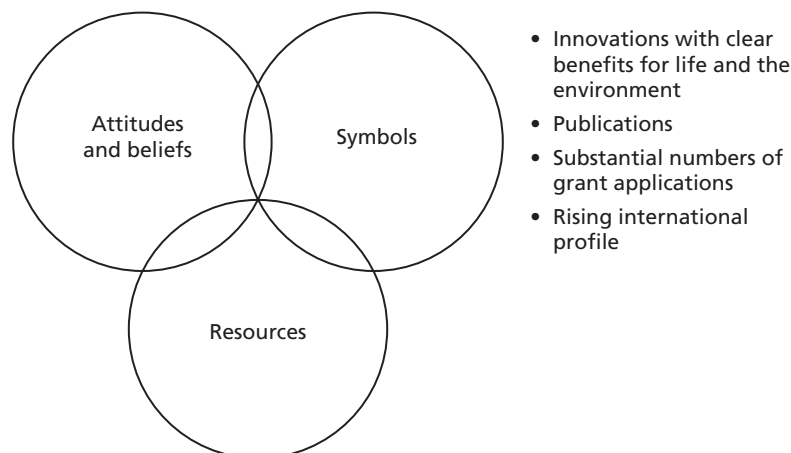
Symbols

The symbols of a research culture include items and markers that members of the community use and value equally (Figure 2.3). They are *evidence* of the culture’s attitudes and beliefs. For example, publications reinforce the shared elite identity of the research community (i.e., the community is elite in part because its work merits publication) and confirm the community’s emphasis on advancing knowledge.

A thriving research culture in Qatar will evidence the following symbols:

- **Research being funded and carried out and innovations being created that directly address problems of interest to Qatar, the region, or the world, enhancing life and**

Figure 2.3
Symbols That Will Signal a Flourishing Research Culture in Qatar



the environment. Innovations from research conducted in Qatar will endure as an output of the research community. They will also confirm the community's attitudes and beliefs. A Qatari research culture will focus research efforts first on Qatar's priorities, which may include, for example, public health, sustainable development, and resource management. Innovations that solve problems elsewhere in the region and help the world as a whole are also important signs of progress toward establishing a flourishing research culture.

- **QNRF grant programs attracting substantial numbers of applications, as many as possible for projects led by Qatari principal investigators (PIs).**
- **Research teams publishing completed research.**
- **Qatar's international profile in research rising.** Qatar will gain recognition and prestige internationally for its efforts to promote high-quality research. Qatari researchers will feel less geographically isolated, and they will integrate with the global research community, to their own benefit and that of Qatar.
- **Human capital being built.** QNRF will be using research funding and related activities (such as conferences and research surveys) to help attract, retain, and develop good faculty at Qatar University and in Education City. It will also be helping other institutions, such as Hamad Medical Corporation, to do so. Fundamentally, human capital is also built by education, which benefits from research, as evidenced by the UREP. As Qatar's research culture grows, the number of students earning higher degrees will be a valuable symbol of progress.
- **Students engaged in research receiving good mentorship and participating in research-related activities.** A key factor in the perceived quality of an undergraduate research experience is being involved in a research culture by participating in a range of research-related activities. These include receiving good mentorship and mentoring fellow students, attending conferences, authoring and coauthoring journal articles, and understanding the broader context of research topics and goals (Russell, Hancock, et al., 2006b).

Resources

A thriving research culture in Qatar will have the following resources (Figure 2.4):

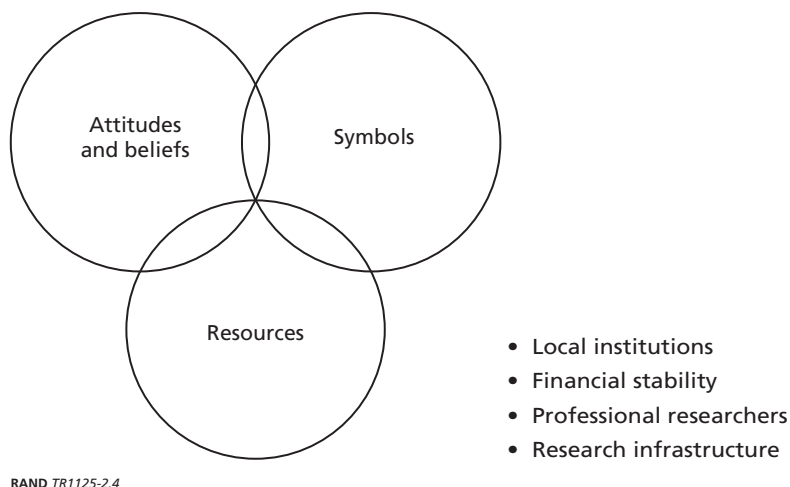
- **Committed local institutions**
- **Financial stability and sustainability**
- **Professional researchers**
- **Research infrastructure.**

Metrics for Evaluating the Growth of a Research Culture in Qatar

To ensure QNRF's sustainability well into the future, QNRF should be making steady progress toward fostering a research culture, and that progress should be *measurable*. Accurate measurement of the characteristics that indicate a flourishing research culture is possible only with concrete metrics that stem directly from those characteristics.

Because QNRF is largely modeled on established research-funding organizations in other countries, we reviewed those organizations to determine how they measure progress in meeting their visions and missions (i.e., how they measure sponsored-research outputs). NSB offers the most comprehensive list of metrics (see Appendix A). Certainly, this list has grown

Figure 2.4
Resources That Will Signal a Flourishing Research Culture in Qatar



considerably over NSB’s long tenure, and we do not recommend that QNRF undertake each of the NSB measurements. Instead, we provide the list as an example of what a leading organization measures to suggest metrics that will be applicable to Qatar and QNRF’s major programs.⁴

On the basis of this list and related research, we have created an initial set of metrics that stem directly from the characteristics of a research culture in Qatar. QNRF has already begun to use some of these metrics. While one of its objectives is to monitor the performance of current QNRF processes to assure quality, identify areas for improvement, and exercise due diligence that QNRF funds are wisely expended, an additional objective is to gather evidence for identifying how successfully QNRF has met its goals to date and how well QNRF programs have contributed to QF’s vision for the fund. In this sense, QNRF has already taken important steps to implement the first of RQPI’s recommendations for achieving long-term sustainability.

Although not all of the characteristics of a Qatari research culture have metrics at this time, by measuring those that do, QNRF can gain insights for developing a more complete set. Building and measuring a research culture is a long-term, continuous process.

Metrics: Attitudes and Beliefs

Among the attitudes and beliefs in a flourishing Qatari research culture will be the sense of esteem participants in the culture gain from being part of a collaborative research community. It is difficult to measure an individual’s sense of esteem, but one approach is to use *referent identification*—that is, the researchers to whom the members of the research community compare themselves. QNRF might take this measurement with perception surveys. If members of Qatar’s research community indicate that they perceive themselves as the equals of members of other highly esteemed research communities, that will indicate that a research culture is being established in Qatar.

QNRF has already taken an initial step in this direction by conducting short online surveys of both participants and non-participants in the UREP and the NPRP to gain understanding of how QNRF can improve participation in the programs and can enhance the

⁴ We selected a subset of the NSB metrics that seem most appropriate for QNRF (see Appendix A).

research experience for researchers, mentors, and students. QNRF could also use such surveys to measure the sense of esteem mentors and students and researchers gain from being part of the UREP or the NPRP and the larger Qatari research community. Similar surveys could be taken of other key participant groups in the community as well.

Metrics: Symbols

Among the symbols that will be evident when a Qatari research culture is in place is QNRF-funded research that directly addresses problems of interest to Qatar, the region, or the world. Projects will be in the process of completion and innovations will be created that help solve these problems. The extent to which these things are happening in Qatar can be measured by, for example,

- Conducting a regular survey of the research being done in Qatar
- Establishing reporting requirements for QNRF-funded research projects
- Requiring deliverables for QNRF-funded research projects.

A Regular Survey of Research. QNRF already provides this metric with its Biennial National Research Survey (BNRS). Slated to be conducted every two years, the BNRS gives a high-level overview of all research being done in Qatar, including that conducted under QNRF. Over time, the research done under the auspices of QNRF grants should occupy a more prominent place in the survey. The core survey approach involves querying all organizations currently doing research in Qatar about publications resulting from the research that appeared in the two years prior to the current survey year. The QNRF conducts internal consistency checks and cross-checks the data when possible to ensure the correctness of all published data. QNRF also has openly solicited corrections to the published database.⁵

QNRF recently issued the results of the first BNRS survey as an online database on the QNRF website.⁶ The survey lists all published research conducted within Qatar from 1970 through 2007.⁷ This comprehensive list helps enable QNRF to determine whether research teams have completed projects successfully. Future surveys will offer incremental data beyond 2007.⁸ The QNRF website includes online facilities that allow researchers to document research conducted between 2008 and the present.

Reporting Requirements for QNRF-Funded Research Projects. Both the UREP and the NPRP have reporting requirements that (on acceptance) trigger the release of additional funding. These requirements include a status/progress report and a budget expenditure report. QNRF compares status/progress reports with the proposed timelines of the projects, notes any discrepancies, and may take appropriate further action, including requests for clarification from PIs, or, in extremis, denial of further funding. QNRF also exercises due diligence

⁵ Because an online database is mutable, QNRF staff can correct data if the evidence warrants such corrections.

⁶ <http://www.qnrf.org>.

⁷ Because of the need to go so far back in time to bring the first BNRS up to date, QNRF not only queried organizations currently doing research in Qatar but also reviewed historical sources and formal reports from Qatar University and the Qatar Planning Council. The Qatar Planning Council was the predecessor organization to the current Qatar General Secretariat for Development Planning (GSDP).

⁸ At the time this report was written, the 2009 BNRS survey was being planned, and results were not yet available.

in examining the reports detailing budget expenditures—again, primarily to identify any discrepancies that may signal problems with the project.

Beyond these immediate uses, the status/progress reports potentially can be used to provide in-progress assessment of program success, while the budget expenditure information can provide insights into the accumulation of physical infrastructure for research in Qatar.

Deliverables for QNRF-Funded Research Projects. Project deliverables provide a simple but useful measure of success. The final payment of a grant is triggered by the delivery of a final report. QNRF defines a final report broadly: It may be a traditional research report or a report documenting the delivery of the final product of a non-technical project (e.g., a music composition, a performance, or a work of art). The final report serves as evidence that the project has been successfully concluded.

A second symbol of a flourishing Qatari research culture will be QNRF grant programs attracting substantial numbers of high-quality applications, many led by Qatari PIs. QNRF can measure the extent to which this is happening by, for example,

- Gathering information on the number of applicants and grants awarded for each program and periodically examining participation and award rates across institutions
- Examining the distribution of scores given during the peer-review process for both the UREP and the NPRP
- Collecting data on proposals.

Information on the Number of Applicants and Grants Awarded for Each Program and on Participation and Award Rates Across Institutions. To date, QNRF has used these metrics to help determine where to expend outreach resources. These efforts seem to have been successful in encouraging more participation and have been useful in indicating where capacity constraints may be required to support increasing participation. Tracking participation rates is also a very direct way to assess whether the numbers of high-quality applications being received are meeting the levels deemed necessary to indicate that a thriving research culture is in place.

The Distribution of Scores Given During the Peer-Review Process for the UREP and the NPRP. QNRF examines the distribution of scores given to proposals in the peer-review process to (1) identify how particular groups of researchers are performing in the proposal process at a given time, (2) identify how a group may improve over time as it gains familiarity with the competitive proposal submission process, and (3) determine the inter-rater reliability⁹ of the review process—in particular, to identify whether any of the peer reviewers consistently deviate from the consensus of their peers in such a way as to cast doubt on the credibility of their reviews.¹⁰

Measuring peer-review scores can also be a way of assessing the quality of applications and whether they are improving over time. Improvements in quality will indicate that the Qatari research culture is developing and becoming stronger.

⁹ This reliability measure indicates the degree to which reviewers agree on the quality of a proposal. A high reliability score is desirable, as it indicates consensus among reviewers and a low likelihood of bias.

¹⁰ QNRF is very cautious in these evaluations of peer reviewers, is inclined to give individual peer reviewers the benefit of the doubt, and in general is very reluctant to tamper in any way with the peer-review process. However, it does reserve the right to take past experience with a particular reviewer into account when deciding whether or not to solicit his or her services in future rounds of QNRF programs.

Data on Proposals. For both the UREP and the NPRP, QNRF issues a detailed RFP, which specifies the format of the proposals and the required data elements. The data gathered from proposals are extensive; they include

- Information that can be used to evaluate the worthiness of the proposal topic (including an abstract, a detailed project description, an argument for the novelty of the topic, and an argument for the potential contributions of the topic to the benefit of Qatar, the region, or the world)
- Information on the capability of the proposed research team to execute the topic (including curricula vitae [CVs] and relevant publications)
- A moderately detailed budget (including price documentation for any pieces of capital equipment).

Demographic data are also collected, including the education, institutional affiliation, nationality, and gender of each of the key members of a research team.

These measures can be compared over time to determine whether the complexity and quality of proposals, as well as the diversity and quality of research teams, are improving with each granting cycle.

Another symbol of a research culture is publication of the results of completed research. The core metrics involved in measuring the extent of such publication concern publication in peer-reviewed journals. QNRF does not yet take such measurements but is planning to do so. The fund intends to calculate the raw numbers of publications by QNRF-funded research teams as well as the numbers of publications weighted by an index rating of the “influence” of the journal in which each publication appears. QNRF will eventually also count citations of published QNRF-funded research.

Another symbol will be Qatar’s rising international profile as a research leader. An effective metric for measuring the extent to which Qatar’s profile is rising is media surveys. QNRF has periodically gathered information on press coverage of QNRF activities and programs, including the date and geographic location of press coverage, as well as the original articles, where available. In addition, QNRF has periodically gathered coverage information from non-traditional media sources (e.g., web pages and blogs). Informal analysis of this information has helped QNRF gauge its success in spreading information regarding its activities to the general public in Qatar, the region, and the world. The QNRRF can also use these data to measure how well Qatar is known and regarded in the international research community for its efforts to promote world-class research and the results QNRF-funded projects are producing.

Metrics: Resources

Resources in a Qatari research culture will include a local network of high-quality, smoothly running research facilities and institutions involved in QNRF-sponsored research. The number of institutions, the amount of research facilities, and the amount of research equipment can be readily measured. The quality of the facilities and equipment can be benchmarked against that of other research institutions. The quality of facilities and equipment can also be assessed through surveys of researchers and grant applicants to determine whether their research needs are being met: Does Qatar provide an attractive enough research infrastructure to draw high-quality researchers to QNRF-funded projects?

QNRF Progress in Fostering a Research Culture in Qatar

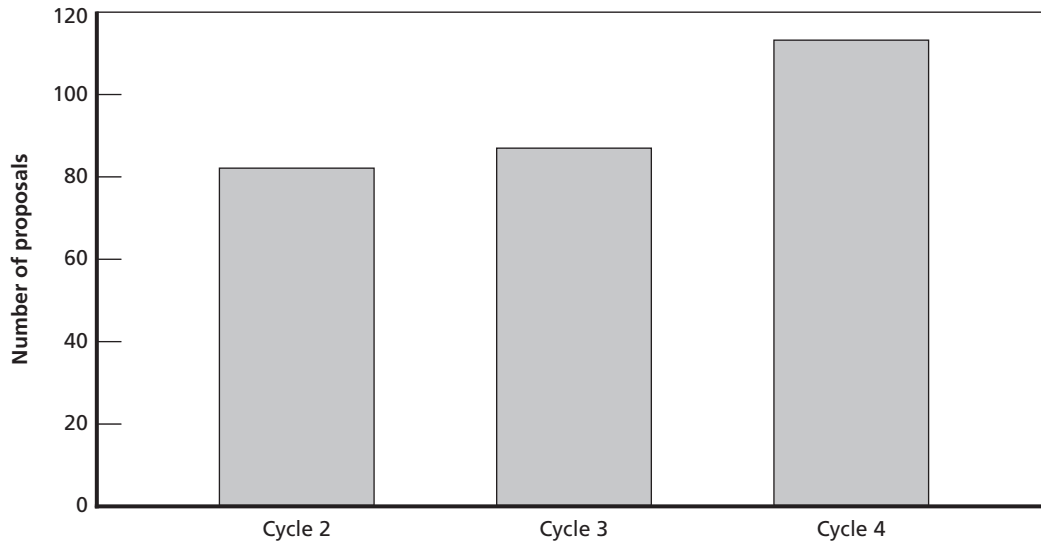
To assess QNRF progress to date in fostering a research culture, RQPI looked at assessments of the application and award processes of QNRF's two major funding programs, peer-review scores, and demographic information on grant applicants.

The UREP

The results of the UREP application and award process have been promising. Figure 2.5 shows that the total number of proposals submitted rose over UREP cycles 2, 3, and 4 (data were not available for the first cycle). In addition, the number of Qatari students who participated in the proposal process increased with each UREP cycle (Figure 2.6). Figure 2.7 shows that the numbers of mentors participating in the proposal process has also increased. The ratio of students per mentor has remained fairly constant at approximately 1.7, well below the maximum ratio of 3.0 allowed in the UREP.

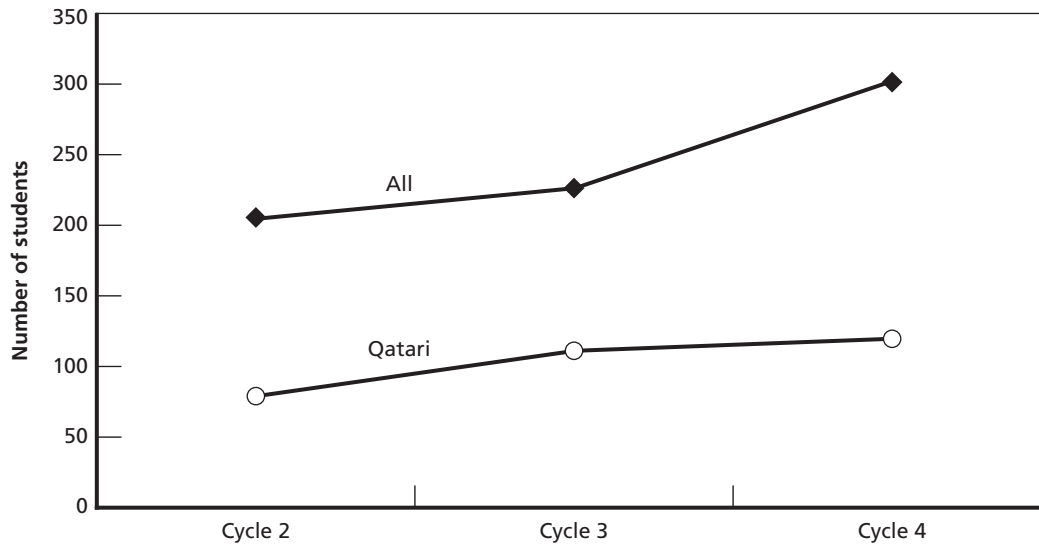
QNRF also tracks peer-review scores for UREP proposals. Figures 2.8 and 2.9 illustrate the distribution of scores for all the UREP proposals, which indicates that the quality of proposals has generally improved over time. Figure 2.8 shows a kernel density estimate of the probability distribution over possible scores for each of the cycles. One can think of these distributions as histograms that are weighted so that the heights of the curves are comparable from cycle to cycle. The weight of the distribution generally moves toward higher scores over time.

Figure 2.5
Increase in UREP Proposals



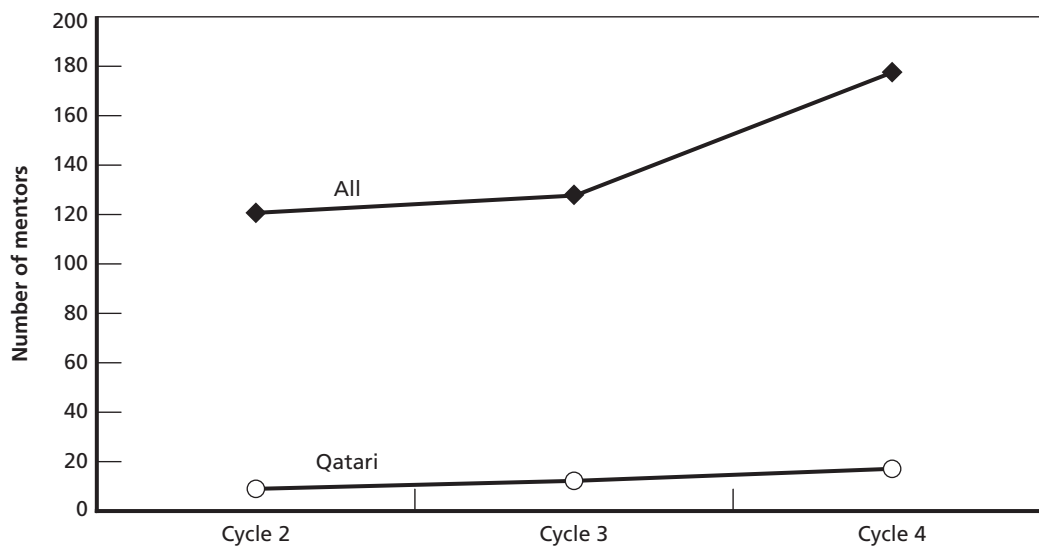
RAND TR1125-2.5

Figure 2.6
Increase in Student Participants in the UREP Proposal Process



RAND TR1125-2.6

Figure 2.7
Increase in Mentor Participants in the UREP Proposal Process



RAND TR1125-2.7

While it is impossible to completely rule out grade inflation as a cause for these distributions, it seems unlikely that it would account for the movement we see between rounds 1 and 2, for two reasons: First, each proposal was reviewed by three to five international peers, and thus a uniform decline in standards seems unlikely. Second, the movement between rounds 1 and 2 is largely due to an improvement in the scores given to proposals submitted by Qatar University; there was a much smaller improvement in the scores given to proposals with PIs from Education City branch campuses. If grade inflation had been taking place, we would expect to see a similar improvement in both sets of scores.

Figure 2.8
UREP Score Densities

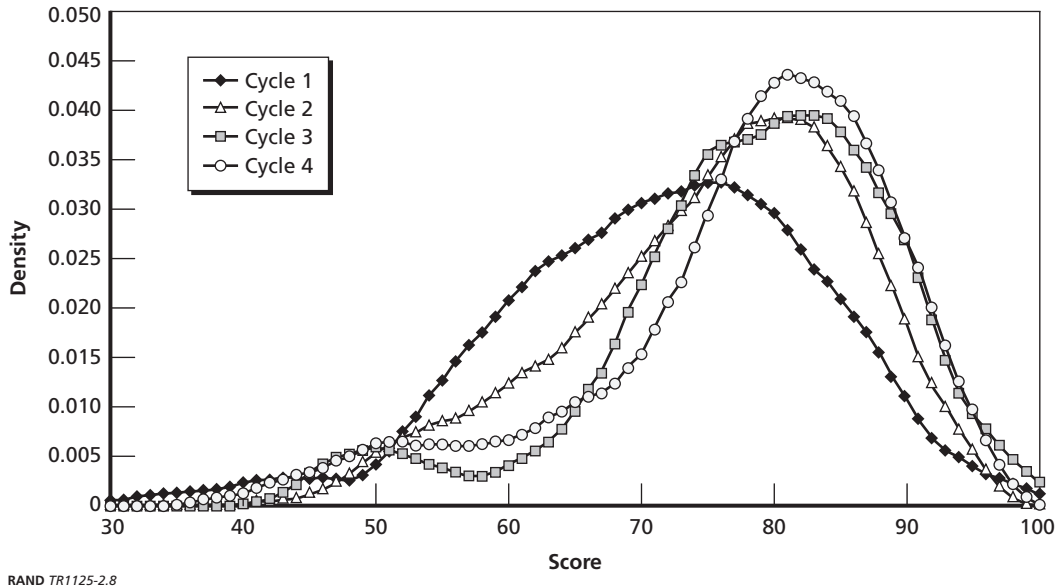


Figure 2.9
UREP Score Cumulative Distributions

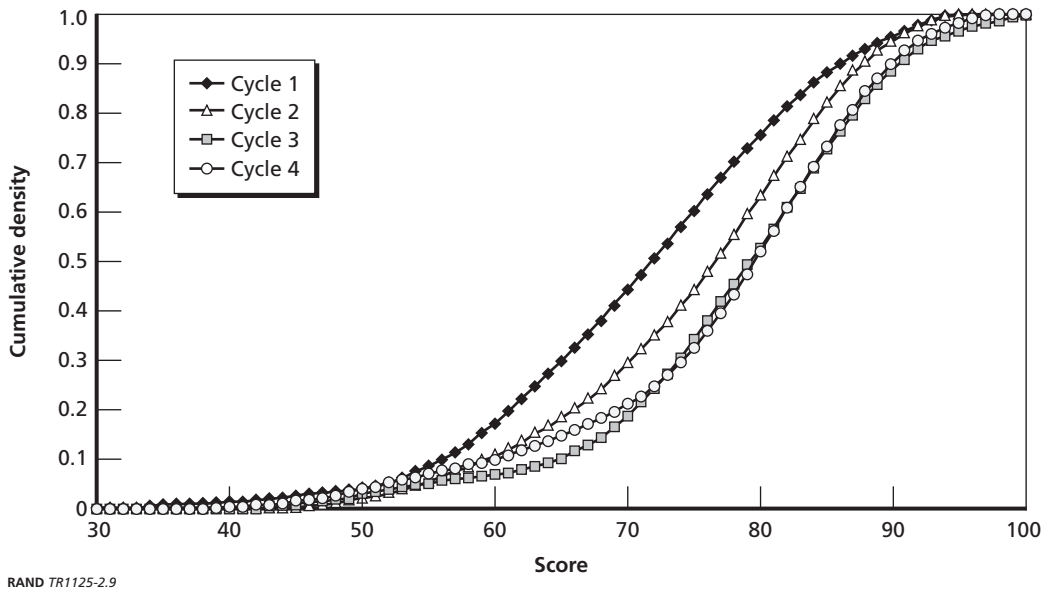


Figure 2.9 shows the same estimates as in Figure 2.8, but presented as cumulative curves. The number on the vertical axis of a curve is the probability that a randomly chosen score was at or below the figure on the horizontal axis. So, for example, if one looks at the number 80 on the horizontal axis and examines the point on each curve that lies directly above the 80, one sees that in cycle 1 the probability of scoring 80 or below was about 80 percent in the first cycle, 60 percent in the second cycle, and about 50 percent in the third and fourth cycles.

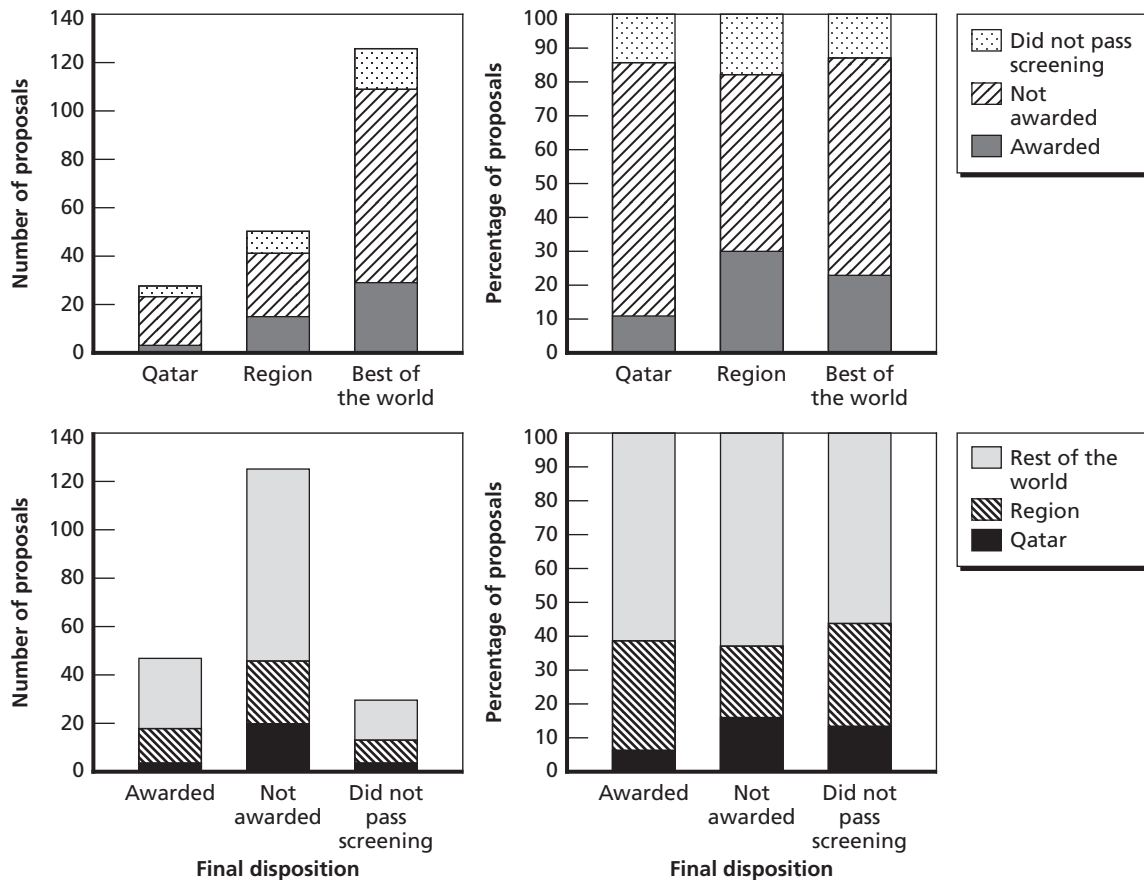
Thus, the probability of scoring 81 or higher has increased over time—from 20 percent in the first cycle to about 50 percent in the third and fourth cycles.¹¹

The NPRP

More than 200 proposals were submitted in the first cycle of the NPRP. Figure 2.10 shows the final distribution of proposals received, by nationality of their PIs, in both absolute and relative terms.

The upper left-hand graph of Figure 2.10 shows that proposals with Qatari PIs constituted a small fraction of the total in the first NPRP cycle. In addition, proposals with Qatari PIs had a lower relative success rate, as shown in the upper right-hand chart. While these fractions are not insignificant, there is room for an increase in both the number of Qatari partici-

Figure 2.10
NPRP Cycle 1 Proposals, by Nationality of PI



RAND TR1125-2.10

¹¹ However, the proposal scores may be reaching a practical limit, as the results for cycles 3 and 4 are nearly indistinguishable.

pants and the scores of proposals submitted by them. The lower two graphs in the figure indicate the same basic result, this time showing that proposals with Qatari PIs constituted only a fraction of the awarded proposals.

QNRN's Achievements to Date in Laying the Foundation for a Qatari Research Culture

QNRN has made significant progress in the few short years since it was established. RQPI believes that it is on a successful path to achieving its vision of a research culture. The UREP and the NPRP have solicited hundreds of proposals and funded millions of dollars of research conducted around the world. QNRN has taken significant strides toward putting in place characteristics that indicate that a research culture has begun to take root in Qatar.

These data give us direct insight into how QNRN is currently doing in terms of receiving many high-quality applications from Qatari PIs. It also provides guidance for what the fund might do to increase the number. What we observe here suggests that QNRN is starting with a local research community that may need further encouragement to participate in the NPRP and that this community may also need more experience or assistance in formulating competitive proposals.

Future QNRN Actions to Continue to Make Measurable Progress Toward Building a Research Culture in Qatar

The metrics QNRN has focused on to date appraise symbols (such as proposal data and reporting requirements for funded projects) and resources (such as research institutions and facilities). This approach is appropriate for QNRN at this early stage of its development, because these are readily available measurements.

For QNRN to continue to make measurable progress, it will need to start putting other characteristics in place. At the same time, as the research culture in Qatar matures, QNRN will need to increasingly take additional measurements to evaluate its progress, particularly on attitudes and beliefs.

We offer the following recommendations.

Increase Measurement of Research Outcomes

Most of QNRN's measurements to date have been about inputs, e.g., researchers' demographics and the quality of their proposals. While QNRN plans to measure some outcomes in the future, such as research publications, many more measurements of research outputs should be taken. RQPI has suggested potential measurements based on its working definition of a Qatari research culture, but QNRN is best positioned to determine which measurements are most applicable to its programs.

Measure Against the Working Definition of a Research Culture

An innovative approach would be to base future QNRN measurements on RQPI's working definition of a research culture. This approach could be iterative, with measurements added or removed as needed. QNRN should consider a modest undertaking to gather, analyze, and publish the data that already exist as a preliminary approach. In particular, measurements about attitudes and beliefs are lacking now but could be made soon.

A Successful Research Culture Includes Motivations

In general, both intrinsic and extrinsic motivations contribute to individuals' job satisfaction, organizational behavior, and commitment. Intrinsic motivations in a Qatari research culture include certain attitudes, beliefs, and symbols, such as the esteem that comes with sharing in the research community's elite identity. Extrinsic motivations include the research-funding opportunities available in Qatar. In any setting, extrinsic and intrinsic motivations ideally should complement each other, with neither category dominating. This should be no less true for the Qatari research community. Some considerations gleaned from RQPI's review of the available literature about these motivations are presented here (this literature is summarized in Appendix C).

The research literature contains many examples of how extrinsic and intrinsic motivations can relate to each other. For example, intrinsic motivations include a work environment that promotes an individual's self-esteem or provides a sense of belonging. An individual may be willing to work in an environment that does neither of these things if his salary, an extrinsic motivation, is sufficiently high. Conversely, an individual may accept lower extrinsic benefits for greater intrinsic benefits.

RQPI's experience with QNRF provides some perspective on how motivations might be balanced in the Qatar research community. QNRF does not control the salaries paid to researchers, but it can affect extrinsic motivations through the maximum level of grant funding it awards. QNRF funding has been an initial extrinsic motivation for researchers to participate in a research community in Qatar. It appears that QNRF's current grant funding levels are consistent with those of other funding organizations around the world.

QNRF is well positioned to affect the balance between extrinsic and intrinsic motivations in the future. For example, QNRF can focus efforts on creating sustained interactions between members of the research community in Qatar that contribute to a greater sense of belonging and engagement. Ideally, the Qatari research community should have a research identity, and participants should be intrinsically motivated to belong to it for reasons such as intellectual interaction and the esteem associated with participating in the community, as well as because of attractive funding opportunities.

Use a Survey to Determine Job Satisfaction and Commitment Among Researchers

Ascertaining the level of commitment among researchers—which is often measured by job satisfaction—is important for understanding how well intrinsic motivations are being promoted within the research community. There is a well-developed body of literature on the design and conduct of surveys to measure this type of motivation. No matter what specific technique QNRF adopts or develops, research indicates that it is essential for respondents to consider the people who administer the surveys to be objective and impartial.

Balance Extrinsic and Intrinsic Motivations for Researchers

QNRF has no influence over the salaries paid to researchers, but it can and does provide external motivation through grant funding. QNRF must stay aware of the grant funding levels of other organizations supporting quality research and not exceed those levels gratuitously. At the same time, it should allow for any increased cost of performing research in Qatar, relative to other locations. A goal for QNRF should be to attract researchers because they *want to belong* to the research community in Qatar, not simply because they are *paid to participate*.

Continue to Promote a Social Research Community

Ideally, the identity of a research community supported by QNRF will be framed as a *research* identity, and participants will be intrinsically motivated to belong for reasons such as intellectual interaction and the esteem associated with participating in the community. Interaction within such a community is key and can be promoted in a variety of ways. QNRF has already been active in hosting events that enable researchers to learn about and comment on each other's work.

Ensuring Long-Term Sustainability: Evolving QNRF's Infrastructure to Accommodate New Responsibilities

The original QNRF business plan recommended a board-based governance structure,¹ since board-based governance models had performed admirably in similar organizations. It also recommended appointing a start-up manager to lead QNRF in its early stages, with a permanent director to be appointed after the fund was solidly established.

During QNRF's early days, however, at the direction of senior QF management, these recommendations were modified. QF management decided that instead of immediately appointing a board of directors, it would set up an ad hoc steering committee, transitioning to a board-based model only after QNRF had matured sufficiently.

The steering committee model offered a number of advantages for the start-up phase:

- A steering committee could be formed immediately. Thus, it would be available to give counsel and direction sooner and more frequently (typically monthly) than an as-yet-unnamed board could.
- Membership criteria for a steering committee could be flexible enough to permit entities eligible to receive grants from QNRF to serve on it. In this way, QNRF could secure valuable "customer" feedback. Such entities would likely be precluded from membership on a board because of perceived or real conflicts of interest.
- A board would have been expected to consist almost entirely of members recruited from outside Education City and QF, while the original steering committee comprised mainly individuals affiliated with QF or Education City entities.

During the launch of QNRF, senior QF management appointed a "start-up director." The person selected, Dr. Abdul Sattar Al-Taie, received the title of Director (eventually, Executive Director) to reinforce his administrative authority, minimize confusion, and bolster his role for interacting with other organizations. When the time came to seek a permanent director, this start-up director was to be eligible to compete for the position.² QNRF's founding documents called for a full-fledged international search to fill the position.

As of fall 2008, QNRF had successfully executed at least one round of each of its major programs (and in the case of the UREP, several rounds) and therefore had reached a certain level of maturity. In appreciation of this development, senior QF management began to move toward appointing both a board of governors and a permanent director.

¹ The original governance plan for QNRF is documented in the RQPI report by Greenfield et al. (2008).

² This had been envisaged in the original plans for QNRF.

Impact of Decree-Law No. (24) of 2008

When Decree-Law No. (24) of 2008 went into effect, both the scope and scale of QNRF's responsibilities seemed slated to change dramatically,³ since the decree called for establishment of the QFSSR and gave QNRF a role to play in support of this new foundation. The QFSSR's basic mission was to finance and support scientific research and technological development that benefit the State of Qatar.⁴ The new decree provided for 2.8 percent of total government revenue to be allocated from the nation's annual budget toward that end.⁵ The decree also made the QFSSR responsible for setting priorities and, ultimately, deciding where the 2.8 percent was to be spent.

According to the new legislation, QNRF's formal role was to support the QFSSR's decisionmaking authority. The law mandates that the director of QNRF report to the QFSSR's board, and it outlines reporting requirements that would tie QNRF organizationally to the QFSSR. In effect, QNRF was slated to become the QFSSR's executive agent, implementing decisions made by the QFSSR board and carrying out a full spectrum of technical and executive tasks related to initiating, regulating, evaluating, and following up on scientific research projects.⁶ The law also requires QNRF to prepare twice-yearly reports on QNRF activities and submit its annual budget to the QFSSR.⁷

Because QNRF houses most of Qatar's resident expertise in research funding, the relationship between QNRF and the QFSSR as envisaged in Decree-Law No. (24) of 2008 created the further possibility that the QFSSR would solicit QNRF support in executing some tasks not directly assigned by the law. This essentially meant that in addition to its primary responsibility—managing research funds for the QFSSR—QNRF could potentially be called on to supply staff members to help meet QFSSR needs.

The projected expansion of QNRF's responsibilities and its potential new role as the QFSSR's executive agent tended to suggest that the original governance plan, including the qualifications initially envisioned for both the QNRF board and the director, needed to change. If the new relationship between QNRF and the QFSSR were to evolve in the way envisioned, it would also have a substantial impact on the funding model QNRF uses, its organizational structure, and its staff levels. QNRF's ability to adapt on all of these fronts seemed likely to play a decisive role in determining its sustainability.⁸

³ The law specifically addresses QNRF in Article (1) and Articles (22) through (26). See Appendix E.

⁴ This mission supports and furthers the educational and economic development goals of Qatar National Vision 2030, which was being formulated at the same time the decree establishing the QFSSR was being finalized.

⁵ This budget allocation decision was made prior to the worldwide economic downturn in late 2008. Qatar seems to have weathered that storm relatively well. As of 2011, there had been no indication of any intent to change the fraction of the government budget devoted to R&D.

⁶ The law specifically addresses QNRF in Article (1) and Articles (22) through (26). These articles mandate many new responsibilities for QNRF: Article (22) specifies nine broad classes of tasks, and Article (23) states that QNRF should actively coordinate with the GSDP.

⁷ Articles (24) through (26) list the administrative responsibilities of QNRF as they relate to the QFSSR, including these reporting requirements.

⁸ In the course of our research for this report, we benefitted from discussions with QF leadership. Those discussions made clear that one long-term expectation was for QNRF to attract, develop, and manage sources of funding for research that are external to the QF funding QNRF has historically received. As envisaged, this external funding would also be separate and distinct from any resources the QFSSR might provide. Thus, regardless of any future relationship of the QFSSR to QNRF

The Original Model for QNRF's Governance Structure

Board of Governors

The board-led governance model originally envisioned for QNRF was similar to that used by the National Science Foundation (NSF) and many other respected national and private foundations and programs. The governing board was to draw on its broad base of knowledge, experience, and interest to establish QNRF's overall direction, set policy, and provide institutional oversight. Among its mandates was ensuring that QNRF's mission and goals were implemented in a sound and timely manner. The board would be accountable to QF for the performance of QNRF's basic programs—e.g., the NPRP, the UREP, and the BNRS. At the same time, it was supposed to select the permanent director and delegate significant authority to him or her, since the director was to run the organization on a day-to-day basis.

RQPI recommended that specific governing-board duties include the following:

- Approving the general policy, operational model, and selection criteria for final awards granted by the NPRP
- Approving the general policy, operational model, and selection criteria for final awards granted by the UREP
- Approving the implementation of new grant programs at QNRF.

RQPI also recommended that the QNRF governing board be actively engaged, i.e., it should participate in institutional assessments, bring “thought-provoking and important concerns”⁹ to the director's attention, provide “financial and strategic stewardship,”¹⁰ and periodically and candidly assess its own performance. Finally, RQPI recommended that QF discourage micromanagement by the board.

It was anticipated that, like members of the Supreme Councils in Qatar, board members would typically serve four-year terms.

Composition and Size of the Board. The original concept was that board membership should ensure representation along several lines:

- **Subject areas.** The members of the board should reflect the diverse subject areas funded by QNRF.¹¹

(and even if no such relationship ever develops, as the current lack of progress tends to suggest), QNRF would still have to deal with the expectation that, in the future, it will need to attract and develop external funding for some of the research efforts it manages. Bearing this expectation in mind, we continue to refer in this report primarily to the QFSSR-QNRF relationship, since that relationship, as described in Decree-Law No. (24) of 2008, enables us to illustrate, with specific examples, a broader future context in which external (but not necessarily QFSSR) funding for QNRF research efforts plays a part.

⁹ Center for Effective Philanthropy, 2002.

¹⁰ Center for Effective Philanthropy, 2002.

¹¹ These subject areas currently include arts and humanities; computer science and information technology (IT); health and biosciences; industry and engineering; physical sciences; public policy and management science; and social sciences. Representation by subject area (as opposed to, e.g., economic sector) was a deliberate design choice. Hopefully, this choice will lead to balanced, equitable, and appropriate funding choices for QNRF's research portfolio. It should also help guard against resources being concentrated solely in those fields that are currently economically dominant. This is in line with QNRF's mission to help diversify Qatar's economy.

- **Qatar.** The majority of the board members should be Qatari nationals to help assure that QNRF implements programs that serve Qatar's long-term interests.
- **The international community.** Since the international research community is viewed as a vital resource, QNRF should actively encourage collaboration between researchers inside and outside of Qatar. To this end, it is important for the board to have several international members. In addition, international members would bring practical knowledge of international best practices in research funding and organizational governance. Ideally, international representation should come not only from North America but also from Europe and Asia.
- **Qatar Foundation.** Because QF has been the historical incubator and source of funding for QNRF, it is important to assure it directly and continually that the governance of QNRF is in good order. This end would be most readily served by having a QF representative serve as a board member.

Ultimately, RQPI recommended that, in line with best management practices, the QNRF board be of a size sufficient to get the job done, but no larger, and that the actual size be determined by the need to meet all four of the main criteria for representation. This implied a board of eight individuals: one person for each of the primary subject areas traditionally funded by QNRF and one to represent QF's interests and vision. An additional member could also be appointed to serve as chair of the board, which would result in a total of nine members. This total was slightly larger than the one originally envisioned in the first RAND business and implementation plans for QNRF, but it was true to those plans in spirit, because a board of this size would be sufficient to ensure representation for the diverse interests served by QNRF.¹²

The permanent director of QNRF was to be an ex officio, non-voting member of the governing board who would work with it to execute QNRF policy and planning. But whether the QF representative on the board should be a voting or non-voting member remained an open question. On the one hand, given its historical and continuing financial role, QF would appear to be entitled to a vote. On the other hand, because of the participation of Education City universities in the competition for QNRF grants, the appearance of a conflict of interest could arise over time. Lack of voting rights on the board would help to counteract any suggestion of a conflict.

Selection Criteria. RQPI recommended that board members be selected on the basis of their ability to fulfill five criteria, each of which was a personal attribute:

- **Established reputation.** Each candidate should have an established reputation that would reflect well on QNRF and help assure that its management would be subject to close scrutiny by trusted and respected individuals.

¹² At the time the details of the size of the board were being worked out, RQPI presented an alternative model that could be used if QF determined that nine was too unwieldy a body for efficient operations or if the number of primary subject areas funded by QNRF was expected to change over time. In either case, RQPI suggested, a smaller board could be constituted along the following lines: four members could represent even-more-generic subject areas (e.g., physical sciences, biological sciences, social sciences, arts and humanities); one member could represent QF; and an additional member (for a total of six) could serve as the chair.

- **Experience in decisionmaking.** Each candidate should have a proven track record of exercising sound judgment when confronted with complex problems.
- **Expertise in governance and management.** Each candidate should have demonstrated experience in management or matters of governance and policymaking, enabling him or her to provide appropriate oversight to QNRF's management of activities.
- **Subject-matter expertise in one or more of the areas supported by QNRF programs.** Each candidate should possess appropriate knowledge within a particular subject area. That expertise should inform decisionmaking, while providing guidance that could advance knowledge and education within the member's subject area.
- **Lack of apparent or perceived conflict of interest.** Candidates should not be directly associated with organizations that could seek funding from QNRF.

These attributes would go a long way toward making QNRF feel confident that it could rely on its board as it sought, developed, and followed guidance on broad policy matters. RQPI's thinking was that these attributes would help to validate the objectivity and, therefore, the trustworthiness of any guidance formulated by the board.

The selection criteria and desiderata for board size and composition were stringent, but stringency was desirable for an institution seeking to establish a reputation for being well conceived, well managed, and above reproach.

Permanent Director

As provided in the original QNRF implementation plan, the director was to be responsible both for providing a long-term direction and focus for QNRF and for managing the fund on a day-to-day basis. To fulfill these responsibilities, the director would need to complement technical excellence with management, leadership, and interpersonal skills.

Responsibilities and Key Relationships. The director was to be responsible for implementing the QF's vision of building a merit-based funding organization that addresses national needs and meets the highest international standards for research and research-oriented education and training. To these ends, the director was deemed responsible for crafting the organization's funding activities and operational plans. Key programmatic leadership responsibilities included

- Recommending the work plan and budget, including the selection of priority research areas, to the governing board
- Receiving program/funding activity input and guidance from the advisory council, through the governing board
- Approving research programs and projects
- Establishing quality-assurance and peer-review standards and ensuring compliance with them
- Serving as a member of the governing board and performing board functions, within limits, as identified above
- Identifying and nominating candidates for membership on the governing board and advisory council.

The director was also to be responsible for putting in place a qualified and capable organization that can effectively fulfill QNRF's mission. Key operational management responsibilities to fulfill the mission included

- Hiring and retaining QNRF staff
- Reviewing performance and compensation for staff
- Managing day-to-day operations, including supervision of staff
- Preparing periodic reports on QNRF financial, program, and other funding activities, as well as management activities for the governing board and QF
- Certifying all financial statements from the chief financial officer (CFO)
- Reporting to the governing board on a regular basis
- Reporting annually, or as otherwise required, to QF
- Assuring QNRF compliance with policies, directives, and requests made by the governing board and with Qatari law.

A critical task for the director would be to promote knowledge of and support for QNRF in Qatar and abroad. This outreach, relationship-building, and communications responsibility was envisioned to have several aspects:

- The director would be the single most important bridge builder between various groups interested in research within Qatar and between Qatar and other countries.
- A related task would be managing QNRF's formal relationships with Education City, Science and Technology Park, Qatar University, and other key stakeholders. This role would extend to actively promoting the application of research results to potential users in Qatar through meetings and workshops.
- The director would need to promote research ideas, continuously look for funding opportunities that are likely to yield benefits for Qatar, and make matches between and among potential research partners.
- Over the longer term, the director would be expected to encourage partnerships and collaborations with other Qatari and international research institutions.
- Finally, the director would need to be able to effectively communicate QNRF's mission and goals, its research priorities and funding activities, and the results of its work to diverse audiences.

Appointment. The director was to be appointed by and serve at the discretion of the governing board of QNRF. The QF board was to appoint the initial director to expedite the start-up of the fund. The director might be recruited either from the Qatari research and education community or from abroad.

The original job description laid out the following requirements for a permanent director:

- A Ph.D. in the physical, life, or social sciences; engineering; the arts; or the humanities
- Proven management and leadership abilities, strong interpersonal and negotiating skills, and grants-administration experience
- Breadth of knowledge and experience across academic and professional disciplines
- An understanding of the management of basic and applied research

- The ability to quickly acquire an accurate understanding of Qatar's educational and research infrastructure and operations and the greater economic, institutional, and social environment of Qatar
- Strong communications skills, including the ability to interact effectively with educators, researchers, businesspeople, officials, and other leading members of the Qatar community
- Well-developed ties with the international research and academic community.

Evolving QNRF's Governance Structure and Related Infrastructure to Accommodate New Responsibilities

Governance Structure

Board of Governors. In light of the new relationship envisioned for QNRF with the QFSSR, modifications to (1) the criteria for selection to the board and (2) the requirements for individual board members appeared to be needed.

RQPI concluded that while the original board selection criteria could largely remain intact, members of the board should not be potential recipients of QFSSR (or other external) research funding. Just as the original criteria excluded potential board members who might receive QNRF funding on conflict-of-interest grounds, the revised criteria need to be expanded to exclude individuals who might receive funding from the QFSSR or some other external source. Also, the criterion that board members must possess subject-matter expertise in one or more of the areas supported by QNRF programs should be expanded to include expertise in programs managed by QNRF for the QFSSR or for some comparable external entity that funds QNRF research projects.

In addition, RQPI concluded, the caliber of the QNRF board should be raised to a higher level than originally envisaged. RQPI reasoned that this would likely be necessary for QNRF to maintain a commensurate relationship with a QFSSR-like board, which would undoubtedly be of very high caliber, if and when it was appointed. A QNRF board that does not carry adequate weight will find it difficult to ensure that the original missions of QNRF are preserved, not neglected, in the potential rush to fulfill QFSSR-like needs. Conceivably, the QNRF board might also be called upon in the future to help the QNRF director negotiate tasking levels with the QFSSR or a similar funding entity and would need the heightened authority to be effective.

Permanent Director. Decree-Law No. (24) of 2008 gave the position of permanent director of QNRF a significantly higher profile than before and expanded its responsibilities. The full scope of the work the director must perform now includes all of the elements of the original job description plus additional elements appropriate to QNRF's changed circumstances. The individual who fills the position must now have two essentially different sets of qualifications:

- The ability to run a growing research grant program successfully
- The necessary stature and experience, both in Qatar and internationally, to manage high-level board relationships effectively.

In other words, a combination of two distinct positions is likely to be required to meet the demands of an expanded role for QNRF, should such a role eventually come to pass—for

example, as a result of Decree-Law No. (24) of 2008 or of QNRF itself having to develop and manage external sources for funding research.

It may be unrealistic to expect that QF will be able to identify and recruit candidates who possess both sets of qualifications. Consequently, RQPI recommends a two-person, two-position approach. A managing director or Chief Operations Officer (COO) who would continue to run QNRF and another, higher-level director or Chief Executive Officer (CEO) who would take responsibility for QNRF's expanded responsibilities under the new law and would interface directly with the QFSSR.

Funding Model for QNRF

On the basis of estimated government revenue for 2007, the 2.8 percent to be devoted to R&D would amount to \$0.76 billion, or 2.8 billion Qatari riyals (QAR) per year. Even if government revenue decreases in subsequent years, the 2.8 percent will still amount to hundreds of millions of dollars. And even if QNRF were to receive only a fraction of the 2.8 percent, the total amount of funding would still be increased by an order of magnitude.

Consequently, it would be prudent for QNRF to consider alternative, even multiple, funding models to support its potential future relationships with the QFSSR or other external funding sources. RQPI suggested several possible models, listed below. The list is not meant to be exhaustive; rather, it is illustrative of at least some of the major alternatives QNRF should consider.

- Expand the investigator-driven NPRP (this can be considered a “baseline” model)
- Establish a National Research Council like the U.S. NRC¹³
- Establish national laboratories or R&D centers
- Fund branches of international research centers
- Fund the full spectrum of phases of R&D (this may cause some overlap with the QSTP initiative)
- Partner with private sector firms in R&D
- Build new research centers at universities
- Fund research outside of Qatar
- Partner with government ministries.

Some of these funding models will face capacity limits. That is, there will be a limit to the amount of funding that can be absorbed productively. This is particularly true for models in which funding is spent solely within Qatar. For example, the “baseline” model of investigator-driven research would clearly face capacity problems—there simply are not currently enough researchers in Qatar. Thus it seems almost inevitable that QNRF will ultimately have to manage multiple funding models.

¹³ NRC functions under the auspices of the National Academy of Sciences (NAS), the National Academy of Engineering (NAE), and the Institute of Medicine (IOM). NAS, NAE, IOM, and NRC are part of a private, nonprofit institution that provides science, technology, and health policy advice under a congressional charter signed by President Abraham Lincoln in 1863. The four organizations are collectively referred to as the National Academies (<http://sites.nationalacademies.org/NRC/index.htm>).

Organizational Structure

It is not immediately clear that the current QNRF organizational structure is appropriate for managing QFSSR or other externally funded programs. The new research budget and each of the funding models we suggest for consideration imply a very different organizational structure. Distributing awards for investigator-led research is different from setting up a national laboratory, for example.

Consider the following possibility: Suppose Qatar's Supreme Council for Health were to ask the QFSSR, or some other funding source in Qatar, to launch a remote-surgery research program.¹⁴ This could have the following consequences for QNRF:

- The fund would have to deal with research grants of significantly larger scope and scale (probably tens of millions of dollars per grant).
- It would have to address a variety of functional challenges and programmatic changes; for example, it would need to learn how to
 - Manage and evaluate consortia (analogous to the difference between grants to individual researchers and grants to “centers of excellence”)
 - Liaise with multiple nations representing both proposing and awarded consortia
 - Field teams of program managers whose expertise spans the breadth of professional credentials needed to select and evaluate multidisciplinary proposals and reviewer evaluations in medicine, robotics, communications, etc.
- It would also need to evaluate, perhaps coordinate, and possibly manage the required research infrastructure. This might include
 - Front-loaded capital spending needed to procure experimental apparatus
 - Supporting the establishment of highly reliable support infrastructure, including communications networks, computational resources, and power
 - Managing operating rooms and theaters in multiple global locations
 - Coordinating global meetings and workspace (virtual and physical) for the consortia members
 - Helping to ensure a sufficient pool of well-trained technicians in multiple disciplines.

This hypothetical possibility demonstrates that funding sources external to QNRF could potentially create a need for it to develop a wide variety of new capabilities, which in turn would have implications for its organizational structure. Simply expanding the legacy organizational structure of QNRF would not be adequate.

Another relevant possibility is similarly instructive. Decree-Law No. (24) of 2008 mandates that the QNRF director report to the QFSSR on activities QNRF might undertake on behalf of the QFSSR. It also calls for QNRF to coordinate with the GSDP in Qatar on matters related to planning and programming.¹⁵ QNRF will therefore likely need an office specifically devoted to government relations and coordination—in this case, with the QFSSR and the GSDP. This office would obtain planning guidance on and clarification of QNRF's roles and tasks; help QNRF develop alternative implementation plans consistent with national leg-

¹⁴ This example concerns the particular requirements of remote surgery. QF has recently initiated a program to enhance national capabilities in robotic surgery, which is an intrinsic element of remote surgery.

¹⁵ See Article (23).

isolation such as Decree-Law No. (24) of 2008; gather and analyze data needed to inform decisionmaking; and revise plans based on feedback from, for example, the QFSSR and the GSDP.

Given these and many other possibilities, it is clear that to ensure sustainability, the fund will need a more flexible and adaptive organizational structure, particularly in light of the current uncertainty regarding the amount of funding it may receive from the QFSSR or from other funding sources external to QNRF and the kinds of programs QNRF may be called upon to implement.

Several key considerations should inform an assessment of alternative organizational structures. These include

- The number and types of *initial* externally funded tasks QNRF will have to perform
- The scope and scale of these tasks and QNRF's current ability to perform them
- The time required for QNRF to be ready to perform tasks it is not prepared to carry out now—and the assumptions needed to implement a plan to become ready
- The number and types of *future* QFSSR-like tasks and functions QNRF will have to perform.

Such considerations suggest that the QFSSR (or other funding sources external to QNRF) will need to provide further information before QNRF can fully assess its long-term requirements. In the meantime, however, QNRF should begin thinking about and preparing questions that will help facilitate such an assessment when the need arises.

RQPI believes that *any* potential QNRF organizational structures should

- Emphasize positions certain to be needed under nearly any scenario (e.g., leadership; support staff for administration, finance, and data management; and staff to support the NPRP and the UREP at current and possibly higher levels)
- Provide flexibility and adaptive budgeting mechanisms from the start. In particular, as new programs are instituted, QNRF will need to gain rapid approval for creating new departments and hiring new staff, and the steering committee/governing board should require (and support the need for) maximum flexibility and adaptability in any future organizational plans.

Staffing Levels and Tasks

The potential magnitude of the budgets QNRF would be called upon to manage under Decree-Law No. (24) of 2008 and the different possible funding models will also directly affect the number of staff QNRF will require. If, for example, QFSSR funding were to increase to approximately \$0.5 billion a year and remain at or near that level, QNRF would have to at least double the size of its staff simply to manage the money.

A comparison with the staffing practices of other funding organizations accentuates the current differences between management and staffing levels at those organizations and the levels at QNRF (Table 3.1). The ratio of funding to number of staff at the two U.S. research organizations shown in Table 3.1 is considerably higher than that at QNRF. Currently, this is mainly a consequence of QNRF not being able to take advantage of economies of scale because it is a (relatively) small organization. But the comparisons in the table strongly suggest that if QNRF becomes responsible for more funding, staff levels will need to increase accordingly. If, for example, QFSSR funding ever, in fact, rises to approximately \$0.5 billion a year, QNRF would likely have to expand its staff to more than 100.

Table 3.1
QNRF Funding Ratio Compared with That of Other Funding Institutions

Institution	Annual Budget (\$ billions)	Full-Time Staff	\$/Staff Member (millions)
QNRF (2007)	0.01	~15	0.7
NSF	6	~1,700	3.5
National Institutes of Health (NIH)	28	~6,000	4.7

NOTE: Data on NSF were obtained from <http://www.nsf.gov/about>; data for NIH were obtained from <http://www.nih.gov/about/budget.htm> (both as of May 1, 2009).

New QNRF staff levels should also be set in line with the full range of tasks that were either directly mandated by Decree-Law No. (24) of 2008 or stem indirectly from the legislation. These fall into three categories:

- Tasks that strongly resemble work carried out at QNRF in the past and that are covered by the fund's originally planned staffing levels
- Tasks that are new in either scope or scale, or both; these may require further expansion of the QNRF staff
- Tasks assigned to the QFSSR (or requirements of some other external funding source) that may require QNRF to provide staff support, at least in the short term; these will also present additional staffing needs.

The following specific QNRF tasks can currently be identified in these three categories.

Tasks similar to work QNRF has done in the past:¹⁶

- Set criteria for evaluating quality and granting awards to scientific research projects on a competitive basis and in accordance with international standards and norms [Article (22) 3]
- Enter into agreements, memoranda of understanding, and contracts related to scientific research projects with national, regional, and international parties [Article (22) 6]
- Sponsor, organize, and participate in local, regional, and international conferences, meetings, seminars, and gatherings related to scientific research [Article (22) 9]

Tasks new to QNRF in scope, scale, or both:

- Coordinate with the GSDP—without compromising the objective quality standards and criteria noted above—on annual research and scientific plans, the intended effects of such plans, and their consistency with the comprehensive vision and general strategic development plan of the State of Qatar [Article (23)]
- Set plans and strategies related to scientific research and submit these to QF for approval [Article (22) 1]
- Determine the areas of scientific research that the comprehensive development plans of the state suggest should have priority [Article (22) 2]

¹⁶ These task lists contain unofficial English translations of the original Arabic law.

- Receive scientific research projects for study; approve their validity, economic or social feasibility, and future effects; and list the same in the annual plan of the fund [Article (22) 4]
- Supervise and follow up on the execution of scientific research and evaluate the results thereof periodically [Article (22) 5]
- Build national capacity in the fields in which QNRF conducts research and verify research results [Article (22) 7]
- Track scientific developments both inside Qatar and abroad, cooperating and coordinating with the parties involved [Article (22) 8]

QFSSR-like tasks for which QNRF might be asked to provide support (to the QFSSR or to some other external source of funds) in the future:

- Declare strategies and policies for scientific research and determine the priorities thereof [Article (7) 1]
- Allocate the amounts necessary to support and finance research, studies, and scientific projects [Article (7) 2]
- Obtain data, statistics, studies, reports, and research related to QFSSR activities from ministries, government authorities, and other competent bodies [Article (7) 3]
- Establish the basis for and rules of QFSSR's cooperation with educational and scientific parties inside and outside the country; set policies and strategies related to such cooperation; and determine appropriate implementation and follow-up mechanisms [Article (7) 4]
- Support and encourage contributions from the private sector and civil society institutions to scientific research activities in Qatar [Article (7) 5]
- Suggest and draft legislative instruments related to scientific research affairs in Qatar [Article (7) 8]
- Help implement any other actions related to scientific research assigned to the QFSSR by the Amir [Article (7) 9]

Tasks that are new in scope or scale greatly outnumber tasks that are similar to what QNRF has undertaken in the past. Thus, as noted above, it seems likely that QNRF would need to increase the number of its personnel to meet both the needs of its current programs and the tasks outline in Decree Law No. (24) of 2008.

Progress to Date in Evolving QNRF's Infrastructure

The changes envisaged in Decree-Law No. (24) of 2008 have not yet been implemented. Indeed, it seems as if the provisions of this legislation exist only in law, not in fact. This limited or attenuated state of development has implications for how well QNRF has done to date in evolving its infrastructure.

Board of Governors

At the time Decree-Law No. (24) of 2008 went into effect, QNRF was well into the process of putting a board of governors in place. The next steps were to elicit a selection of board can-

didates from senior QF leaders and to forward the resulting list to the QF executive board of directors. The QF board was then to select the QNRF board. The selection process would conclude once the new members had been formally invited to join and the invitees had accepted.

In 2009, RQPI worked with QF to identify a list of qualified candidates for the QNRF board of governors, and a slate was forwarded to the QF leadership for vetting. As far as we know, this slate of candidates or one like it remains under scrutiny, but to date, the QNRF board selection process has not been concluded. As of early 2011, no board had been announced. The steering committee established by QF continues to oversee QNRF policies, programs, and operations.

Permanent Director

In 2008, QF formed a search committee to identify qualified candidates for the position of permanent director of QNRF. Members of this committee included senior QF decisionmakers and the director of RQPI. The search committee reviewed, finalized, and approved the draft job description (presented earlier in this chapter) originally prepared by RQPI, and QF retained a recruiting firm whose credentials and experience were appropriate to a search for candidates to fill a high-level, international, academic administrative position. The recruiting firm identified a pool of candidates, from which the search committee developed a short list. The search committee then interviewed several promising prospects, using a set of interview questions provided by RQPI. The search committee narrowed the field to two candidates and forwarded their names, qualifications, and the committee's evaluations to the QF leadership for final review and decision.

This search process began before Decree-Law No. (24) of 2008 was issued. Although the candidates who interviewed for the position in the early stages of the search were asked how they would manage the new responsibilities included in the decree-law, the initial recruiting effort focused for the most part on a lower-level, pre-QFSSR concept of the position, as well as on individuals who met the requirements inherent in that concept. Thus, the search process did not fully take into account the changed, post-QFSSR possibilities of the job. Ideally, these new possibilities should have prompted a wholesale reevaluation of the permanent director's job description. Although the QF leadership acknowledged the need for such a reevaluation, it has yet to occur, not least because the provisions of the legislation have failed to materialize.

The new law did serve, however, to focus higher levels of attention in QF on the director position, as it became evident that that job would assume added importance and responsibility in the future. Consequently, senior QF management became even more painstaking in their evaluation of available candidates. Over time, however, when it became clear that development of QFSSR-QNRF relationships as envisaged in the 2008 legislation had effectively ground to a halt, and since the QNRF start-up team had proved its effectiveness in launching the organization, the leadership of QF confirmed as permanent director of QNRF one of the candidates selected as a finalist in the international search effort—namely, the former start-up director and current executive director, Dr. Abdul Sattar Al-Taie.

Funding Model, Organizational Structure, Staffing Levels, and Tasks

Funding of QNRF's research programs has remained largely ad hoc and under the continuing purview of QF. The fund's current organizational structure also remains the same. Staffing levels and tasks continue to follow the expansion plans originally approved by the steering committee and QF leadership in March 2009. At that time, QNRF was planning to expand its

staff to between 40 and 50 people to support current and projected QNRF programs. QNRF and QF leadership also planned to engage with the QFSSR, once it was established, to understand what types of QFSSR programs QNRF might need to support and to make further staffing decisions in light of the new information. Such discussions appear to be on hold pending implementation of Decree-Law No. (24) of 2008.

These facts indicate that QNRF has made some progress in evolving its infrastructure as originally envisioned, but challenges remain. In sum, the history of QNRF is marked by a number of governance and infrastructure challenges. Chief among these have been the formation of a governing board and the appointment of a permanent director. QNRF eventually met the second challenge, selecting its former acting director as the permanent director, but it has yet to meet the first. As of 2011, a governing board of the kind called for in QNRF's founding documents still had not been established. With the advent of Decree-Law No. (24) of 2008, a historic change appeared to be at hand. However, because that decree-law has not yet been implemented, current QNRF governance and infrastructure issues remain geared, largely as before, toward investigator-driven research in clearly defined fields.

Actions QNRF Should Take to Evolve Its Infrastructure in Anticipation of the Need to Accommodate New Responsibilities

Governing Board

RQPI continues to recommend that QF establish a QNRF governing board that meets the enhanced criteria spelled out in this chapter, which include a higher level of qualifications than originally envisaged for board members. Until a tangible QFSSR-QNRF relationship develops or QNRF becomes independent as originally envisaged, the QNRF board should remain accountable to QF for the performance of its basic programs (e.g., by including QF representation on the board). A board of nine members seems to be most appropriate, and a majority of the board should be Qatari nationals. The next steps are to elicit a selection of board candidates from senior QF leaders and to forward the resulting list to the QF executive board of directors for approval and final selection of members.

Permanent Director

Similarly, at some point in the future, the position of permanent director of QNRF might have a higher profile and much more responsibility than originally envisaged. Consequently, RQPI recommends that the QF leadership take into account the full scope of work QNRF's permanent director could ultimately have to perform. This encompasses all of the elements of the director's original job description, as well as additional elements that stem from QNRF's potential future relationship to external funding sources—to include, but not necessarily be limited to, the QFSSR.

RQPI still maintains, therefore, that two distinct positions may be required to meet the demands of QNRF's potential future role as both a developer and an experienced manager of externally funded research projects. Hence, RQPI recommends that QF continue to consider this potential future model and develop concrete plans (including detailed job descriptions) for a two-person, two-position approach.

Organizational Structure

If and when QNRF begins operating as Decree-Law No. (24) of 2008 envisions, simply expanding its legacy organizational structure will be inadequate. However, until some basic questions about QNRF's (and the QFSSR's) future roles are answered, RQPI is unable to recommend any particular organization from among the potential structures it has outlined in this report.

In the interim, therefore, RQPI abides by its original recommendation that any proposed organizational structure for QNRF should (1) emphasize positions that are certain to be needed under nearly any scenario and (2) provide flexible organizational structures and adaptive budgeting mechanisms. In this way, QNRF will be well prepared and positioned to expand and diversify its organizational structure when the time comes to accommodate a new operating environment of the kind envisioned in Decree-Law No. (24) of 2008.

Concluding Observations

Development of a Research Culture

QNRF has made significant progress in the years since it was established. Its two main funding programs, the UREP and the NPRP, have successfully solicited hundreds of proposals and funded millions of dollars in research conducted by individuals around the world, including in Qatar. RQPI concludes that the administration of these programs has been conducted responsibly and in the spirit of QF's vision for QNRF. But how successful these programs are—either in meeting that vision or in comparison with other funding programs—cannot yet be determined fully. Both the NPRP and the UREP are, after all, relatively new, and most of the measurements that would be required to make such a determination still need to be developed and taken.

To date, QNRF's own measurements of these programs have focused primarily on *inputs*—for example, the demographics of individuals applying for research funding and the quality of their proposals. QNRF is planning to measure *outputs* in the future, using metrics similar to those used by other funding organizations. However, many more measurements are available than what QNRF currently envisions (see Chapter Two and Appendix A).

QNRF's current plan is to focus the majority of its future measurements on symbols and resources. While these are both important aspects of RQPI's working definition of a Qatari research culture, few or no measurements are planned for the other aspect, attitudes and beliefs. These are rarely identified and measured by other funding organizations, but that does not make it any less advisable for QNRF to measure them.

For these reasons, RQPI cannot state definitively at this point that QNRF's efforts are leading directly to its overarching goal of fostering a research culture in Qatar, although there are indications of productive movement in this general direction. To know whether and when such a culture has been achieved will require measuring attitudes and beliefs, as well as symbols and resources (see Chapter Two).

The concept of a research culture, while often discussed, is not well defined anywhere. Qatar has a unique opportunity to be a leader in defining more precisely what the concept means, at least in Qatar (by linking it initially to QNRF's goals and eventually to a broader national vision), and in demonstrating how the concept can be used to measure success. Because the two main QNRF funding programs are still in development, this is the right time to establish research-culture measurements that can be used in the future to help define, assess, and present QNRF results to interested parties both inside and outside of Qatar.

Governance of QNRF

The history of QNRF has been marked from the outset by governance challenges, chief among which have been the formation of a governing board and the appointment of a permanent director. QNRF eventually met the second challenge when QF appointed the former acting director of QNRF to direct the fund on a permanent basis. It has yet to meet the other challenge, however, and a governing board of the kind called for in QNRF's founding documents has yet to be established. An ad hoc steering committee appointed by QF has provided board-like governance on a de facto basis since the launching of QNRF's two major research-funding programs.

With the enactment of Decree-Law No. (24) of 2008, a historic juncture appeared to be at hand, both for Qatar and for QNRF. The decree-law envisaged a formidable expansion of QNRF's role, as well as of the State of Qatar's governance and infrastructure in support of research. Such an expansion may yet come to pass. For now, however, it would appear to be on hold. RQPI recommends that the best course of action in the interim would be for QNRF to prepare itself to meet such new challenges if and when they do materialize.

The new governance challenges appear to imply the following for QNRF: First, the fund will have to raise its governance profile, as both its board of governors and its permanent director may have to operate at higher echelons of government than was previously expected. Should Decree-Law No. (24) of 2008 eventually be implemented as written or should QNRF develop other sources of funding external to itself, QNRF's status and responsibilities will change dramatically, requiring its governing board and its permanent director to have higher qualifications than originally envisaged. As a result, QNRF's governing structures as now defined will almost certainly have to change. Simply expanding current governance, organizational, and funding structures, which are geared toward investigator-driven research in clearly defined fields, will not be adequate for the new tasks envisioned by Decree-Law No. (24) of 2008.

Ensuring QNRF's Sustainability Well into the Future

At this stage in QNRF's development, ample opportunity exists for QF and QNRF stakeholders to lay the groundwork for ensuring that the fund continues to build on what it has accomplished thus far and remains sustainable for decades to come. To this end, the QF initiative that commissioned this study has served, in effect, as a building block. In RQPI's view, other such building blocks should include the study's core recommendations: (1) formulate new metrics that contribute to the development of a measurable research culture in Qatar and (2) evolve QNRF's infrastructure to meet foreseeable changing circumstances over time. Taking these steps will indeed help to ensure that QNRF can and will be sustainable well into the future, possibly even indefinitely.

Benchmarking

QNRf was modeled on several other research-funding organizations (see Greenfield et al., 2008), so it is logical to look to other organizations when developing a set of metrics QNRf could use to measure its progress.

This appendix documents the approaches taken by several research-granting programs to measure and evaluate progress achieved toward strategic goals and considers how these approaches may be applied to QNRf research programs. It reviews methods and criteria used to assess the outcomes of undergraduate and professional research programs. In general, undergraduate research programs seek to build human capital in research, and assessing their success requires that award recipients be monitored as they progress through their careers. Professional research programs have a wide range of goals, for which a correspondingly large set of measures exists. In this appendix, we review methods and criteria for program evaluation at QNRf and suggest ways in which QNRf might adopt some of the practices identified to monitor the achievement of UREP and NPRP goals.

Methods

There are a number of methods for assessing the achievements of research-granting programs. RAND's office in Cambridge, UK (RAND Europe) described the following six approaches to evaluating research-granting programs in the European Union (RAND Europe, 2006):

- **Bibliometric analysis.** Bibliometric analysis uses the number of citations to publications of sponsored research as an indicator of the acceptance of the research in the scientific community. This method can also be used to measure collaborative goals by linking coauthors. Limitations of the approach include the fact that the value of research is not necessarily indicated solely by the number of publications, and cross-field assessments may be difficult.
- **Rate-of-return analysis.** For applied-research programs, it is sometimes possible to calculate an economic rate of return based on the discoveries and products derived from sponsored research. This method is limited in its applicability, because it quantifies only financial benefits, and not social benefits, which may also be desired outcomes.
- **Peer review.** The standard for ensuring scientific quality is peer review, which is used to evaluate research proposals, results, and requirements for publication. Peer review may also be used to evaluate research programs themselves. It tends to be a time-consuming process, and it often varies in quality. Peer reviews may or may not be any-

mous. A closely related evaluation technique uses assembled panels of experts to perform review functions.

- **Case studies.** For large research programs, case studies of individual research projects or subprograms are often used to provide in-depth assessments. However, case studies are limited in the number of programs they evaluate, so they may not be indicative of the overall performance of the research program. NSF, for example, uses both expert panels and randomly selected case studies to evaluate its research programs (Spencer and Dawes, 2008).
- **Influence models.** Over the long term, it is possible to construct models of the contributions of scientific discoveries to societal value through a chain of interactions. For example, the development of advanced medical treatments may lead to an overall improvement in health for a segment of the population. Research-program evaluation may model and assess the contribution of sponsored research to such outcomes.
- **Benchmarking.** Research programs can be evaluated by direct comparison of one program with another. However, similar programs often have divergent goals, management experience, or grant sizes, as well as other differences, and these factors must be taken into account when considering the results of a benchmarking exercise.

Because QNRF's funding programs are in their first few cycles, we have chosen the benchmarking approach to compare the UREP and the NPRP with similar research programs; other approaches may be applicable as the programs mature and more information becomes available. The UREP and the NPRP have yet to produce a body of published research, so it is not possible to apply the bibliographic approach, or to support the development of an influence model, or to conduct a rate-of-return analysis for applied research. As the programs mature, applying additional approaches to assess them will become feasible.

Our benchmarking process is slightly modified in the sense that we are benchmarking *how* other research programs measure the performance of their programs rather than the *outcomes* of these measurements. To provide a basis for analysis, we collected information on and evaluations of several existing research programs that are based in the United States and that provide grants to students and researchers in the United States. We selected U.S.-based programs because program information and evaluations are readily available. Since the purpose of this analysis is to inform approaches that QNRF may wish to pursue, this choice should not affect the results.

Table A.1 lists the research programs included in the study. These programs often track award recipients over the long term, and no single approach is likely to cover all aspects of program evaluation. Therefore, multiple approaches may be desirable.

The principal reason given for evaluating the outcomes of the research programs listed in Table A.1 is to determine whether a program is providing a value to society. This value can be economic, such as a rate of return on investment, but more often it is not so easily quantified. For undergraduate research programs, which are generally not expected to advance scientific knowledge significantly, the principal program goal may be providing initial research experiences and developing human capital in a research community.¹ For professional research pro-

¹ Some graduate research programs also share this goal. For example, the Ford Foundation Fellowships are intended to increase the number of researchers from underrepresented minorities. This program performs a regular, detailed survey of award recipients.

Table A.1
Research Programs Considered as Part of Analysis

Program	Type of Research Supported	Approximate 2008 Research or Educational Funding (\$U.S.)
U.S. National Science Foundation (NSF)	Undergraduate, graduate, and professional	6 billion
U.S. National Institutes of Health (NIH)	Undergraduate, graduate, and professional	28.5 billion
U.S. National Aeronautics and Space Administration (NASA)	Undergraduate, graduate, and professional	55 million
National Science Board (NSB)	NA	NA
Gates Millennium Scholars Program	Undergraduate	70 million
Ford Foundation Fellowships	Graduate and postdoctoral	1.7 million

SOURCES: Brown, 2008; National Institutes of Health, 2009a; National Science Foundation, 2009; The National Academies, 2009; United Negro College Fund, 2009; Universities Space Research Association, 2008.

NOTES: The United Negro College Fund administers the Gates Millennium Scholars Program (The Gates Millennium Scholars, 2009). The National Academies administer the Ford Foundation Fellowships. NSB does not provide direct support; it monitors research activities for the U.S. government.

grams, the measures of program outcomes may vary significantly, depending on such factors as the discipline and overall goals of the program. The results of the evaluations are used to modify the programs appropriately to better achieve stated goals and to assist in the design and execution of new programs.

The analysis in this appendix assumes that the research programs are being administered effectively; it focuses on measures that may be useful in evaluating whether QNRF programs are achieving their goals with respect to research outcomes. Guidelines exist for appropriate program administration. For example, NSF convened a series of workshops to explore best practices in the management of international research experiences for undergraduates and subsequently compiled a handbook of best practices (Loretz, 2002). Though specifically focused on international undergraduate research, the handbook provides guidance that is relevant to domestic programs as well. It includes guidance on program development, program planning and execution, and post-research-experience activities (Loretz, 2002). An important best practice in research-program management is program evaluation and modification.

Measurements of Undergraduate Research Program Outcomes

Undergraduate Research Programs

Like the UREP, several of the research programs listed in Table A.1 support undergraduate research. In the United States, three large programs support a plurality of undergraduate research: As of 2003, NSF listed 22 programs that provide direct or indirect funding to undergraduate students (Ailes et al., 2003); NIH manages several undergraduate research programs in which students perform research at NIH laboratories over the course of a summer (National Institutes of Health, 2009b); and NASA funds the Universities Space Research Association (USRA), which is a consortium of U.S. universities that provide academic-year undergraduate research opportunities as well as opportunities to perform summer research at NASA centers

(Universities Space Research Association, 2008). Funding for undergraduate research is also provided by other government agencies, foundations, and industry, and a large number of universities have their own undergraduate research programs that match motivated students with ongoing research.

Undergraduate research programs offer students their first opportunities to perform sponsored research, typically under the guidance of a faculty mentor, and to participate in a research community. Although there is significant variation in the requirements for researchers in these programs, three components are considered standard: writing a research plan, executing and documenting the research, and presenting the results of the research to peers. The results can be delivered in the form of a presentation, a poster session, a written report, or any combination of these. By offering the opportunity to perform research, undergraduate research programs encourage students to seek graduate degrees and pursue careers in research. Evaluating whether undergraduate research programs are achieving the goal of building human capital in research requires long-term monitoring of students as they progress through their careers. Two examples of program-specific activities are described below.

Several years ago, the USRA developed a web-based database to track participants in its programs. The system now holds several years of data and is beginning to indicate program success.² The Gates Foundation Millennium Scholars program provides support for undergraduate education in general, not specifically for research. However, like research programs, the Gates program has tracking systems in place that compare recipients and non-recipients in order to assess the overall success of the program. Gates also prepares annual reports on student progress (National Opinion Research Center, 2004).

The effectiveness of undergraduate research programs can also be evaluated through random surveys of the workforce. SRI International, a consulting firm, received an NSF contract to conduct a large-scale survey of recipients of undergraduate degrees to determine the effect of undergraduate research opportunities on their career choices. Titled “Evaluating NSF Support for Undergraduate Research Opportunities,” the multiyear study comprised an inventory of U.S. undergraduate research opportunities (Ailes et al., 2003); surveys of NSF undergraduate research-program participants (Russell, Ailes, et al., 2005; Russell, Hancock, et al., 2006b); a survey of recent science, technology, engineering, and mathematics (STEM) graduates (Russell, Hancock, et al., 2005b); a survey of recent social, behavioral, and economic sciences (SBES) graduates (Russell, Hancock, et al., 2005a); and a synthesis of findings (Russell, Hancock, et al., 2006a).³

The results of the SRI study indicated a correlation between students participating in undergraduate research programs and the pursuit of later careers in research. Approximately one-half of surveyed recent U.S. undergraduate students performed sponsored research,⁴ the majority of whom indicated that the research experience shaped their career choices, including the choice to pursue a Ph.D.—30 percent of undergraduates with 12 or more months of

² Sherry Klug, Administrator, Universities Space Research Association, interview with David Ortiz, August 25, 2008.

³ Complete documentation of SRI International’s evaluation of NSF undergraduate research opportunities is available online at <http://www.sri.com/policy/csted/reports/university/index.html> (as of January 8, 2009).

⁴ The surveys of recent undergraduate students revealed that 10 percent of SBES undergraduate researchers and 16 percent of STEM undergraduate researchers were supported by NSF, NIH, or NASA; the remainder were supported by university programs or individual professors or were not formally supported.

research experience reported a desire to seek a Ph.D., compared with 8 percent of undergraduates without research experience. Moreover, the results were robust across both STEM and SBES graduates, although STEM graduates typically are presented with opportunities earlier than SBES graduates.

More relevant to QNRF are the SRI International surveys of NSF-program participants. In addition to direct support for undergraduate research (see Ailes et al., 2003), many NSF research programs include support for undergraduate research. In 2003 and again in 2005, SRI International randomly surveyed several thousand undergraduates who had received direct or indirect support from NSF. More than 65 percent of the respondents had had research experience of more than one year. The results of the follow-up survey indicated that students who participated in NSF-sponsored undergraduate research were more likely to seek Ph.D. degrees; the majority of the respondents were in graduate school pursuing a Ph.D. at the time of follow-up. Of course, this result may reflect a self-selection bias: Students who already planned to seek higher education were also more likely to participate in undergraduate research. Notably, however, a key factor in the perceived quality of an undergraduate research experience was becoming involved in a “culture of research,” defined broadly here as participating in a range of research-related activities, including receiving good mentorship and mentoring fellow students, attending conferences, authoring or coauthoring journal articles, and understanding the broader context of the research topic and goals (Russell, Hancock, et al., 2006b).

Finally, fostering opportunities throughout a student’s undergraduate career is seen as an important activity. The USRA attempts to keep interested students engaged by offering research support throughout the academic year, over multiple years if necessary, and through summer internships at NASA facilities.⁵ As noted above, many NSF-sponsored undergraduate researchers also receive multiple years of support.

Discussion

The SRI International study demonstrated the value of undergraduate research opportunities for developing and maintaining a research community. Evaluating the success of the UREP program in developing Qatar’s future research leaders will require a system for tracking award recipients and comparing them with (randomly selected) non-recipients throughout their undergraduate education and the early stages of their careers. Tracking both recipients and non-recipients is an important activity, because some members of the research community will not have participated in undergraduate research, and some recipients of awards will choose to pursue careers outside of research. Evaluating both groups allows for more effective program development, and establishing such a system soon would provide a robust dataset for analysis, as the UREP, like other QNRF programs, is relatively new. This need not be an entirely new system—for example, the current system that provides notifications and facilitates the dissemination of awards may also be used to facilitate tracking of students after their research concludes.

⁵ Barbara Hammond, Universities Space Research Association, interview with David Ortiz, August 25, 2008.

Measurements of Professional Research Programs

NSF Goals

NSF is a key funder of research in the United States; its budget in 2008 was more than \$6 billion. Founded in 1950, the foundation today funds more than 10,000 grants annually across seven directorates: Biological Sciences; Computer and Information Science and Engineering; Engineering; Geosciences; Mathematical and Physical Sciences; Social, Behavioral, and Economic Sciences; and Education and Human Resources. NSF's overarching goals include expanding national research across this range of disciplines, supporting transformative discoveries within these disciplines, fostering national competitiveness through government-industry partnerships, and sponsoring international research collaboration. These institutional goals are similar in many ways to those of QNRF. They drive the program goals and metrics chosen, as well as the national R&D measures they track and NSF's self-evaluation program.

Program and Organizational Evaluation

NSF uses dozens of metrics to track the thousands of research grants it funds each year. The metrics are based on the four NSF strategic objectives: discovery, learning, infrastructure, and stewardship. These objectives are defined by the NSF as follows (National Science Foundation, 2008):

- **Discovery.** Foster research that will advance the frontiers of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering [S&E]. This goal focuses on developing new knowledge and research techniques that will lead to important new discoveries.
- **Learning.** Cultivate a world-class, broadly inclusive S&E workforce and expand the scientific literacy of all citizens. With this goal, NSF seeks to increase the role of women and minority researchers and improve science education at all levels while expanding international collaboration.
- **Research infrastructure.** Build the nation's research capability through critical investments in advanced instrumentation, facilities, IT [information technology] infrastructure, and experimental tools. This research infrastructure includes research facilities, instrumentation networks, accelerators, telescopes, research vessels, aircraft, and earthquake simulators. NSF provides funds for construction, upgrades, operations, maintenance, and personnel of this infrastructure.
- **Stewardship.** Support excellence in S&E research and education through a capable and responsive organization. This includes the management of the NSF facilities and personnel as well as responsiveness to grantees.

The NSF program metrics within the *discovery* objective predominately assess output by researchers, including journal publications, books, and other published materials, as well as new patents, equipment, or instruments developed through the grant funding. These metrics are replicable, can show trends, and are generally easy and low-cost to apply. However, this approach makes it difficult to assess progress across various fields, since different metrics for research output may be required, depending on the discipline. In addition, publications and patents may not be the only means of measuring progress or outcomes, and those metrics may

fail to account for transformational research discoveries that can lead to future innovations and create new industries. To address this, NSF tracks the use of this research output by other researchers, particularly those outside the field or discipline of the grantee. NSF's assumption is that with a larger number of outside researchers using the output, there is greater likelihood that the research will have a transformative impact across disciplines. Conversely, output used by only a small number of researchers within a single discipline is more likely to incrementally advance that discipline. The discovery category also tracks collaboration across researchers, which supports one of NSF's strategic goals, international collaboration.

The metrics for assessing achievement of the *learning* objective focus on the recipients of the research grants, including students and faculty. These individual measures can include number of participants, demographic information, and quality of faculty research (as measured by survey instruments), as well as student outcomes such as retention and coursework completed. These measures also assess outreach activities completed under the grants.

The metrics for assessing the development of *research infrastructure* quantify the construction and upgrades of facilities and equipment used by the grantees. Infrastructure includes new technologies, tools, databases, and other inventions developed via the grants. Materials gathered by the researchers, including specimens collected, germ lines developed, and other products, are also considered to be research infrastructure. These metrics are most often applicable to STEM research and may be difficult to track for non-STEM facilities and research. They are also often used for academic accreditation, with the goal of ensuring that research can be performed at a proposed location.

NSF sets the fourth strategic goal, *stewardship*, for itself to evaluate its own performance on an annual basis (National Science Foundation, 2008). Stewardship evaluation metrics include time-to-decision, merit review process, support provided to grantees, expanding participation to new PIs, facilities management, post-award monitoring of participant careers, success of e-government initiatives, and security.

One component of the stewardship-evaluation effort includes the results from NSF's Program Assessment Rating Tool (PART), which is mandated by the U.S. government's Office of Management and Budget for federal agencies, including NSF, the Departments of Health and Human Services and Labor, and the Small Business Administration. The PART evaluation includes 20 quantitative metrics focused on NSF's management capabilities (rather than program evaluation), which are divided into three categories: time-to-decision, broadening participation, and management of large facilities. Each metric has a clear target and annual measurement to determine whether NSF was able to attain the goal or maintain adequate performance. For example, in 2007, NSF achieved its goal of notifying 70 percent of grant applicants within six months to tell them whether they won the grant. However, it missed the goal of having new PIs for 68 percent of Small Business Innovation Research (SBIR) grants for the past two years.

These measures are tracked and evaluated every year under the Government Performance and Results Act (GPRA) by the Advisory Committee for the GPRA Performance Assessment (AC/GPA). NSF's strategic goals of discovery, learning, and research infrastructure are used as the foundation for the program monitoring and evaluation process. This process combines case studies with peer review, gathering metrics from a sample of approximately 1,000 grant recipients, the results of which are reviewed by a committee of outside experts.

Experts are organized into committees of visitors to review the programs across disciplines. In addition, each of the seven NSF directorates has an advisory committee that provides

input from academic and industry researchers, ensuring that NSF has updated information on the state of the art in each field of inquiry.

Once a committee has reviewed its sampling of grant recipients, it seeks to determine whether NSF is meeting its strategic goals. Based on this review process, AC/GPA offers annual recommendations to NSF on issues such as grant management, broadening participation, and expanding high-risk/high-reward research. In response to these recommendations, NSF management recently developed new grant evaluation and monitoring criteria, created new programs for increasing the participation of women and minorities in science, and revised its 2006–2011 Strategy Plan.

The self-evaluation program that is part of NSF's stewardship goal is shown in Figure A.1

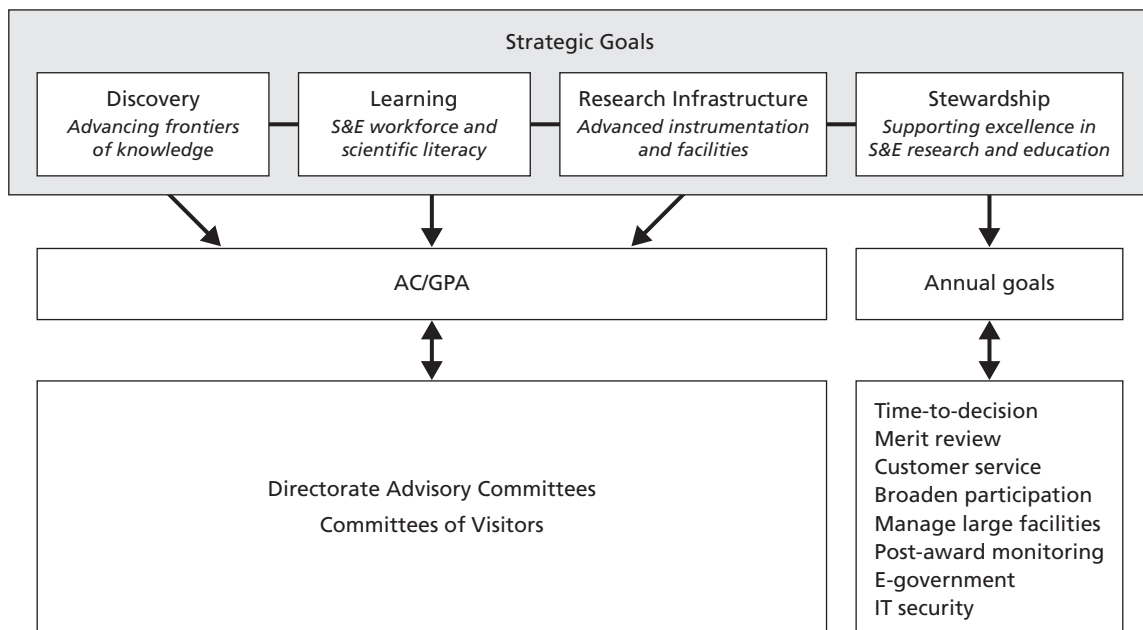
Categories of Metrics

NSF also tracks extensive national and state-level metrics related to research and development, along with completing surveys of public attitudes toward science and technology. These data are then compiled by NSB, which comprises 24 members appointed by the president from both industry and academia. NSB meets six times each year to provide oversight over NSF policies and budget approval, along with major programs and projects. Board members also present congressional testimony on science and technology policy issues and NSF's research directions.

NSB tracks science and technology metrics and publishes an analysis and policy recommendations every two years for decisionmakers. There are more than 400 of these metrics, in eight categories (National Science Foundation, 2008):

- Elementary and secondary education
- Higher education in S&E
- S&E labor force

Figure A.1
NSF Program and Organizational Review Process



- R&D: national trends and international linkages
- Academic R&D
- Industry, technology, and the global marketplace
- S&T [science and technology]: public attitudes and understanding
- State indicators.

The resulting NSB report, *Science and Engineering Indicators*, provides policymakers with data for prioritizing S&T goals (National Science Board, 2008). Policymakers at national and state levels also use these metrics to assess the competitiveness and the innovative capacity of the United States. NSB includes specific policy recommendations in its reports. Recommendations from its 2008 report include:

- The Federal Government should increase funding for basic research while enhancing its transformational nature and should drive future innovations. These innovations will create new industries and jobs while enhancing the country's global competitiveness.
- Industry, government, and universities need greater intellectual interchange. Industry researchers should participate as authors and reviewers for peer-reviewed publications.
- New data are needed to track the implications for the U.S. economy of the globalization of manufacturing and services in high-technology industries.

Measurements of the U.S. National Science Board¹

Overview Measurements

- Real gross domestic product (GDP) growth, by region/country
- World GDP shares, by region/country
- Real GDP growth and population increase, by region/country
- Per capita GDP, by region/country
- Per capita GDP gap with United States, by region
- Per capita GDP gap with United States relative to region's GDP
- Productivity output per employed individual
- Inflation-adjusted productivity gap with United States, by region
- High-technology manufacturing share of total manufacturing, by region/country
- World share of high-technology manufacturing, by region/country
- Export volume of high-technology manufactures, by region/country
- World share of high-technology manufacturing exports, by region/country
- U.S. trade balance in high-technology goods
- U.S. advanced technology product trade balance, by region
- U.S. receipts and payments of royalties and fees for intellectual property
- U.S. Patent and Trademark Office (USPTO) patent applications, by region/country
- Proportion of total USPTO patent applications from Asia and the European Union (EU)
- Scientific and technical articles in peer-reviewed journals, by region/country
- Estimated research and development (R&D) expenditures and share of world total, by region
- Gross domestic expenditures on R&D, by selected region/country
- Share of industrial R&D, by industry sector and selected region/country
- Organisation for Economic Co-operation and Development (OECD) industry R&D, by funding sector
- Industrial R&D financed by foreign sources
- Composition of GDP and R&D/GDP ratio for selected countries, by sector
- R&D share of GDP, by selected countries
- Basic research share of GDP, by country/economy
- Basic research share of R&D, by country/economy
- R&D performed by U.S. affiliates of foreign companies in the United States, by investing region, and performed by foreign affiliates of U.S. multinational corporations, by host region

¹ National Science Board, 2008.

- R&D performed in Asia by majority-owned affiliates of U.S. parent companies, by region and selected country
- National R&D expenditures, by funding sector
- Federal R&D budget authority, by budget function
- National R&D expenditures, by character of work, and basic research, by performer and source of funds
- Population 15 years old or older with tertiary education, by country/region
- Researchers in OECD and selected non-OECD locations
- Science and technology employment
- Average annual growth rates of S&E occupations versus all workers
- U.S. workforce in S&E occupations
- Largest sectors of employment for individuals in S&E occupations, by North American Industry Classification System (NAICS) sector
- Workers in S&E occupations, by age group
- S&E workers by cohort and age group
- Bachelor's degree-level S&E knowledge needed by individuals in workforce with highest degree in S&E
- Employment sector for individuals with highest degree in S&E and S&E doctorate holders
- Distribution of S&E degree holders with R&D as major or significant work activity, by field of highest degree and occupation
- Total tertiary degree attainment by 25- to 64-year-olds, by country
- Difference in total tertiary degree attainment between 25- to 34-year-olds and 25- to 64-year-olds, by country
- Attainment of four-year tertiary and advanced research degrees by 25- to 64-year-olds, by country
- Attainment of four-year tertiary and advanced research degrees by 25- to 34-year-olds, by country
- First university natural sciences and engineering degrees, by selected country
- Natural sciences and engineering doctoral degrees, by selected country
- S&E doctoral degrees earned by foreign students, by selected industrialized country and field
- Foreign-born individuals in U.S. S&E workforce, by degree level
- Student, exchange, and other high-skill-related U.S. temporary visas issued
- Average mathematics score of students in grades 4 and 8
- U.S. and international math and science scores for grades 4 and 8 and 15-year-old students

Elementary- and Secondary-Education Measurements

- Proficiency in specific mathematics knowledge and skill areas of students in grades 3 and 5
- Proficiency in specific mathematics knowledge and skill areas of students in grades 10 and 12
- Average mathematics score of students in grades 4 and 8
- Proficiency in mathematics and science, grades 4, 8, and 12
- High school graduates completing advanced mathematics courses, by subject

- High school graduates completing advanced S&E courses, by subject: selected years
- High school graduates completing advanced mathematics courses, by gender and race/ethnicity
- High school graduates completing advanced S&E courses, by gender and race/ethnicity
- High school graduates completing advanced mathematics and other S&E courses, by school poverty level
- Practice teaching of public middle and high school teachers with less than 5 years of teaching experience
- Preparedness for first-year teaching of public middle and high school mathematics and science teachers with less than 5 years of experience, by participation in practice teaching
- Professional development of public middle and high school teachers during past 12 months, by topic
- Professional development of public middle and high school teachers during past 12 months, by topic and time spent
- Professional development of public middle and high school teachers during past 12 months, by format
- Collaborative professional development activities of public middle and high school teachers
- Teaching vacancies at public secondary schools, by subject
- Public middle and high school mathematics and science teachers not satisfied with salary, by minority enrollment and school poverty level
- One-year attrition rate of public school teachers
- Bachelor's degree recipients working in the next year and in ten years in same or different occupation
- Perceptions of working conditions of public middle and high school mathematics and science teachers, by minority enrollment and school poverty level
- Serious student problems reported by public middle and high school mathematics and science teachers, by minority enrollment and school poverty level
- High school completion rates of 18- to 24-year-olds, by race/ethnicity
- High school graduates enrolled in college in October after completing high school, by gender and type of institution
- High school graduation rates, by OECD country

Measurements of Higher Education in Science and Engineering

- Higher education faculty employed part time, by highest degree
- Average annual tuition, fees, room, and board for public 4-year institutions, total student aid dollars, and disposable personal income
- Grants and loans as percentage of undergraduate student aid
- Full-time S&E graduate students, by field and mechanism of primary support
- Full-time S&E graduate students with primary support from federal government, by field
- Primary mechanisms of support for S&E doctorate recipients, by citizenship, gender, and race/ethnicity
- Freshmen intending S&E major, by race/ethnicity
- Foreign students, by field of study

- Foreign undergraduate student enrollment in U.S. universities, by field (S&E and all fields) for top 10 places of origin
- U.S. engineering enrollment, by level
- First-time full-time graduate enrollment in engineering and computer sciences and unemployment rate of all workers
- S&E graduate enrollment, by citizenship and race/ethnicity
- Underrepresented minority share of S&E degrees, by degree level and field
- S&E bachelor's degrees, by field
- Female share of S&E bachelor's degrees, by field
- Minority share of S&E bachelor's degrees, by race/ethnicity
- S&E master's degrees, by field
- S&E master's degrees, by gender
- S&E master's degrees, by race/ethnicity and citizenship
- S&E doctoral degrees earned in U.S. universities, by field
- U.S. citizen female share of doctoral degrees, by field
- U.S. citizen underrepresented minority S&E doctoral degrees, by race/ethnicity
- S&E doctoral degrees, by gender, race/ethnicity, and citizenship
- Foreign share of U.S. S&E degrees, by degree and field
- U.S. S&E doctoral degree recipients, by selected Asian country/economy of origin
- U.S. S&E doctoral degree recipients, by selected Western European country
- U.S. S&E doctoral degree recipients from Europe, by region
- U.S. S&E doctoral degree recipients from Canada and Mexico
- Plans of foreign recipients of U.S. S&E doctorates to stay in United States
- Short-term stay rates of foreign recipients of U.S. S&E doctorates, by place of origin
- Postdoctoral students at U.S. universities, by field
- Postdoctoral students at U.S. universities, by citizenship status
- Attainment of tertiary-type A and advanced research programs, by country and age group
- First university S&E degrees in Asia, Europe, and North and Central America, by field
- First university natural sciences and engineering degrees, by selected countries
- S&E doctoral degrees earned in Europe, Asia, and North America, by field
- Natural sciences and engineering doctoral degrees, by selected country
- Foreign students enrolled in tertiary education, by country
- S&E foreign graduate student enrollment, by selected industrialized country and field
- S&E doctoral degrees earned by foreign students, by selected industrialized country and field

Measurements of the Science and Engineering Labor Force

- Science and technology employment
- Average annual growth rates of S&E occupations versus all workers
- Annual average growth rate of degree production and occupational employment, by S&E field
- U.S. workforce in S&E occupations
- Projected increase in employment, for S&E and selected other occupations

- Projected job openings as percentage of 2004 employment, for S&E and selected other occupations
- Inflation-adjusted change in mean salary 1 to 5 years after degree, by field and level of highest degree
- Mean salaries of S&E and S&E-related degree recipients 1 to 5 years after degree, by field and level of highest degree
- Median salaries for bachelor's degree holders, by years since degree
- Individuals with highest degree in S&E employed in jobs closely or somewhat related to highest degree, by years since highest degree
- S&E bachelor's degree holders employed in jobs closely related to degree, by field and years since degree
- Unemployment rate, by occupation
- Unemployment rates for individuals with highest degree in S&E, by years since highest degree
- Involuntarily out-of-field rates of individuals with highest degree in S&E, by years since highest degree
- Employment distribution across science, technology, engineering, and mathematics (STEM) occupations
- Employment sector for individuals with highest degree in S&E
- Largest sectors of employment for individuals in S&E occupations, by NAICS sectors
- Individuals with highest degree in S&E employed in private business, by employer size
- Educational distribution, by nonacademic S&E occupations
- Distribution of S&E degree holders with R&D as major work activity, by level of education
- Distribution of S&E degree holders with R&D as major work activity, by field of highest degree
- S&E doctorate holders with R&D as major work activity, by field and years since degree
- Salary distribution of S&E degree holders employed full time, by degree level
- Median salaries of S&E graduates, by degree level and years since degree
- Age distribution of individuals in S&E occupations, by gender
- Age distribution of doctorate holders in S&E occupations, by gender
- College-educated women and ethnic minorities in nonacademic S&E occupations
- Women and ethnic minority doctorate holders in nonacademic S&E occupations
- Women as proportion of S&E workforce, by broad field of occupation
- Age distribution of individuals in S&E occupations, by race/ethnicity
- Age distribution of S&E doctorate holders in S&E occupations, by race/ethnicity
- Recent S&E recipients in career-path jobs within 3 months of degree, by field
- Doctorate recipients holding tenure and tenure-track appointments at academic institutions 4–6 years after degree, by field
- Field of doctorate of U.S.-educated S&E doctorate recipients in postdoctoral (postdoc) positions
- Proportion ever holding a position among S&E doctorate holders, by field and year of doctorate
- Median time spent in positions for S&E doctorate recipients completing postdocs, by field and year of doctorate
- Growth of job benefits for S&E doctorate holders in postdoc positions, by field and year of doctorate

- Former or current postdocs who took first postdoc position because other employment not available, by field and year of doctorate
- Former postdocs' evaluation of degree to which postdoc position helped career, by year of doctorate
- S&E doctorate holders in tenured or tenure-track positions in 2006, by field, postdoc status, and year of doctorate
- S&E doctorate holders in 1997–2001 graduation cohort in tenured or tenure-track positions, by degree field and postdoc status
- S&E doctorate holders in 1997–2001 graduation cohort with R&D as primary or secondary work activity, by degree field and postdoc status
- S&E doctorate holders in 1997–2001 graduation cohort with job closely related to degree field, by degree field and postdoc status
- Salary of former postdocs relative to non-postdocs for S&E doctorate holders in 1992–96 graduation cohort, by degree field and sector of employment
- Age distribution of individuals in labor force with highest degree in S&E
- Age distribution of individuals in labor force with highest degree in S&E, by degree level
- Cumulative age distribution of individuals in labor force with highest degree in S&E, by degree level
- Age distribution of S&E doctorate holders in labor force
- Employed S&E degree holders older than 50, by selected field
- Older S&E degree holders working full time, by degree level
- Researchers in OECD countries
- Tertiary-educated population more than 15 years old
- R&D employment of U.S. multinational corporations (MNCs) at their foreign affiliates and foreign MNCs at their U.S. affiliates
- R&D employment of U.S. MNCs in United States and at their foreign affiliates
- Canadian awards of permanent residency to university graduates, by degree level
- Stock of workers in Canada on high-skilled temporary work visas, by skill level
- High-skilled workers with visas in Japan, by region of origin
- Foreign-born individuals with highest degree in S&E living in the United States, by place of birth
- Citizenship of junior and guest scientists at Max Planck Institutes
- Foreign-born S&E degree holders with highest degree from foreign institution, by year of entry to the United States
- Distribution of foreign-born S&E degree holders, by citizenship/visa status and year of entry to the United States
- Distribution of occupations of new recipients of U.S. H-1B temporary work visas
- Country of citizenship for new recipients of U.S. H-1B temporary work visas
- Country of citizenship for new recipients of U.S. H-1B temporary work visas holding doctorates
- Five-year stay rates for U.S. S&E doctorate recipients with temporary visas, by place of origin
- Top countries of origin of persons with tertiary-level education or better who reside abroad in OECD countries

Measurements of Research and Development: National Trends and International Linkages

- National R&D, by performing sector and source of funds
- Shares of national R&D expenditures, by performing sector and source of funds
- National R&D expenditures, by funding sector
- National R&D, by character of work, and basic research, by funding and performing sectors
- R&D performing and funding sectors, by character of work
- Projected federal obligations for R&D, by agency and character of work
- Federal obligations for R&D, by performing sector
- Estimated federal obligations for research, by agency and major S&E field
- Difference in U.S. performer- and agency-reported federal R&D
- External users at Department of Energy facilities, by science program
- Federal R&D budget authority, by budget function
- Research and experimentation credit claims as percentage of industry-funded R&D
- U.S. states with credits for company-funded R&D
- Estimated R&D expenditures and share of world total, by region
- R&D expenditures of United States and G-7 and OECD countries
- Composition of GDP for selected countries, by sector
- R&D share of GDP
- R&D share of GDP, by selected countries
- Basic research share of GDP, by country/economy
- Basic research share of R&D, by country/economy
- Total OECD R&D, by funding sector
- Share of industrial R&D for selected countries and European Union, by industry sector
- OECD industry R&D, by funding sector
- Industrial R&D financed, by foreign sources
- Industrial R&D by information and communications technologies sector for selected countries and European Union
- Academic R&D share of all R&D for selected countries/economies and all OECD
- Academic R&D financed by industry for selected countries and all OECD
- Government R&D support for selected countries, by socioeconomic objective
- R&D performed by U.S. affiliates of foreign companies in the United States, by investing region, and performed by foreign affiliates of U.S. MNCs, by host region
- Regional shares of R&D performed abroad by foreign affiliates of U.S. MNCs
- R&D contracted out in United States by manufacturing companies as ratio of company-funded and -performed R&D
- U.S. trade in research, development, and testing services
- Worldwide industrial technology alliances and those with at least one U.S.-owned company
- SBIR awards and funding

Measurements of Academic Research and Development

- Academic R&D, basic and applied research, and basic research as share of total of each category
- Academic R&D expenditures, by character of work, and national R&D expenditures, by performer and character of work
- Average annual R&D growth, by performing sector
- Federal and non-federal academic R&D expenditures
- Sources of academic R&D funding
- Academic R&D expenditures, by field
- Changes in share of academic R&D in selected S&E fields
- Federal agency academic research obligations, by field
- Major agency field shares of federal academic research obligations
- Sources of academic R&D funding for public and private institutions
- Share of academic R&D, by rank of university and college academic R&D expenditures
- Components of institutional R&D expenditures for public and private academic institutions
- Academic institutions receiving federal R&D support, by selected Carnegie classification
- Current fund expenditures for research equipment at academic institutions, by field
- Source of funds for new construction of S&E research space
- Average annual growth rate for employment of S&E doctorate holders
- S&E doctorate holders employed in academia, by degree field
- S&E doctorate holders, by type of academic appointment
- Share of doctoral S&E faculty positions held by women, by rank
- Share of underrepresented minorities among S&E doctorate holders employed in academia, by citizenship status and years since degree
- Share of Asians/Pacific Islanders among S&E doctorate holders employed in academia, by citizenship status and years since degree
- Share of all whites and white males among S&E doctorate holders employed in academia, by years since degree
- Age distribution of S&E doctorate holders employed in U.S. academic institutions
- S&E doctorate holders with recent degrees employed at academic institutions, by type of position
- Faculty and tenure-track status of S&E doctorate holders employed in academia 4 to 7 years after receiving degree
- S&E doctorate holders employed in academia with research or teaching as primary or secondary work activity, by degree field
- S&E article output, by major S&E publishing region/country
- Worldwide output of S&E articles, by number of article-producing countries
- Worldwide S&E articles, institutional authors, and author names
- Share of worldwide S&E articles coauthored domestically and internationally
- S&E article output of U.S. nonacademic sectors
- S&E articles from Federally Funded Research and Development Centers (FFRDCs), by field
- S&E articles and citations in all fields, by selected region/country
- United States, European Union, and Asia-10 share of cited papers, by citation percentile

- Index of highly cited articles, by selected region/country
- U.S. academic share of patenting by U.S. private and nonprofit sectors
- Median net royalties from academic patenting activities

Measurements of Industry, Technology, and the Global Marketplace

- Average annual GDP growth for the United States, the European Union (EU), and Japan
- GDP per capita for the United States, the EU, and Japan
- GDP per hour worked for the United States, the EU, and Japan
- Hourly compensation costs for manufacturing production workers for the United States, EU-15, and Japan
- Services and goods shares of global economic activity
- Value-added revenue and world share of market-oriented knowledge-intensive service industries, by selected regions/countries
- Global value-added revenue of communication services and world share of selected regions
- Global value-added revenue and world share of selected service industries, by selected regions/countries
- Global high-technology manufacturing industry gross revenue and share of all manufacturing industries
- Value-added revenue and world share of high-technology manufacturing industries, by selected regions/countries
- World share of apparent consumption of high-technology manufacturing industries
- Value-added share of gross revenue of U.S. manufacturing industries
- High-technology share of all manufacturing industry value-added revenue for selected regions/countries
- Global value-added revenue of communications equipment and world share of selected regions/countries
- Global value-added revenue of computer manufacturing industry and world share of selected regions/countries
- U.S. industry investment in capital equipment and share of equipment type
- Global exports of high-technology manufacturing industries and world share of selected regions/countries
- U.S. world export share for individual high-technology manufacturing industries
- Trade balance and share of gross revenue for U.S. high-technology manufacturing industries
- U.S. trade balance for individual high-technology manufacturing industries
- U.S. merchandise trade balance, by product type
- U.S. advanced technology product trade balance, by world and region
- U.S. trade balance, by technology area
- U.S. receipts and payments of trade for intellectual property and receipts share of trade volume
- U.S. trade in intellectual property between unaffiliated companies
- U.S. S&E articles by authors in private industry as share of all U.S. S&E articles, by selected field

- U.S. S&E basic research articles by authors in private industry as share of all U.S. S&E basic research articles, by selected field
- Industry S&E basic research articles as share of all industry S&E articles, by selected field
- S&E articles with industry authors, by institutional author type
- Industry-coauthored S&E articles, by sector of coauthorship
- USPTO patent applications and share of total, by inventors from selected regions/countries/economies
- Average annual growth rate of USPTO patent applications for inventors from selected regions/countries/economies
- USPTO patents granted per capita for inventors from selected U.S. states
- USPTO patents granted, by type of ownership
- European Patent Office (EPO) patent applications and share of total, by inventors from selected regions/countries/economies
- USPTO Information and Communications Technology (ICT) patents granted and share of total, by inventors from selected regions/countries/economies
- USPTO biotechnology patents granted and share of total, by inventors from selected regions/countries
- Triadic patent applications and share of total, by inventors from selected regions/countries
- U.S. high-technology small business formation
- U.S. high-technology small business formation, by share of selected technology areas
- Share of angel and venture capital investment, by financing stage
- Angel and venture capital investment
- Angel investment, by share of seed-startup and early activities
- Share of top three technology areas receiving angel capital investment
- U.S. venture capital investment, by stage of investment
- U.S. venture capital investment, by share of selected industry

Measurements of Public Attitudes and Understanding About Science and Technology

- Primary source of information, by use
- Primary source of current news events and science and technology information
- Primary source of information about specific scientific issues
- Network nightly news coverage of science and technology
- Attendance at informal science institutions, by institution type and education level
- Correct answers to scientific literacy questions
- Correct answers to polar and nanotechnology questions, by factual knowledge of science
- Correct answers to scientific literacy questions, by country/region
- Scientific literacy in Europe
- Public assessment of scientific research
- Attitudes toward government funding of scientific research
- Importance of process, credentials, and external validation to belief that something is scientific, by education level
- European perceptions of scientific nature of various fields
- Worry about quality of environment

- Public priorities for environmental protection versus economic growth
- U.S. and Canadian views on credibility of sources of information on biotechnology
- Trust in information sources about genetically modified foods
- Public attitudes toward stem cell research

State Indicators

- 4th grade mathematics performance
- 4th grade mathematics proficiency
- 4th grade science performance
- 4th grade science proficiency
- 8th grade mathematics performance
- 8th grade mathematics proficiency
- 8th grade science performance
- 8th grade science proficiency
- Public school teacher salaries
- Elementary and secondary public school current expenditures as share of gross domestic product
- Current expenditures per pupil for elementary and secondary public schools
- Share of public high school students taking Advanced Placement exams
- Share of public high school students scoring 3 or higher on at least one Advanced Placement exam
- High school graduates or higher among individuals 25–44 years old
- Bachelor's degrees conferred per 1,000 individuals 18–24 years old
- Bachelor's degrees in natural sciences and engineering conferred per 1,000 individuals 18–24 years old
- S&E degrees as share of higher education degrees conferred
- S&E graduate students per 1,000 individuals 25–34 years old
- Advanced S&E degrees as share of S&E degrees conferred
- Average undergraduate charge at public 4-year institutions
- Average undergraduate charge at public 4-year institutions as share of disposable personal income
- State expenditures on student aid per full-time undergraduate student
- Associate's degree holders or higher among individuals 25–44 years old
- Bachelor's degree holders or higher among individuals 25–44 years old
- Bachelor's degree holders potentially in the workforce
- Individuals in S&E occupations as share of workforce
- Employed S&E doctorate holders as share of workforce
- Engineers as share of workforce, by state
- Life and physical scientists as share of workforce
- Computer specialists as share of workforce
- R&D as share of GDP
- Federal R&D obligations per civilian worker
- Federal R&D obligations per individual in S&E occupation
- Industry-performed R&D as share of private-industry output

- Academic R&D per \$1,000 of GDP
- S&E doctorates conferred per 1,000 S&E doctorate holders
- Academic article output per 1,000 S&E doctorate holders in academia
- Academic article output per \$1 million of academic R&D
- Academic patents awarded per 1,000 S&E doctorate holders in academia
- Patents awarded per 1,000 individuals in S&E occupations
- High-technology share of all business establishments
- Net high-technology business formations as share of all business establishments
- Employment in high-technology establishments as share of all employment
- Average annual federal SBIR funding per \$1 million of GDP
- Venture capital disbursed per \$1,000 of GDP
- Venture capital deals as share of high-technology business establishments
- Venture capital disbursed per venture capital deal

Table B.1
NSB Measurements That May Be Applicable to QNRF

Measurement Category	Metrics
S&T outcomes	<ul style="list-style-type: none"> U.S. Patent and Trademark Office (USPTO) patent applications European Patent Office (EPO) patent applications Receipts and payments of royalties and fees for intellectual property Scientific and technical articles in peer-reviewed journals Science and technology employment New business start-ups, by field Angel and venture capital investment Productivity output per employed individual
R&D	<ul style="list-style-type: none"> National R&D expenditures, by funding sector Government funding for R&D, by performing sector Industrial R&D financed by domestic sources Industrial R&D financed by foreign sources Basic research share of R&D Applied research share of R&D
Education	<ul style="list-style-type: none"> Total tertiary degree attainment by 25- to 64-year-olds Foreign-born individuals in workforce, by degree level Higher education faculty employed part time, by highest degree Higher education faculty employed part time, gender, race/ethnicity, and citizenship Full-time graduate students, by field and mechanism of primary support Bachelor's degrees, by field Bachelor's degrees, by gender, race/ethnicity, and citizenship Master's degrees, by field Master's degrees, by gender, race/ethnicity, and citizenship Doctoral degrees, by field Doctoral degrees, by gender, race/ethnicity, and citizenship Individuals employed in jobs closely or somewhat related to their highest degree Five-year stay rates for undergraduate recipients with temporary visas, by place of origin Five-year stay rates for graduate recipients with temporary visas, by place of origin
Resources and capital investment	<ul style="list-style-type: none"> Current fund expenditures for research equipment at academic institutions, by field Source of funds for new construction of research space Source of funds for new construction of performance space Industry investment in capital equipment and share of equipment type

Selected Bibliography of Measuring Research and Development

- Abdallah, W. M., and E. Geisler, *The Metrics of Science and Technology*, Greenwood Publishing Group, 2000, p. 380.
- Adams, J. D., E. P. Chiang, and J. L. Jensen, "The Influence of Federal Laboratory R&D on Industrial Research," *Review of Economics and Statistics*, 85(4), 2003, pp. 1003–1020.
- Block, F., and M. Keller, "Where Do Innovations Come From? Transformations in the U.S. National Innovation System, 1970–2006," *Innovation, 1970, 2006*, p. 1.
- Bremser, W. G., "Utilizing the Balanced Scorecard for R&D Performance Measurement," *R&D Management*, 34(3), 2004, p. 229.
- Coccia, M., "New Models for Measuring the R&D Performance and Identifying the Productivity of Public Research Institutes," *R&D Management*, 34(3), 2004, pp. 267–280.
- Cozzarin, B. P., "Performance Measures for the Socio-Economic Impact of Government Spending on R&D," *Scientometrics*, 68(1), 2006, pp. 41–71.
- Cozzens, S. E., *Measuring and Ensuring Excellence in Government Laboratories: Practices in the United States*, School of Public Policy, Georgia Institute of Technology, 2001.
- Dalkir, K., E. Wiseman, M. Shulha, and S. McIntyre, "An Innovative Measurement Framework for a Government Knowledge Management Initiative," *Proceedings, European Conference on Knowledge Management, Budapest, Hungary*, September 2006.
- , "An Intellectual Capital Evaluation Approach in a Government Organization," *Management Decision*, 45(9), 2007, p. 1497.
- Debackere, K., and R. Veugelers, "The Role of Academic Technology Transfer Organizations in Improving Industry Science Links," *Research Policy*, 34(3), 2005, pp. 321–342.
- Gallagher, M., "Measuring Service-Sector Research and Development," *RTI Project*, RTI International, 2002.
- Geisler, E., "What Do We Know About: R&D Metrics in Technology-Driven Organizations," paper prepared by invitation for the Center for Innovation Management Studies at North Carolina University, 2002.
- Godin, B., "Science, Accounting and Statistics: The Input-Output Framework," *Research Policy*, 36(9), 2007, pp. 1388–1403.
- Grupp, H., and M. E. Mogege, "Indicators for National Science and Technology Policy: How Robust Are Composite Indicators?" *Research Policy*, 33(9), 2004, pp. 1373–1384.
- Hauser, J. R., *Metrics to Value R&D: An Annotated Bibliography*, Marketing Science Institute, Special Report, 1996.
- Hipp, C., and H. Grupp, "Innovation in the Service Sector: The Demand for Service-Specific Innovation Measurement Concepts and Typologies," *Research Policy*, 34(4), 2005, pp. 517–535.
- Liebowitz, J., and C. Y. Suen, "Developing Knowledge Management Metrics for Measuring Intellectual Capital," *Journal of Intellectual Capital*, 1(1), 2000, pp. 54–67.
- Moore, M. C., D. J. Arent, and D. Norland, "R&D Advancement, Technology Diffusion, and Impact on Evaluation of Public R&D," *Energy Policy*, 35(3), 2007, pp. 1464–1473.

Olsen, K. L., N. M. Call, M. A. Summers, and A. B. Carlson, "The Evolution of Excellence: Policies, Paradigms, and Practices Shaping U.S. Research and Development," *Technology in Society*, 30(3-4), 2008, pp. 309–318.

Organisation for Economic Co-operation and Development, *Proposed Standard Practice for Surveys on Research and Experimental Development*, 2002.

———, *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, Committee for Scientific and Technological Policy, Paris, 2005.

Rubenstein, A., "Payoffs from Government-Sponsored R&D in the U.S. and Japan," *Management of Engineering and Technology*, 2003, PICMET '03: Portland International Conference on Management of Engineering and Technology for Reshaping the World, 2003, pp. 133–139.

Tassey, Gregory, *Methods for Assessing the Economic Impacts of Government R&D*, National Institute of Standards and Technology, 2003.

Literature on Balancing Intrinsic and Extrinsic Motivations

Research on motivation emphasizes the importance of individuals believing that they are supported by their organization. A 1993 review of prior research indicated that individuals' perception of the extent to which the organization values their contributions and cares about their well-being (defined as perceived organizational support) relates to their level of organizational citizenship behavior (Shore and Wayne, 1993). Organizational citizenship behavior includes extra-role behavior, or additional effort beyond that required for daily job responsibilities. Shore and Wayne (1993) emphasize the importance of perceived organizational support as a determining factor in employees' behavior. They also find that employees bound by economic exchanges rather than by social exchanges are less likely to be contributing citizens. A meta-analysis of 128 studies spanning multiple decades concluded that extrinsic rewards significantly undermine intrinsic motivation (Deci et al., 1999). In other words, those responding to financial incentives will engage in organizational citizenship behavior only if there is direct financial reward. In contrast, those who perceive greater organizational support in a social sense will act as strong and contributing citizens for reasons other than financial. Therefore, financial incentives should be carefully calibrated so as not to overshadow intrinsic motivators.

Establishment of Qatar Foundation for the Support of Scientific Research (QFSSR)

His Highness Sheikh Tamim Bin Hamad Al-Thani, deputy of the Crown Prince has issued, yesterday, the Decree-Law No. (24) of 2008, concerning the support and organization of the scientific research.

The Decree stipulated the execution thereof and that it shall be published in the Official Gazette, as follows:

Decree-Law No. (24) of 2008, concerning the support and organization of the scientific research

We, Tamim Bin Hamad Al-Thani, deputy of the Crown Prince of Qatar, Having perused the Constitution and Law No. (5) of 1989, concerning the general budget of the State and the Draft-Law submitted by the Council of Ministers, have decided to promulgate the following law:

Chapter 1: Definitions

Article (1)

By application of the provisions of this law, the following words and expressions shall have the meanings assigned to them, unless the context provides another meaning:

The Foundation: Qatar Foundation for the Support of Scientific Research

Board: Board of directors

Chairman: Chairman of the board of directors

General manager: General manager of the Foundation

Fund: Qatar National Fund for Research at Qatar Foundation for Education, Sciences and Social Development.

Chapter 2: Support of the Scientific Research

Article (2):

8,2% of the government revenues of the State budget shall be allocated to support the scientific research and the rest of the said proportion shall be deemed as the main annual income of the Foundation.

Article (3):

The Foundation shall undertake the management, development and investment of the said remaining proportion, in a way based on economic basis and standards. It shall determine the aspects of spending such proportion in order to support the scientific research and to raise the level thereof, according to the provisions hereof.

Chapter 3:

Establishment of the Foundation, Its Objects and Competences

Article (4):

A Foundation named “Qatar Foundation for the Support of Scientific Research” shall be established. It shall have a legal personality and an independent budget and it shall directly report to the Amir.

Article (5):

The headquarters of the Foundation shall be in the city of Doha. Other locations or offices may be established inside or outside the State, by a resolution of the board of directors.

Article (6):

The Foundation aims at supporting and financing scientific research, raising the level thereof, managing, developing and investing the sources allocated thereto. It works particularly on achieving the following:

1. Spreading the creation and innovation culture and the scientific research among citizens, promoting the awareness regarding the importance of scientific research and technology as an essential pillar for progress and future achievement.
2. Providing support and service for the development plans in a comprehensive way and linking the scientific research to the society’s needs and local problems, participating in the settlement of regional and international problems in order to achieve more progress.
3. Attending for the support of research submitted by national authorities and institutions which work on developing techniques to enhance productivity and services, to decrease their costs and reach high levels of quality and safety in the various public sectors.
4. Orienting, encouraging and supporting investment in the fields of scientific research and providing the necessary support to the institutions, authorities and researchers interested therein.

Article (7):

The Foundation may initiate all the acts and deeds necessary for the achievement of its goals, particularly:

1. Declaration of strategies and policies of scientific research and determination of the priorities thereof
2. Allocation of the amounts necessary for the support and financing of research, studies, study and scientific projects
3. Obtaining of data, statistics, studies, reports and research related to its activities from ministries, government authorities and other competent bodies

4. Establishment of the basis and rules of cooperation with educational and scientific parties inside and outside the country, setting of policies and strategies related to such cooperation and determination of the implementation and follow-up mechanisms
5. Support and contribution of the private sector and civil society institutions in the scientific research activities
6. Investment of the Foundation's funds and increase of the revenues thereof pursuant to economic standards and setting of the regulations ensuring the same
7. Suggestion of a system for the payment of the revenues generated from the investment of the Foundation's funds in the methods determined by virtue of a decision issued by the board of directors
8. Suggestion of legislative draft instruments related to the scientific research affairs
9. Any other scientific research-related acts assigned to the Foundation by the Amir

Chapter 4: Management of the Foundation

Article (8):

The Foundation shall be managed by a board of directors formed of a chairman and a vice-chairman, as well as a number of experienced members who are interested in the scientific research. A decision as to their appointment and the determination of their remunerations shall be issued by the Amir.

The term of membership of the board is three years, renewable for another similar term or terms.

The board shall have a secretary. The board shall appoint such secretary and determine his competences and remuneration by virtue of a decision.

Article (9):

The board shall have the necessary powers and authorities which enable it to manage the Foundation's affairs. It shall take all the actions it deems appropriate to achieve its goals, without complying with the government rules and regulations, and it shall, in particular:

1. Set the general policies of the Foundation and supervise the execution thereof
2. Declare the plans and strategies and set the policies for scientific research
3. Issue the organization structure of the Foundation
4. Issue the administrative and financial bylaws and the Foundation employees affairs bylaw
5. Declare the annual balance sheet and final account of the Foundation
6. Issue an investment regulation for the Foundation's funds
7. Acceptance of aids, endowments and donations offered to the Foundation by individuals, authorities or national and foreign institutions

Article (10):

The board shall hold a meeting upon the invitation of its chairman or his deputy, at least once every month and whenever it is necessary. The meeting shall not be deemed properly convened unless with the presence of the majority of its members, provided that the chairman or his deputy is present. The decisions of the board are issued by the majority of votes of the members

present. In the event of tie votes, the chairman or his deputy in the event where he is absent shall cast the decisive vote. Delegation as to presence or voting is not allowed and the sessions of the board shall be closed.

Article (11):

The board may call any employee of the Foundation or others which it deems experienced or having the scientific stature to attend the meeting. The persons invited to the meeting shall have the right to participate in the discussions without having the voting right.

Article (12):

The minutes of the meetings of the board and the decisions thereof shall be noted in a special register signed by the chairman and the secretary.

Article (13):

The chairman has the right to sign on behalf of the Foundation in everything related to its affairs. He may delegate one of the members of the board to sign, in relation to matters it shall determine.

Article (14):

The chairman shall represent the Foundation before the courts and in its relations with others.

Article (15):

The Foundation shall have a general manager, whose appointment shall be determined by virtue of decision issued by the board. The general manager shall attend the sessions of the board without having the right to vote.

Article (16):

The general manager undertakes, under the supervision of the board and within the framework of the general policy of the Foundation, the settlement of the administrative and financial affairs of the Foundation, according to internal bylaws and regulations and the decisions issued by the board, within the prescribed annual budget, and in particular, the following:

1. General supervision of the administrative body of the Foundation
2. Execution of the decisions of the board
3. Suggestion of draft bylaws related to the Foundation
4. Preparation of the annual balance sheet and final account of the Foundation
5. Preparation of a report on the Foundation's business during the financial year
6. Suggestion of an organization structure for the Foundation
7. Any other works assigned to it by the board according to the provisions hereof

Article (17):

Neither the chairman of the board, his deputy, any member of the board, the general manager or any of the Foundation's employees shall have a personal interest, whether directly or indirectly, in the contracts entered into with or for the account of the Foundation or in the projects which it undertakes or in any of its business fields.

Chapter 5: Financial System of the Foundation

Article (18):

The resources of the Foundation are formed of the following:

1. A proportion of 8,2% of the government revenues in the general budget of the State
2. Other financial appropriations allocated thereto by the State
3. Revenues made by the Foundation from the practice of its business
4. Aids, donations, endowments and recommendations accepted by the board
5. Returns of the Foundation's funds investment

Article (19):

The Foundation shall have an estimated annual budget to be prepared according to rules set out in the internal bylaws. It shall also have a special account to deposit its funds therein.

The financial year of the foundation shall commence on April 1 and shall end on March 30 of each year, provided that the first financial year of the Foundation shall start as of the effective date of this Law and shall end on March 30 of the next year.

Article (20):

The Foundation shall keep the surplus of its budget and carry it forward from year to year.

Article (21):

The audit bureau shall handle the control and auditing of the Foundation's accounts according to the provisions of the law and shall submit its annual report to the Amir.

The Amir shall appoint one or more auditors to control the accounts of the Foundation. The auditor shall have the right, at all the times, to review all the books, records and documents of the Foundation, to request data he deems necessary to obtain in order to duly perform his job. He may verify the assets and liabilities of the Foundation. In the event where he is unable to exercise such rights, he shall submit a report in relation thereto to the Amir.

Chapter 6:

Article (22):

Technical and executive tasks related to the orientation, regulation, evaluation and follow-up of the scientific research projects shall be assigned to the Fund, which shall perform the following:

1. Setting plans and strategies related to scientific research and submitting the same to the Foundation for approval
2. Determining the scientific research scopes which have a priority which serves the comprehensive development plans of the State
3. Setting criteria for the evaluation of quality, adopting scientific research projects on competitive basis and by virtue of international standards and specifications
4. Receiving scientific research projects for study, approving the validity, the economic or social feasibility as well as the future effects thereof and listing the same in the annual plan of the Fund

5. Supervising and following-up the execution of the scientific research and evaluating the results thereof periodically
6. Entering into agreements, memoranda of understanding and contracts related to scientific research projects with national, regional and international parties
7. Qualifying national cadres in the fields of research it makes and approves its results
8. Following-up the scientific developments inside and abroad, cooperating and coordinating with the concerned parties in relation thereto
9. Sponsoring, organizing and participating in local, regional and international conferences, meetings, seminars and gatherings related to scientific research

Article (23):

The Fund shall coordinate with the secretariat for the developmental planning, regarding its annual research and scientific plan, its effects and consistency with the comprehensive vision and the general strategic development plan of the State.

Article (24):

The Fund shall submit to the Foundation a half yearly periodical report regarding its activity, business and development of research it carries out or supervises and its evaluation thereof. It shall also submit to the Foundation a detailed report on the aspects of its activity, research and scientific projects and work progress related thereto, its financial status, within a period not exceeding three months from the date of the end of the financial year of the Fund, comprising its suggestions and recommendations and accompanied with a copy of the final account.

Article (25):

The Fund shall submit to the Foundation the project of its annual balance sheet for the scientific research for approval. The Foundation shall amend the same in consultation with the Fund.

The balance sheet project shall state the amounts fixed by the Fund for the execution of its annual scientific plan and the methods of expenditure of the same.

Article (26):

The Fund shall start its tasks and competences in accordance with the provisions hereof and its regulations and internal bylaws.

Chapter 7:

General Provisions

Article (27):

All the ministries, other government authorities, public bodies and institutions shall provide the Foundation with all the data and information it shall request and shall cooperate with it to execute the decisions issued by the board within its scope of competence.

Article (28):

The chairman shall submit to the Amir a detailed report on the Foundation's activities, projects, work progress, financial position in a period not exceeding three months from the date of the end of the financial year, provided that the report comprises its suggestions and recommendations and that it is accompanied with a copy of the auditor's report, if any.

Article (29):

The Amir may require the board to submit reports on the administrative, financial and technical status of the Foundation or on any of its business aspects or information related thereto. He may issue general instructions regarding matters that the board shall observe in relation to the issues related to the general policy.

Article (30):

In all matters not provided for herein, the law regulating the civil service in the State shall be applied on the employees of the Foundation.

Article (31):

The board shall issue the decisions necessary for the implementation of the provisions hereof.

Article (32):

All the competent authorities shall, each within its scope of competence, execute this law. It shall be published in the Official Gazette.

Tamim Bin Hamad Al-Thani
Deputy Amir of the State of Qatar

Issued at the Amiri Diwan on 25/9/1429 H, corresponding to 25/9/2008 AD.

References

- Ailes, Catherine P., H. Roberts Coward, et al., *Evaluation of NSF Support for Undergraduate Research Opportunities: Inventory of Undergraduate Research Opportunities*, final draft, Arlington, Va.: SRI International, 2003.
- Armstrong, Karen, *A History of God: From Abraham to the Present, the 4000-Year Quest for God*, New York, N.Y.: Random House, 2003.
- Brown, David, "Next Director of National Institutes of Health Faces Budget Challenges," *Washington Post*, December 12, 2008, p. A02. As of July 18, 2011:
<http://www.washingtonpost.com/wp-dyn/content/article/2008/12/12/AR2008121203973.html>
- The Center for Effective Philanthropy, *Indicators of Effectiveness: Understanding and Improving Foundation Performance*, 2002.
- , *Foundation Governance: The CEO Viewpoint*, 2004.
- Deci, Edward L., Richard Koestner, et al., "A Meta-Analytic Review of Experiments Examining the Effects of Extrinsic Rewards on Intrinsic Motivation," *Psychological Bulletin*, Vol. 125, No. 6, 1999, pp. 627–668.
- The Gates Millennium Scholars, "About GMS," 2009. As of January 9, 2011:
<http://www.gmsp.org/>
- Greenfield, Victoria A., Debra Knopman, et al., *Design of the Qatar National Research Fund: An Overview of the Study Approach and Key Recommendations*, Santa Monica, Calif.: RAND Corporation, TR-209-QF, 2008. As of July 18, 2011:
http://www.rand.org/pubs/technical_reports/TR209.html
- Kroeber, A. L., and C. Kluckhohn, *Culture: A Critical Review of Concepts and Definitions*, New York: Random House, 1952.
- Locke, Edwin A., "The Nature and Causes of Job Satisfaction," in M. Dunnette, ed., *Handbook of Industrial and Organizational Psychology*, Chicago, Ill.: RAND-McNally, 1976, pp. 1297–1349.
- Loretz, Christopher A., *Looking Beyond the Borders: A Project Director's Handbook of Best Practices for International Research Experiences for Undergraduates*, produced by the NSF Workshop on Best Practices for Managing International REU Site Programs, April 9–10 and November 8–9, 2001, Arlington, Va.: National Science Foundation, 2002.
- The National Academies, "Ford Foundation Fellowship Program," 2009. As of January 7, 2011:
<http://sites.nationalacademies.org/pga/fordfellowships/>
- National Institutes of Health, "NIH Budget," 2009a. As of January 7, 2011:
<http://www.nih.gov/about/budget.htm>
- , "NIH Student Training Opportunities," 2009b. As of January 9, 2011:
https://www.training.nih.gov/_search/Student%20Training%20Opportunities
- National Opinion Research Center, *Gates Millennium Scholars (GMS) Tracking and Longitudinal Study: 2003–2004*, Final Report, Cohort 3, Chicago, Ill.: University of Chicago, 2004.

National Science Board, "Science and Engineering Indicators 2008," Washington, D.C.: National Science Foundation, January 2008. As of July 18, 2011:
<http://nsf.gov/statistics/seind08/>

National Science Foundation, "FY 2007 Performance Highlights," undated. As of July 18, 2011:
http://www.nsf.gov/pubs/2008/nsf0803/highlights_complete.pdf

———, *Science and Engineering Indicators*, 2008. As of July 18, 2011:
<http://www.nsf.gov/statistics/seind08/>

———, *About the National Science Foundation*, 2009. As of January 9, 2011:
<http://www.nsf.gov/about/>

Porter, Lyman W., W. J. Crampon, et al., "Organizational Commitment and Managerial Turnover: A Longitudinal Study," *Organizational Behavior and Human Decision Processes*, Vol. 15, 1976, pp. 87–98.

RAND Europe, *Measuring the Benefits from Research*, Cambridge, UK: RAND Europe, RB-9202-RE, 2006. As of July 18, 2011:
http://www.rand.org/pubs/research_briefs/RB9202.html

Russell, Susan H., Catherine P. Ailes, et al., *Evaluation of NSF Support for Undergraduate Research Opportunities: 2003 NSF-Program Participant Survey: Draft Final Report*, Arlington, Va.: SRI International, 2005.

Russell, Susan H., Mary P. Hancock, et al., *Evaluation of NSF Support for Undergraduate Research Opportunities: Survey of SBES Graduates: Draft Final Report*, Arlington, VA: SRI International, 2005a.

———, *Evaluation of NSF Support for Undergraduate Research Opportunities: Survey of STEM Graduates: Draft Final Report*, Arlington, Va.: SRI International, 2005b.

———, *Evaluation of NSF Support for Undergraduate Research Opportunities: Draft Synthesis Report*, Arlington, Va.: SRI International, 2006a.

———, *Evaluation of NSF Support for Undergraduate Research Opportunities: Follow-up Survey of Undergraduate NSF Program Participants: Draft Final Report*, Arlington, Va.: SRI International, 2006b.

Shore, Lynn McFarlane, and Sandy J. Wayne, "Commitment and Employee Behavior: Comparison of Affective Commitment and Continuance Commitment with Perceived Organizational Support," *Journal of Applied Psychology*, Vol. 78, No. 5, 1993, pp. 774–780.

Spencer, David B., and Sharon Dawes, *Report of the Advisory Committee for GPRA Performance Assessment FY 2008*, Washington, D.C.: National Science Foundation, 2008. As of February 28, 2009:
<http://www.nsf.gov/pubs/2008/nsf08064/nsf08064.pdf>

Tett, Robert P., and John P. Meyer, "Job Satisfaction, Organizational Commitment, Turnover Intention, and Turnover: Path Analyses Based on Meta-Analytic Findings," *Personnel Psychology*, Vol. 46, 1993, pp. 259–293.

United Negro College Fund, *Impact 2008 Annual Report*, Fairfax, Va., 2009.

Universities Space Research Association, *2008 Annual Report*, Columbia, Md., 2008.