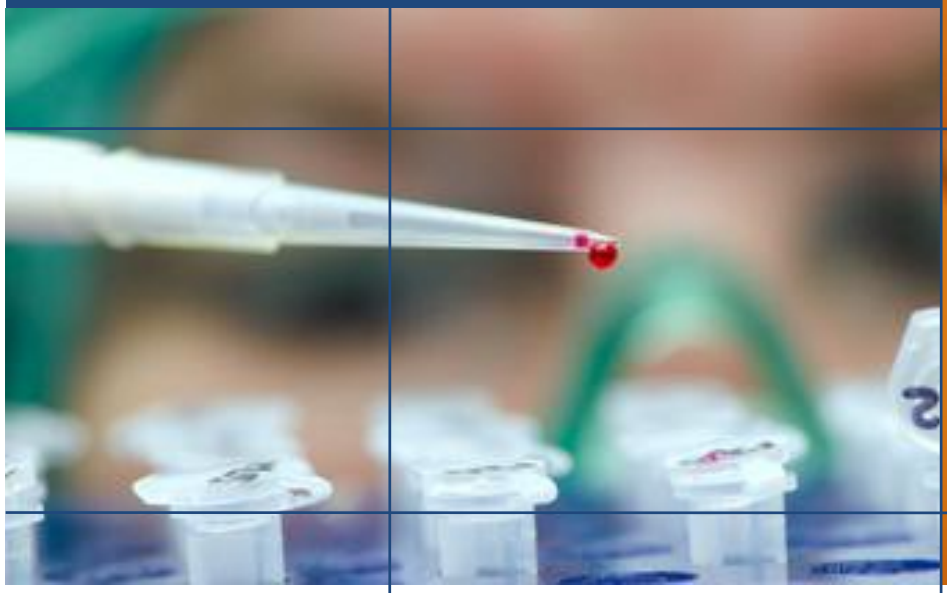
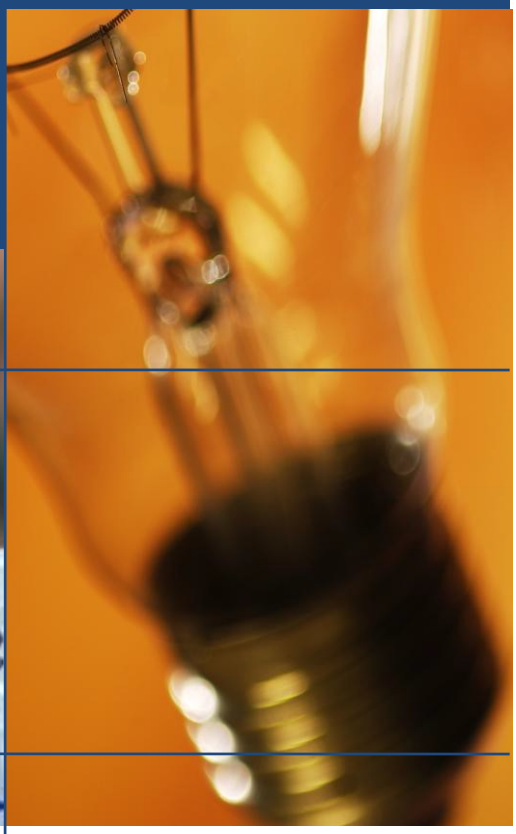
# Invest | Evaluate | Communicate

2012 Assessment of the Oklahoma Center for the Advancement of Science and Technology's Role in Oklahoma's Technology-based Economic Development Ecosystem.





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# ACKNOWLEDGEMENTS

The quotes contained in this report should not be attributed to any one particular individual as stakeholder interviews were conducted with the assurance of anonymity. The findings and observations contained in this paper are those of the authors and do not necessarily reflect the views of the Oklahoma Center for the Advancement of Science and Technology or its staff.

SRI interviewed many people in person and over the phone for the entire series of reports, and we are grateful for their input and time:

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- Mark Ballard, Programs Officer, Oklahoma Center for the Advancement of Science and Technology
- Terry Salmon, Chair, Oklahoma Science and Technology Research and Development (OSTRaD) Board of Directors (OSTRaD is the governing board for OCAST)
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- David Myers, Executive Director, Ponca City Development Authority

- Josh O'Brien, Director of Entrepreneurial Development, Greater Oklahoma City Chamber
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- Roy Williams, President and Chief Executive Officer, Greater Oklahoma City Chamber
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- Susan Shows, Senior Vice President, Georgia Research Alliance

# EXECUTIVE SUMMARY

In January 2012, SRI International was contracted by the Oklahoma Center for the Advancement of Science and Technology (OCAST) to review and benchmark its evaluation process and methodology, strategy for communicating impacts, and position in the state's overall technology-based economic development (TBED) ecosystem. SRI was engaged by OCAST in a similar study in 2000 as the result of a mandate by the Oklahoma legislature. SRI brings deep experience in program evaluation and technology-based economic development in addition to our in-depth historical knowledge of OCAST. This report, the final in a three-report series, combines the first two reports that addressed methods for measuring the economic and other significant impacts of OCAST's programs (report 1) and OCAST's strategies and procedures for communicating those impacts to stakeholders (report 2). The present report builds upon these two reports, expanding SRI's overall assessment to include OCAST's fit in the state-wide technology-based economic-development system. SRI's assessments of these topics are based on extensive document review, interviews with OCAST stakeholders, reviews of seven benchmark states' TBED organizations, and interviews with benchmark-state representatives.

In comparing OCAST's impact on Oklahoma's economic development in 2012 with SRI's findings in our similar study of OCAST completed in 2000, our overall impression is that the role of OCAST programs in state economic development, as well as its mission, are better understood by stakeholders now than in 2000. Accompanying this greater understanding is continued strong support for OCAST among stakeholder groups, who overwhelmingly agreed that OCAST is a key player in the state's economic development strategy and that the state's science and technology capabilities would be much weaker without OCAST.

This Executive Summary follows the organization of the full report: *Invest, Evaluate, Communicate*. This framework reflects the primary questions OCAST asked SRI to address:

1. How effectively does the OCAST evaluation method collect program information?
2. How do OCAST's evaluation methods compare with other states? How does OCAST compare with other states in reporting evaluation findings?
3. Where does OCAST fit in the state's technology-based economic development (TBED) structure?
4. Considering the last five years of OCAST award data, do the agency's programs support TBED needs and the R&D infrastructure in Oklahoma?

These questions derive from three key issues that any state TBED organization must resolve: the size and scope of the organization's portfolio of investments intended to pay off in enhanced economic development for the state; how to collect and analyze data intended to measure the impact of the organization's portfolio of investments; and how to communicate the resulting impact measures to stakeholders, including the Oklahoma legislature.

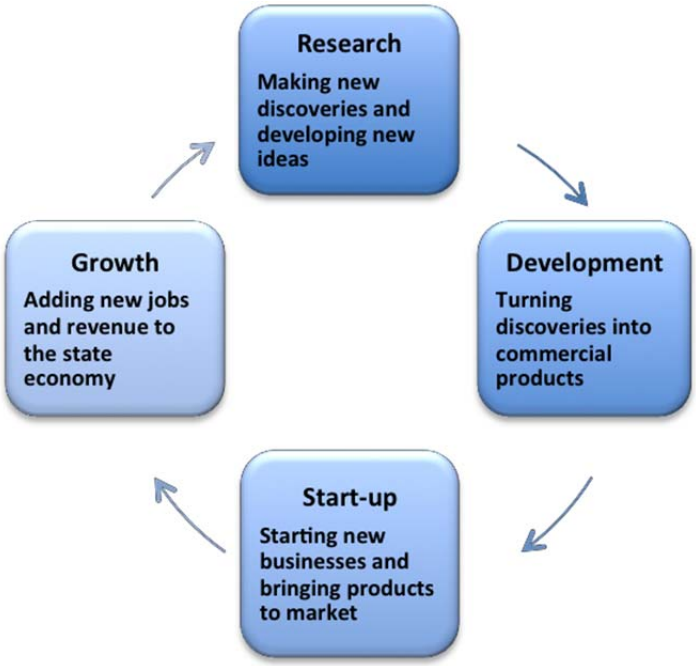


**Figure ES-1.** The Innovation Cycle

## Invest: OCAST in the context of Oklahoma's TBED structure

SRI's stakeholder interviews showed that OCAST is regarded as a valuable asset to the Oklahoma TBED community. In addition, SRI's benchmarking analysis of TBED organizations in seven leading states found that many OCAST practices are consistent with those of the comparison organizations. Like many state TBED organizations, OCAST has evolved over the years from initially supporting targeted research at universities and companies to addressing a variety of perceived weaknesses or gaps within the innovation cycle (see Figure ES-1). OCAST's expansion into new product commercialization and entrepreneurial support is also among current best practices in TBED strategy.

One of the most important components of a competitive, dynamic and successful technology-based economy is the strength of the networks and the degree of collaboration among the various entities in the TBED ecosystem, which OCAST supports through its requirements for collaboration. The one-stop shop aspect of OCAST was a strength cited by stakeholders. As one stakeholder stated, "The strength of OCAST is that there is a single point of contact for a company, and OCAST can walk them through it. OCAST directs traffic, so we aren't running people around."

While some of OCAST's programs may overlap those of other entities in the TBED ecosystem, the overall scale of OCAST's activities and its capacity to reach stakeholders in different parts of the state are also important. Many of OCAST's programs receive many more applications than can be funded. This demand is an indicator of a gap in the availability of funding for higher risk commercialization projects (as long as the quality remains high). Overwhelmingly, stakeholders

interviewed by SRI stated that OCAST is a valuable asset in the state's TBED community and that Oklahoma's science and technology community would be much weaker without the agency.

Stakeholder opinion that OCAST should focus on industries in which it has a clear competitive advantage was widespread in the interviews. Current OCAST programs do focus on some specific areas such as health science, plant science, and nanotechnology. Stakeholders said the Health Science Research Program supports Oklahoma's clear strength in life science/bioscience, which is reflected in the medical university in Oklahoma City and its neighboring research park. However, stakeholders also said there were industry clusters in Oklahoma they felt OCAST was not supporting. Many mentioned the unmanned vehicles segment of the aerospace industry as a possible missed opportunity for OCAST investment; as one said: "I wish that [OCAST] could grow in the aerospace side; the business leaders and legislators are becoming more interested in this." Another said, "With the history of Oklahoma, I believe we ought to be doing more in the space area." Another potential OCAST investment opportunity cited by stakeholders was support for information technology. Of course, more due diligence would need to be conducted to assess if there are actual constraints to the growth of these sectors in which OCAST investment could make a difference.

SRI asked stakeholders if they could identify any gaps in the state's existing TBED ecosystem, and if OCAST is the appropriate entity to attempt to fill those gaps. Most stakeholders said they see no gaps other than the need for more funding for OCAST programs. If OCAST were to receive more funding, stakeholders mentioned opportunities for OCAST programs unrelated to cluster development, including support for major research equipment purchases that would be shared across the state. Another stakeholder would like to see more recruitment of "high-tech minds" to the state. Other stakeholders said OCAST should attract more federal dollars to the region by focusing seed funding on projects that have the greatest potential for leveraging federal funding.

### Recommendation: prepare and periodically update a strategic plan

Many OCAST stakeholders interviewed for this project suggested that OCAST develop a more strategic vision for its funding allocation decisions. As one said, "Many of these programs are quite traditional – since many of them were formed when OCAST was created 20+ years ago, but S&T, the economy, and the state are now in entirely different situations." This is echoed in calls for investment in existing Oklahoma industry clusters and in fields with the greatest prospect of federal grants, for example, the Small Business Innovation Research (SBIR) Program. A strategic plan should be based on an analysis of Oklahoma's existing science and technology skill set, information that stakeholders told us was lacking.

## Evaluate: How and what to measure

OCAST is commended by many for its longstanding commitment to the evaluation of its programs. Measuring impacts accurately and consistently is widely regarded as difficult, but OCAST has been dedicated to systematic collection of impact data from program participants despite these hurdles.

## OCAST impact data collection

OCAST collects impact data directly from awardees (typically principal investigators) in the Plant Science Research program, Applied Research Support program, Small Business Research Assistance (SBRA), Nanotechnology Applications Project program, and R&D Internship Partnership program via surveys distributed to each recipient. The surveys are very similar across the programs. Many of the questions are clear and seek unambiguous information (such as *number of patents awarded*); however, there are also many questions that ask for information that is unclear (such as the *dollar value of patents awarded*) when no definitions or guidance are provided. The surveys contain many questions that were unclear to SRI as to precisely what information was being sought and how that information was relevant to the program. If a survey is returned with unexpectedly high or low impact numbers, an OCAST staff member follows up with the respondent to verify the numbers. Beyond this, however, there is no systematic effort to verify the accuracy of the survey data.

Impact data for the programs managed by OCAST's partners i2E and the Oklahoma Manufacturing Alliance (OMA) are collected by the partners themselves. i2E and OMA analyze their own data and pass along their impact numbers to OCAST.

## OCAST impact measurement

OCAST publishes impact metrics at both the program level and the aggregate level in its impact reports. These impact reports are used to communicate with both the state legislature and the general public. All reports contain case studies of award recipients. There is little consistency from year to year, although dollar-based return on investment (ROI) measures are presented along with a ratio of return on investment for each program and an aggregate for all OCAST programs. OCAST's partners i2E and the Oklahoma Manufacturing Alliance publish their own impact reports that provide impact data on OCAST-funded programs. It is notable that i2E does not generate ROI estimates based on these survey data; however, OCAST uses the i2E data to generate its own ROI estimates. The Oklahoma Manufacturing Alliance's 2010-2011 impact report also does not provide ROI ratios.

Several stakeholders felt the major problem with ROI estimates is that many important program impacts cannot be measured in dollar terms and/or occur long after an original award is made. For example, many stakeholders valued collaborations among companies, universities, and economic development agencies and broadly attributed these collaborations to OCAST programs. Programs requiring collaboration between faculty members and companies are sometimes a faculty member's first introduction to the value of university-industry collaboration in research. OCAST facilitates these connections, and companies benefit from the faculty member's expertise. In the internship program, participating companies benefit from the training and mentoring of the intern by the faculty member. The intern learns from the experience and may accept a job at that company and stay in Oklahoma, thereby reducing brain drain.

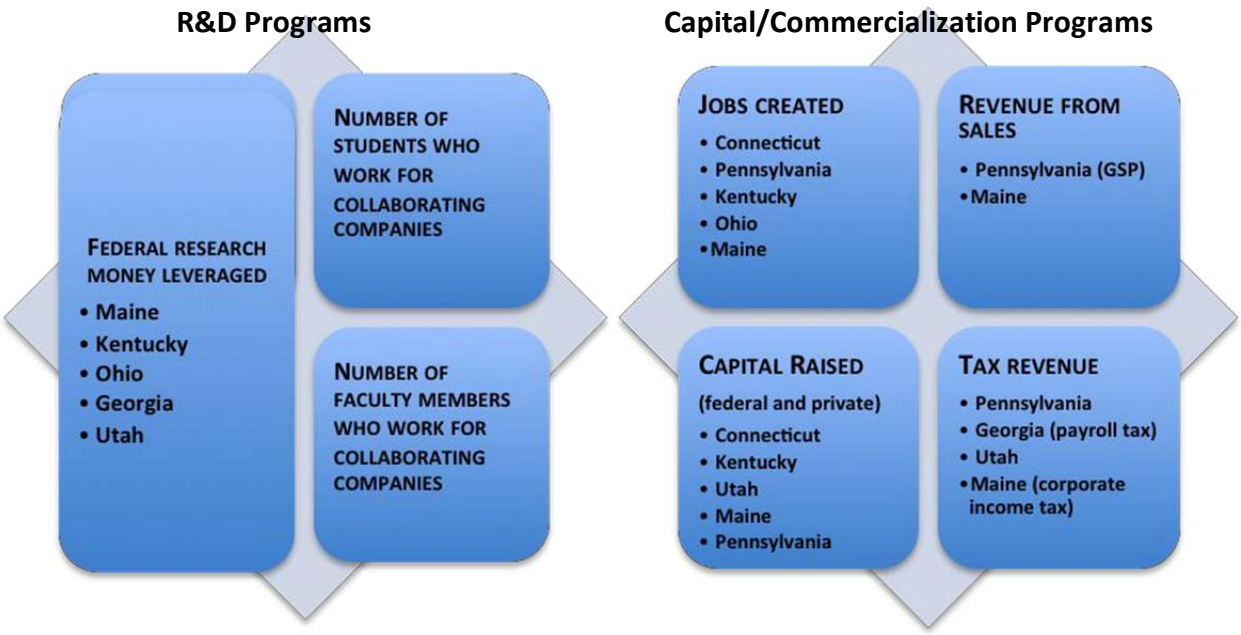


**Figure ES-2.** Recommended metrics grouped by programs across benchmark states.

Almost all the stakeholders SRI interviewed said anecdotal case examples are the most effective way to show impact – especially if the examples are outside of Oklahoma City and Tulsa. However, they also recognized this may be difficult because the number of OCAST awards is small and the geographic distribution of awards – especially research awards – is highly skewed toward urban areas and the comprehensive research universities. In addition, a few stakeholders pointed out that many other state agencies report ROI, so that OCAST's ROI can get lost in the plethora of numbers.

### OCAST's metrics in context of benchmark states

Best practices of measuring results of TBED programs recommend that organizations focus on a relatively few, clearly defined metrics. Many TBED officials recommended the set of metrics summarized in Figure ES-2. For research and development grants, many suggest reporting the federal research funds leveraged by the state investment and the number of graduate students and faculty hired by collaborating companies. For later stage programs, many suggest jobs created, sales revenues, and capital raised (especially from outside the state) – as well as how these metrics have changed over time.

Seven benchmark states (Connecticut, Utah, Pennsylvania, Maine, Kentucky, Ohio, and Georgia) were examined based on recommendations that they are doing an especially good job of measuring the impact of state TBED programs and communicating the results to key stakeholders, especially state legislatures. SRI interviewed the presidents, CEOs, and the directors of communication of key TBED organizations in these seven benchmark states, and reviewed the publications they distribute to the general public and state legislatures. The resources and services provided by these state technology-based economic development

entities vary widely. Some state organizations, such as Connecticut Innovations, do not provide grants for research or support for SBIR applications. Other organizations, such as Utah's USTAR and the Georgia Research Alliance (GRA), focus mainly on attracting star researchers to the state's universities and funding researchers there.

The *Metrics that Matter* box summarizes the metrics SRI identified as effective and in common use by benchmark states. At first glance these metrics seem clear and precise; however, each metric needs to be clearly defined in survey instruments and in impact publications.

SRI's analysis of the benchmarking states' TBED program evaluation reports underscored the uniqueness of Oklahoma's virtually one-agency approach to funding public support for the R&D/innovation cycle. If state funding exists for research and development, programs in benchmark states usually are administered through an agency (and funding source) separate from later stage programs such as seed capital, technology transfer, etc. The suggestion that different impact metrics be used for R&D funding and commercialization support is reflected in the practices of the benchmarking states. Figure ES-2 shows several recommended metrics along with the benchmark states that actually use each metric. Although nearly all benchmark states use federal money leveraged by state program support as an impact metric, apparently no benchmark states report the number of faculty members or students that go on to work for a company funded under a state-funded R&D program. However, most states use the recommended metrics for capital/ commercialization programs.

**Metrics that Matter**

**Capital/Commercialization Metrics**

- Jobs created
- Revenue from sales
- Capital raised
- Changes over time

**Research Metrics**

- Federal research money raised
- Number of students who work for collaborating companies
- Number of faculty members who work for collaborating companies

Although some of the benchmark states (CT, PA, KY, OH) use ROI measures occasionally, if not annually, most do so only in aggregate form rather than for a range of different programs within the scope of their funding. This yields a single measure that can be used to argue that one dollar of state investment in the TBED organization yields multiple dollars of impact on the state economy. This approach is generally considered effective in getting the attention of stakeholders, especially legislators, and serves as a necessary element in the arsenal of arguments used by other agencies competing for public funds. An ROI measure is always supplemented by more detailed, quantitative impact measures that are specific to the objectives of each program within the TBED agency's portfolio, and thereby identify the basis for each ROI presented. Several states employ input-output (I-O) models of the state to generate information on the impact of the TBED agency's investments on employment, tax revenues, gross state product (GSP), change in personal income, and various other measures of economic development. Dan Berglund of the State Science and Technology Institute (SSTI) observes that measures such as increased tax revenues can be compelling to stakeholders, but others argue that the multipliers used in such models have little credibility in some quarters.

Despite the wide variety of metrics, there was widespread agreement in SRI's interviews that the most effective way to influence legislative bodies is a combination of single, "open the door" measures such as aggregate ROI or increased tax revenues with more detailed impact measures such as leverage on federal research funding, job creation (job retention data are viewed with some skepticism), and venture financing attracted from outside the state; and case studies of actual leverage and job creation.

### Implications and recommendations for OCAST

To develop a more balanced scorecard that builds on current metrics, including ROI, SRI recommends that OCAST seek a more balanced presentation that includes (1) a single, "reasonable" ROI for all of OCAST that matches similar numbers in benchmark states, (2) emphasis on the specific impact measures used (e.g., federal dollars leveraged, jobs created, out-of-state-financing obtained, university-industry collaborative research projects initiated, student internships with companies), and (3) case studies of high-payoff investments should further improve OCAST's already highly favorable perception among its stakeholders. The impact measures collected by OCAST should support these goals.

Of the benchmark state survey instruments obtained by SRI to this point, nearly all were simpler than OCAST's survey, and they were similar to those used by i2E. OCAST's current surveys of their R&D-support and internship programs contain many items that are repeated across all instruments, leading to clients facing items that are inapplicable, difficult to interpret, or time-consuming to respond to conscientiously. SRI recommends future surveys be tailored to the program surveyed and reflect the appropriate impact metrics OCAST has chosen. For example, if OCAST will not be using jobs retained in its impact reports, the survey should not ask about jobs retained. A shorter, more efficient survey will reduce the burden on respondents, increase response rates, and improve the accuracy of responses.

OCAST staff pointed out to us they are now designing an online evaluation survey, which we strongly encourage. An online impact survey can provide easily accessible guidance and some internal checks. Such surveys also can provide definitions and examples of the impact measure requested through pop-up boxes. In addition, the previous year's responses can be presented automatically to prevent double counting of impacts such as leveraged grants and to discourage entering lasts year's numbers for this year's numbers.

Augmenting OCAST's annual surveys with periodic – perhaps every five years – in-depth, multi-year assessments that incorporate a variety of data sources and offer a range of impact measures generated by different analytical methods (e.g., survey data, I-O analyses, interviews, documented case studies, use of publicly available state economic data) would strengthen OCAST's overall evaluation efforts. The combination of periodic third-party assessments and a simplified and more reliable annual survey process would offer OCAST a strong mix of both credible and effective impact measures.

## Communicate: OCAST's communication strategy

Following investment and impact evaluation, OCAST must communicate how Oklahoma's TBED programs serve the state and provide stakeholders with clear and convincing evidence of the value of public investment to achieve a set of specific objectives. Many OCAST stakeholders and leaders of TBED organizations in the benchmark states told SRI the most important objective of

an impact communication strategy is to demonstrate to people across the state that OCAST can benefit them, even if they live in rural parts of the state or do not manage a high-tech company. The best way for OCAST to show stakeholders its programs can make their future better is to communicate clear and compelling evidence about OCAST's past performance and its programs and services.

OCAST currently conveys its impact in a variety of ways that target different segments of stakeholders. Forms of communication include print, radio, and hosting and sponsoring events, including:

- OCAST's annual *Impact Report*;
- Weekly radio show (*Oklahoma Innovations*);
- Newspaper articles;
- Legislative testimony and visits;
- *Oklahoma Research Day;*
- Oklahoma Science and Technology Month activities, including recognition of more than 1,400 middle school and high school students each year for achievement in science and technology;
- Rural Action Partnership Program; and
- OCAST staff visits around the state.

> "Over the years, OCAST has done a good job on both measuring and communicating its positive results."
>
> Dan Berglund, President and CEO
> State Science and Technology Institute (SSTI)
> Westerville, OH

OCAST's many methods of communication compare favorably with those in the benchmark states. Although OCAST's staff does an impressive job of outreach, there are some challenges.

## Challenges

### Many Oklahomans lack an understanding of OCAST's goals.

The wide variety of OCAST programs makes communicating OCAST's goals and impacts challenging. Stakeholders who know OCAST's research and development programs may not know about OCAST's commercialization programs. In addition, even if someone is aware of the full array of OCAST's programs, he or she may not realize how these seemingly disparate programs work together in a synergistic way to accomplish broad economic development goals.

### *OCAST's partners are sometimes more visible than OCAST.*

In SRI's conversations with stakeholders and review of OCAST documents, it became apparent that communication opportunities through OCAST's strategic partner organizations have been underutilized. As one stakeholder noted, "Most folks don't realize that the Oklahoma Manufacturing Alliance is [connected to] OCAST; this is a missed opportunity to make it clear that OCAST is helping rural Oklahomans." In addition, other stakeholders mentioned that many people are unaware of the connection between i2E and OCAST.

### *Reporting return on investment ratios (ROI) for OCAST programs is problematic.*

Many OCAST stakeholders are unfamiliar with the concept of return on investment, especially when presented as a single quantitative ratio with little material explaining its basis. Moreover, large ROI numbers can invite skepticism and/or scrutiny, and a wide range of ROIs for different OCAST programs reported side-by-side can invite threats to cut out any activities with relatively low ratios. Furthermore, ROI ratios based on monetized data do not adequately communicate

many important program impacts. The single ROI impact measure misses many important program outcomes that have major economic significance but are not easily quantified.

***Job creation and retention numbers are hard to measure, controversial, and are lagging indicators.***

OCAST currently collects and reports on jobs created and retained; however, the goal of TBED investment is not to create jobs in the short term, but to catalyze development and to fill critical funding gaps private market incentives can fail to fill. Not all program investments will create jobs due to the very nature of TBED funding. In addition, if indeed jobs are created, they often emerge only years after the public investment.

***Oklahoma economic development agencies and OCAST are not as well aligned as they could be.***

Local economic development agencies are many entrepreneurs' and businesses' first stop, and representatives of these agencies told SRI they do not have a solid understanding of OCAST's core services and capabilities.

## Recommendations for communicating impact

***Shift to a new set of metrics.***

SRI recommends OCAST consider an approach that minimizes the use of single number return on investment indicators, especially at the aggregate agency level, but instead use them sparingly and cautiously for individual projects and programs for which there are clear and transparent underlying cost and impact data. OCAST could explain a shift away from emphasis on an aggregate ROI ratio to presenting a small set of impact metrics by arguing that doing so increases the transparency of its program impact measures, thereby improving its overall accountability to the legislature and the taxpayers. OCAST can also point to widespread use by the benchmark states of a suite of metrics to capture TBED program impacts and to the recommendations of the State Science and Technology Institute.

SRI advocates using leveraged, follow-on federal dollars attracted as the key impact metric for OCAST research investments; this shows clearly the causal link between the initial investment OCAST makes in a researcher or piece of equipment and the follow-on funding the researcher subsequently attracts. For internships and applied research grants, SRI recommends tracking the number of students receiving internships and faculty-company partnerships, their home counties, the number of students or faculty hired by the Oklahoma companies at which they interned or partnered, and the number who remain in state because of the job opportunities revealed or connections made during their internship experience.

For companies and entrepreneurs, SRI recommends using measures of follow-on private investment attracted and number of companies assisted (while also trying to keep track of companies that have ceased operations). SRI also suggests publicizing the number of companies assisted, the revenues of sales of products commercialized through these services, and the follow-on private and federal investment in product commercialization. In addition, if tax revenue impact estimates are used, SRI recommends presenting them in a very conservative and transparent way.

### *Communicate the value of R&D internships*

SRI recommends that, in addition to notification of each recipient's hometown newspaper, OCAST also send a letter to each recipient's legislator to let him/her know a constituent student has won an OCAST R&D Internship. These interns come from all over the state, and state representatives should know which companies and students OCAST is using state money to support. Simple notification letters can start a word-of-mouth chain, and notices in recipients' hometown papers can serve as an effective public communication tool.

### *Highlight partnerships with i2E and OMA*

OCAST's 2011 *Impact Report* describes the programs managed by i2E, but does not mention i2E by name and describes OMA as if it is another OCAST-supported stand-alone program like the research grant programs. Failing to emphasize clearly these partnerships (and the key role played by OCAST support) may result in some misunderstanding in the public and the legislators' minds about the nature and importance of the relationships. OCAST should highlight the value of these partnerships in its impact reports and explain clearly how they generate public benefits.

### *Hold press events for awards*

Hold more press events when OCAST awards are made, especially for programs managed by OCAST's strategic partners. An OCAST press event would highlight OCAST's role in all TBED activities.

### *Provide context where possible*

Focusing on single projects with easily verifiable high ROI ratios can provide continuity with OCAST's historical focus on large aggregate and program-specific ROIs, thus easing SRI's recommended transition to more transparent and nuanced use of ROI language and concepts.

### *Distribute the Impact Report and advertise programs widely*

The annual *Impact Report* is easily distributed via email with no cost beyond the maintenance of an email list. In addition, OCAST may want to consider a one-page document that can be distributed to stakeholders to succinctly capture the agency's mission, range of programs, and highlights of recent success stories.

# INTRODUCTION

The goal of technology-based economic development (TBED) is to support the competitiveness of existing industry sectors and to stimulate the emergence of new industry sectors based on the adoption and commercialization of new technologies. TBED organizations play a critical role in the innovative capacity of a region by creating connections and helping foster collaboration between people with business ideas, people with technologies, and people with capital. TBED organizations may also provide critical seed funding to startup companies and/or targeted R&D or commercialization grants to universities. Companies and university researchers often are able to leverage this state-supported funding to procure larger follow-on funding from private and federal sources. Finally, TBED organizations may provide manufacturing extension and other technical services or assist in targeted workforce training or internship programs that help local companies identify human capital talent – one of the major pillars of corporate competitiveness. Through these various mechanisms, TBED organizations support a variety of economic activity in a region. The Oklahoma Center for the Advancement of Science and Technology (OCAST), Oklahoma's primary TBED organization, manages a range of programs whose objectives include funding basic and applied research and development, stimulating new company formation, and fostering technology transfer and commercialization.

Typically, TBED organizations such as OCAST evaluate the impact of their programs to help guide internal program management decisions and to inform external policy decisions. Since the overarching objective of TBED activities is to support sustainable, long-term, and higher-value economic activity, state legislatures are keen to see the translation of the use of taxpayer dollars into economic performance, as indicated by such measures as higher-wage jobs, increased sales of products, new equity investments in companies, federal dollars attracted, and additional tax revenues generated. However, the inputs TBED organizations provide and these kinds of outcomes are not always immediately realized or directly connected. For example, a recent Organization for Economic Co-operation and Development (OECD) study[1] found that one of the most important characteristics of strong innovation systems and competitive regional economies such as Silicon Valley is the strength of the linkages among various entities such as companies, universities, angel and venture capitalists, financial institutions, government actors, etc. TBED organizations seek to catalyze and foster such connections through various programs aimed at promoting collaboration or bringing various actors together to share information that reveals common interests. Indeed, both corporate and regional economic success are attributable to a multitude of factors, and desired effects often cannot easily be traced to specific factors, inputs, or causes.

Because of the nature of TBED programs, it is not surprising a common problem for TBED organizations is a weak understanding by the general public, legislators, and even some clients about what TBED organizations actually do and how they stimulate and support regional economic activity. This is especially true for OCAST because of the wide range of programs it supports. Many clients benefitting from one type of service (such as seed funding) may be

[1] OECD, *Clusters, Innovation and Entrepreneurship*, Paris, France: OECD, 2009.

unaware of OCAST's support of basic and applied research, support for start-up and established businesses, or programs to promote more efficient manufacturing processes. In addition, since many of OCAST's programs focus on the early stages of technology development and commercialization life cycle, there may be a considerable time lag between OCAST investments and their economic impacts (such as job creation) resulting in the connection being lost.

These and other challenges of TBED programs call for a carefully considered communication strategy, especially for communicating credible and transparent evidence of program impacts on the state's economic development to stakeholders. Such a strategy should be designed to address the following goals:

- Make stakeholders aware of the organization's services and capabilities;
- Show principal stakeholders and taxpayers how programs have actually benefitted them; and
- Garner sufficient support from the citizenry and their legislative representatives to generate continuing, stable financial and political support.

In January 2012, SRI International was contracted by OCAST to review and benchmark its evaluation process and methodology, strategy for communicating impacts, and position in the state's overall technology-based economic development (TBED) ecosystem. SRI was engaged by OCAST in a similar study in 2000 as the result of a mandate by the Oklahoma legislature. SRI brings deep experience in program evaluation and technology-based economic development in addition to our in-depth historical knowledge of OCAST. SRI's assessments are based on extensive document review, interviews with OCAST stakeholders, reviews of seven benchmark states' TBED organizations, and interviews with their representatives.

The report addresses four questions OCAST posed to SRI for the study:

1. How effectively does the OCAST evaluation method collect program information?
2. How do OCAST's evaluation methods compare with other states? How does OCAST compare with other states in the reporting of their evaluation findings?
3. Where does OCAST fit in the state's technology-based economic development (TBED) structure?
4. Considering the last five years of OCAST award data, do the agency's programs support TBED needs and the R&D infrastructure in Oklahoma?

These questions address three key issues that any state TBED organization must address: the size and scope of the organization's portfolio of investments intended to pay off in enhanced economic development for the state; the need to collect and analyze data intended to measure the impact of the organization's portfolio of investments; and the strategy to be used to communicate the resulting impact measures to stakeholders, especially the state legislature. In short: *Invest, Evaluate, Communicate* – the titles for the three major sections of this report.

# BACKGROUND

The Oklahoma Center for the Advancement of Science and Technology was established in 1987

as the state's lead agency for technology-based economic development. OCAST's mandate is to "expand and diversify Oklahoma's economy and provide new and higher quality jobs for Oklahomans" by encouraging "the development of new products, new processes and whole new industries in Oklahoma."[2]

OCAST is responsible for eleven programs, as illustrated in Figure 1. OCAST directly administers awards focused both on basic and applied research support through the following:

- The Oklahoma Health Research program provides grants for health research;
- The Oklahoma Plant Science Research program provides grants for plant science research;
- The Oklahoma Applied Research Support program provided grants on a variety of subjects with significant potential for commercialization;
- The Nanotechnology Applications Project program provides for grants to apply nanotechnology;
- The R&D Internship Partnerships program provides grants that place university students in companies through a collaboration between faculty representative(s) and the company;
- The Small Business Research Assistance (SBRA) program provides grants for SBIR/STTR application assistance.

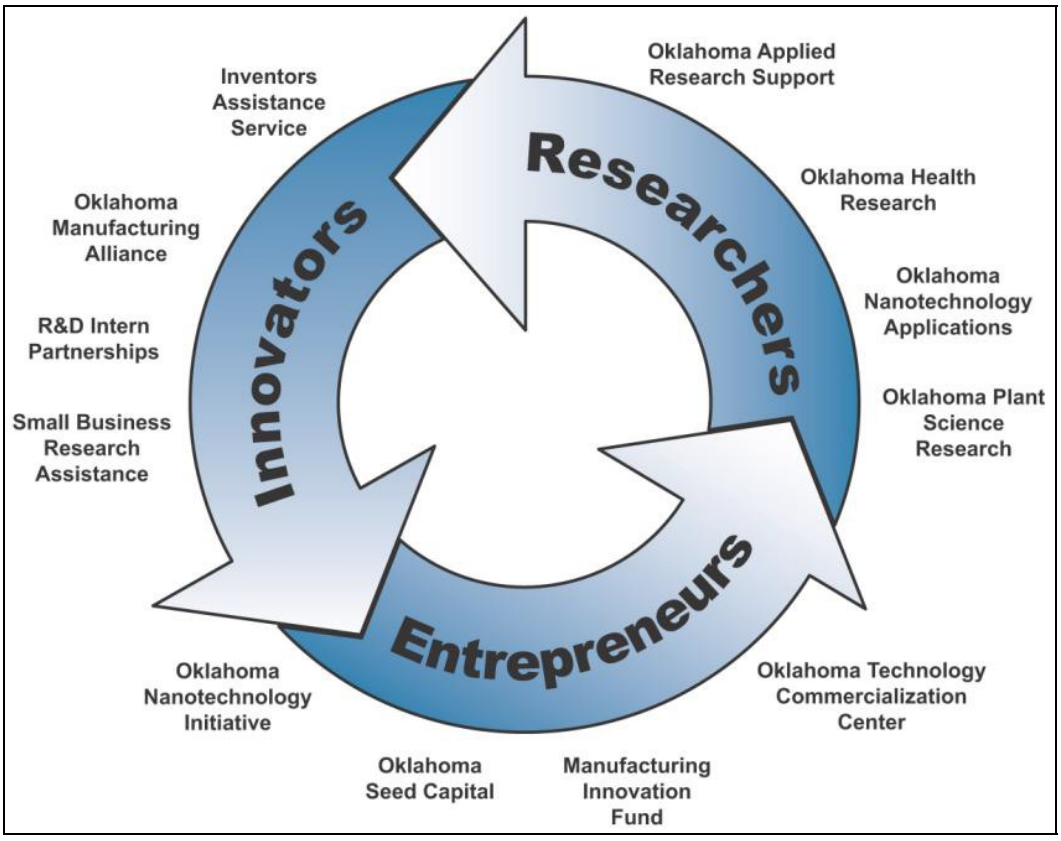


Figure 1. OCAST programs.

[2] Oklahoma Statue 74, Sections 5060.1a and 5060.2A

OCAST supports the following activities through service contracts with the Oklahoma Manufacturing Alliance (OMA), Oklahoma State University (OSU) and i2E:

- The Inventors Assistance Service (OSU) provides assistance and training to inventors;
- The Oklahoma Manufacturing Alliance (OMA) assists small- and medium-sized manufacturers to successfully compete through modernization and efficiency;
- The Technology Commercialization Center (i2E) assists start-up, advanced technology-related companies by providing business development services such as feasibility studies, marketing plans, business plans, and access to early stage risk capital;
- The Manufacturing Innovation Fund (i2E) provides limited pre-seed financing for start-up advanced technology firms that are in a development stage prior to full production;
- The Seed Capital Fund (i2E) makes equity investments in early stage companies engaged in the commercialization of promising new technologies in Oklahoma.

# INVEST: TECHNOLOGY-BASED ECONOMIC DEVELOPMENT

Sustained economic growth, through the increased production of goods and services by local companies that are nationally and internationally competitive, is the source of higher incomes for many Oklahomans. In any given economy, there are some large "pillar" industries that employ a significant number of people, some emerging industries that employ a much smaller number of people but may be growing relatively rapidly, and some declining industries that are shedding workers at a more or less rapid pace. Economic development seeks to catalyze commercial activity in new industries by supporting the emergence of home-grown companies; in existing industries through initiatives that strengthen these industries' workforce and productivity; and in both emerging and existing industries by attracting companies from outside the state that will deepen the industry and make the industry more competitive overall.

Technology-based economic development is a subset of a state's larger economic development portfolio. The objective of technology-based economic development is to support the competitiveness of new and existing industry sectors based on the adoption and commercialization of new technologies. In Oklahoma's case, these would include industries such as advanced manufacturing, biomedicine, agriculture, and oil and gas. For more than 30 years, state governments have been using science and technology funding as an economic development tool. Targeted funding can position universities to attract more federal research dollars in key fields. In the private sector, the adoption and commercialization of new technologies by companies is an important driver of innovation, and it is recognized that "innovation and a skilled labor force appear to make a big difference in explaining why some states have grown more than others."[3]

According to *Innovation America: Investing in Innovation,* the factors behind the push for states' TBED programs include:

- The rise of knowledge economies, where a majority of workers are employed in jobs where they use their heads more than their hands;
- The public desire for cures to illnesses that plague millions, such as Alzheimer's, diabetes and cancer;
- The rapid emergence of new markets in areas such as alternative energy; and
- The realization that every industry – not just high tech and biotech – needs to innovate in order to compete in the global marketplace. [4]

Today, nearly all states have some sort of technology-based economic development program. In some states the programs are part of the suite of economic development programs funded through existing state agencies. Oklahoma has created and funded collaborative partnerships with private and non-profit organizations to implement the OCAST portfolio of programs.

[3] Federal Reserve Bank of Cleveland, *2005 Annual Report: Alternated States: A Perspective on 75 years of State Income Growth*, Federal Reserve Bank of Cleveland: Cleveland, 2005.

[4] National Governors Association and Pew Center on the States, *Investing in Innovation*, 2007.

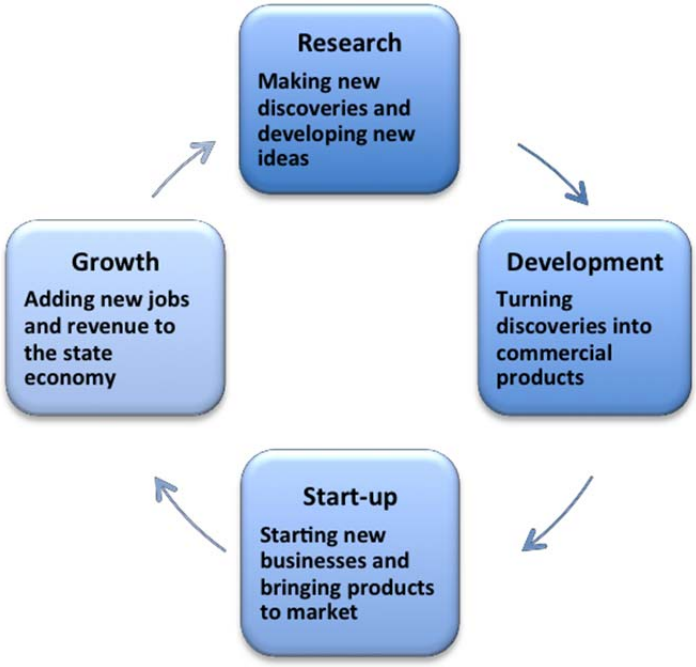


**Figure 2**. Continuum of technology-based economic development. Based on *Innovation America.*

OCAST has implemented science and technology research and development programs since its creation in 1987. Its current mission statement echoes the goals of other TBED organizations: to foster innovation in existing and developing businesses by:

- Supporting basic and applied research;
- Facilitating technology transfer between research laboratories and businesses;
- Providing seed capital for innovative firms in the development of new products or services; and
- Helping Oklahoma's small and medium-sized manufacturing firms become more competitive through increased productivity and modernization. [5]

Many state TBED organizations like OCAST have evolved over the years from initially supporting targeted research at universities and companies to addressing a variety of perceived weaknesses or gaps within the innovation cycle (see Figure 2). In the early 21st century, states have focused their support on creating industry clusters around complementary industry segments, supplier chains, and critical masses of talent, technology, and capital for sustaining and growing future economies. [6] The success of this focus is echoed in the *Innovation America* guidelines: One of the most successful approaches for

> *Highly educated people, great universities, and networks for interaction…come into being as a result of well thought out and strategic public policy.*
>
> *-Innovation America*

[5] Oklahoma Center for the Advancement of Science and Technology, *Fiscal Year 2012 Business Plan.*, 2011.

[6] Plosila, *ibid*.

states involved in funding R&D has been to target groups of companies and research institutions that are highly concentrated in a state and can feed off one another to become more productive and globally competitive.[7]

## OCAST's place in Oklahoma's TBED ecosystem

SRI's benchmarking of other state technology-based economic development programs shows the variety of programs supported by these agencies runs the innovation continuum, from initiatives to bring risk capital to early-stage technology companies to worker training and applied R&D grants to enhance the competitiveness of existing technology companies. However, OCAST, like other state TBED agencies, is not a lone player in the state's TBED ecosystem. A state's TBED ecosystem typically involves a variety of entities including community colleges and universities, departments of commerce, departments of labor, government labs and independent research institutes, manufacturing extension agencies, incubators, angel investors, venture capitalists, etc. Oklahoma has a number of state agencies and organizations that work in technology-based economic development, including:

- The Oklahoma Department of Commerce offers a number of tax incentives to technology companies that create jobs with higher-than-average wages (e.g., the Oklahoma Quality Jobs and 21st Century Oklahoma Quality Jobs Programs, the Aerospace Industry Engineer Work Force Tax Credit, etc.), as well as incentives to increase risk capital investment in early-stage companies (e.g., Venture Capital Tax Credit).[8] These programs aim to spur technology company relocation or expansion within Oklahoma.
- The Oklahoma Department of Labor supports workforce-training programs and competitive grants are available from the U.S. Department of Labor to support training programs targeted to specific industries.
- The Greater Oklahoma City Chamber also promotes TBED though recruitment of new business and high-quality jobs to Oklahoma City particularly focused on the areas of aviation and aerospace, biotechnology, energy and logistics. The chamber is funded mainly through membership fees.[9]
- Oklahoma has a number of foundations that fund research in select areas, such as the Oklahoma Medical Research Foundation, the Presbyterian Health Foundation, and the Samuel Roberts Noble Foundation.
- The Oklahoma Manufacturing Alliance is a not-for-profit corporation that offers manufacturing extension services, technical assistance for new product development, and workforce training to local manufacturing companies.
- The Oklahoma Capital Investment Board is a fund of funds that aims to launch Oklahomans as venture capitalists and to attract venture funds from outside the state.
- i2E is a private, not-for-profit corporation that supports startup companies based on proprietary technologies through the provision of seed capital, angel funding, and venture funding.

[7] National Governors Association and Pew Center on the States, *ibid.*

[8] Oklahoma Department of Commerce, *2011 Oklahoma Incentives and Tax Guide*, 2012, http://www.okcommerce.gov/Libraries/Documents/2011-Oklahoma-Business-Incenti_170.pdf (accessed 8 March 2012); stakeholder interviews.

[9] Greater Oklahoma City Chamber of Commerce, http://www.okcchamber.com.

- The Oklahoma Innovation Institute is a non-profit entity that offers some entrepreneurship programs and grants in the Tulsa region.[10]
- Universities are important players in the TBED ecosystem from both a workforce perspective, as well as from an applied research/tech transfer/idea generation point-of-view.
- Community colleges are important vehicles for providing targeted industry-specific skills. One example is the Aviation Science Institute at the Oklahoma City Community College, which supports workforce development in the state's aerospace industry.
- Oklahoma CareerTech is a vital component of workforce development that supports innovation.

One of the most important components of a competitive, dynamic, and successful technology-based economy is the strength of the networks and the degree of collaboration among the various entities in the TBED ecosystem. Stakeholders cite a major strength of OCAST is its role as an integrator of network. As one stakeholder stated, "The strength of OCAST is that there is a single point of contact for a company, and OCAST can walk them through it. OCAST directs traffic, so we aren't running people around." OCAST incentivizes collaboration among other organizations by requiring research collaboration (e.g., industry-university) as a criterion of the grant. In addition, OCAST encourages and supports collaborations through its sponsorship of events such as *Oklahoma Research Day* and other meetings. Stakeholders praised OCAST for bringing different businesses together as well as business and universities. OCAST also informally provides match making between businesses due to its knowledge of the science and technology resources in the state.

> *They [OCAST staff] give advice; they make calls. When we get into a period of uncertainty when the DoD [Department of Defense] goes quiet, OCAST can call them to get information that we can't. Their status as a government agency results in DoD talking to them.*
>
> *-Stakeholder on OCAST strengths*

While some of OCAST's programs overlap those of other entities in the TBED ecosystem, the overall scale of activities and the capacity to reach stakeholders in different parts of the state are also important. For example, both OCAST and EDGE fund commercialization support; however, stakeholders told SRI that EDGE awards tend to be much larger than OCAST's awards and only a handful of awards are made each year.[11] Many of OCAST's programs receive many more applications than can be funded. This demand is an indicator of a gap in the availability of funding for higher risk commercialization projects (as long as the quality remains high). Overwhelmingly, stakeholders interviewed by SRI stated OCAST was a valuable asset in the state's TBED community and Oklahoma's science and technology community would be much weaker without the agency.

[10] Oklahoma Innovation Institute, http://oklahomainnovationinstitute.com/ (accessed 22 March 2012).
[11] The EDGE endowment was emptied on May 23, 2012 by the Oklahoma Legislature (see Krehbiel, Randy. "Budget shortage eats $170M fund." *Tulsa World.* 23 May 2012).

## Oklahoma TBED needs and the R&D infrastructure

One school of thought about TBED funding is to spread state money around to many projects in order to play the odds. The opposite school of thought is that, when faced with a limited amount of resources, one should focus the money on state strengths. SRI heard both philosophies from stakeholders. Some said OCAST should spread the money out much like they do now because from sheer statistics it is better to spread the money all about. However, many echoed the stakeholder who said Oklahoma is a state with limited resources and people are asking if it would be better to consolidate those efforts on agreed upon areas.

*Innovation America: Investing in Innovation* spells out the theme of focused development that was echoed through stakeholder interviews, the TBED literature, and the national TBED community: "Spending lots of state money on research doesn't translate automatically into economic benefits – but smart spending optimizes the chance of success... But it is clear what smart spending is not. A scattershot approach, for example, simply diffuses opportunities. Investments that don't link to a state's needs and its industry strengths will lack momentum."[12] Successful TBED investments have occurred when states have targeted R&D funding to specific research and industry areas in which the state already has some core strengths and competitive advantage on which to build.

The previously cited stakeholder opinion that OCAST should focus on industries in which it has a clear competitive advantage was widespread in the interviews. Current OCAST programs do focus on some specific areas such as health science, plant science, and nanotechnology. Stakeholders said the health science research program supports Oklahoma's clear strength in life science/bioscience, which is reflected in the medical university in Oklahoma City and its neighboring research park. However, stakeholders also said there were industry clusters in Oklahoma they felt OCAST was not supporting. Many mentioned the unmanned vehicles segment of the aerospace industry as a possible missed opportunity for OCAST investment; as one said: "I wish that [OCAST] could grow in the aerospace side; the business leaders and legislators are becoming more interested in this." Another said, "With the history of Oklahoma, I believe we ought to be doing more in the space area." Another potential OCAST investment opportunity cited by stakeholders was support for information technology. Of course, more due diligence would need to be conducted to assess if there are actual constraints to the growth of these sectors in which OCAST investment could make a difference.

### Oklahoma's recent technology sector performance

Many economic development organizations, including the Greater Oklahoma City Chamber, have commissioned economic development studies focused on identifying industry opportunities for state investment. For example, in 2010, a Battelle report (commissioned by the Greater Oklahoma City Chamber) defined and studied the bioscience clusters in the greater Oklahoma City region. A comparable in-depth study of Oklahoma's technology sector to identify future opportunities for OCAST investment based on existing and emerging competitive advantages in terms of companies, research and workforce, and global and national industry trends is outside the scope of this study. However, it is useful to examine the profile and recent performance of Oklahoma's high-tech industries as a first step in thinking about future OCAST investments.

[12] National Governors Association and Pew Center on the States. *ibid*.

The Bureau of Labor Statistics defines a high-tech industry in terms of the share of total employees engaged in R&D-related occupations. To qualify as a high-tech industry, an industry must have at least twice the national average of R&D-related employment of 4.9%. Using this definition, 44 codes in the North American Industry Classification System (NAICS) are currently classified as high-tech.[13] SRI analyzed employment data for these high-tech industry codes for the period 2005-2011. This time period was selected to avoid business cycle peaks and troughs that can distort employment growth trends. Our analysis was based on BLS Quarterly Census of Employment and Wages data. While an extremely important source of employment, there are some limitations to using this data, which are summarized in the box below.

At first glance, the employment data show that Oklahoma's percentage of high tech industry employment has increased from 7.8% in 2005 to 9.1% in 2011 (see Figure 3). However, oil and gas extraction is included in the BLS's high-tech classification. Oil and gas extraction is a large part of the Oklahoma economy, but many stakeholders do not consider employment in this sector to be high-tech since the vast majority of the Oklahoma jobs in this category are field jobs and not research and development jobs. By removing the oil and gas extraction employment numbers, Oklahoma's high-tech employment increases slightly between 2005 and 2011, but remains around 5.8% of total employment.

**Challenges to Using NAICS Data to Analyze High-Tech Industrial Activity**

**The North American Industrial Classification System (NAICS) is used by government statistical agencies to measure economic activity over time. While an extremely important source of employment, establishment, and wage information (all business establishments with employees covered by unemployment insurance are required to report), there are some challenges in using government economic data based on NAICS (e.g., ES-202 or BLS Quarterly Census of Employment and Wages data) to monitor high-tech industry growth. The first is that there is no NAICS code for bioscience, advanced energy, advanced materials, and other fields. Secondly, NAICS is an arbitrary classification. More than one NAICS classification might be appropriate for a large company, or even a small company. In addition, companies migrate from one NAICS to another over time. So, for example, a pharmaceutical company one might logically think would fall under Pharmaceuticals and Medicine Manufacturing (NAICS 3254) might actually classify itself as Drugs Wholesalers (NAICS 4222) because the bulk of its payroll (which is used to assign NAICS codes) is going to employees engaged in marketing and wholesale activities. Given these difficulties in focusing on specific sectors of interest, we tracked the 44 high-tech NAICS codes and the changes in total technology sector employment.**

[13] Hecker, D., High-technology Employment: A NAICS-based Update, *Monthly Labor Review*, July 2005.

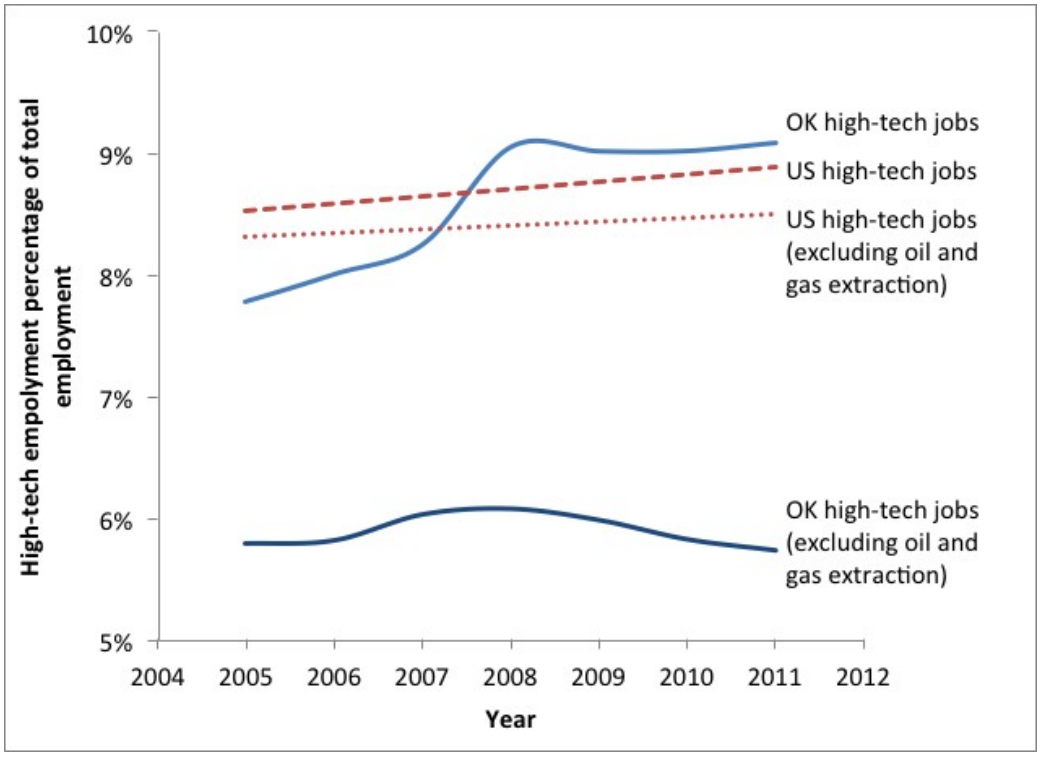


**Figure 3**. Percentage of high-tech employment in Oklahoma with and without oil and gas extraction compared to percentage of high-tech employment in the United States with and without gas extraction. Though Oklahoma high-tech employment appeared to increase significantly between 2005 and 2011, if oil and gas extraction employment is removed, the percentage of high-tech employment in Oklahoma is relatively flat at 5.8%. (Data from Economic Modeling Specialists, derived from US BLS data 2012).

Looking at the breakdown of the top 20 high-tech industries in the state ranked by employment, the data show Oklahoma's technology sector is dominated by oil and gas (see Figure 4). The prominence of this sector becomes even more pronounced in 2011, with oil and gas accounting for nearly 71,500 employees. By comparison, half of the state's other high-tech industries had employment below 5,000 workers in 2011. Moving forward, OCAST may want to do a quantitative and qualitative analysis to identify in which high-tech sectors it may have some existing regional competitive advantages and strengths. Ideally states want to make TBED investments in industries and technologies aligned to these industries where there is strong projected national and international growth.

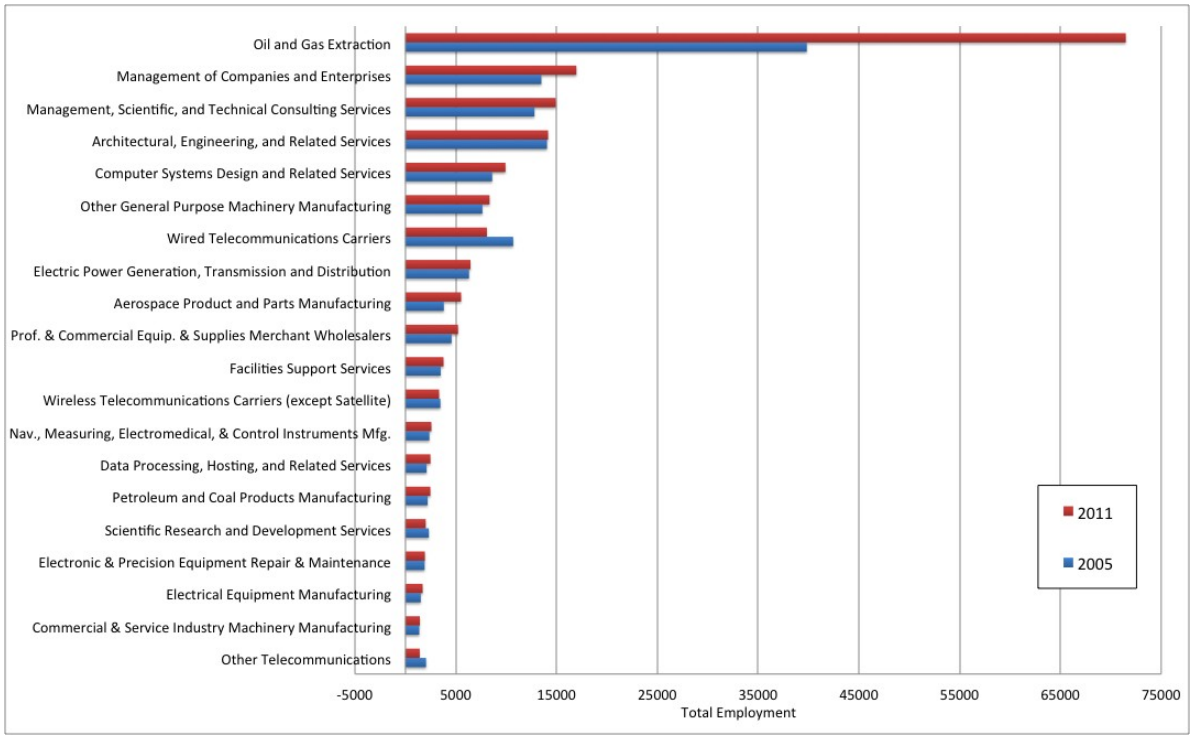


**Figure 4.** Ranking and comparison of total employment by sector in Oklahoma's top 20 high-tech industries in 2005 and 2014 (Data from EMSI, 2012). Please see Appendix A for the raw data.

**Table 1.** OCAST applications and funded projects, 2007-2011, classified by SRI into broad categories.

| Broad Research Area | Award Count | Applications |
|---|---|---|
| **Aerospace** | 1 | 17 |
| **Pharmaceuticals** | 11 | 39 |
| **Semiconductor** | 20 | 25 |
| **Computer system/IT** | 16 | 41 |
| **Medical/Biotechnology research** | 206 | 362 |
| **Chemicals** | 18 | 114 |
| **Sensor** | 23 | 36 |
| **Medical manufacturing** | 0 | 2 |
| **Engineering** | 18 | 47 |
| **Plant** | 46 | 58 |
| **Biotechnology** | 0 | 11 |
| **Weather** | 0 | 1 |
| **Energy** | 10 | 32 |
| **Manufacturing** | 2 | 14 |
| **Total** | 371 | 799 |

### Oklahoma data from 2005-2011

Since 2005, OCAST has funded 371 projects through the Applied Research, Health Research, Oklahoma Nanotechnology Applications Project, Plant Science, R&D Internships program, and SBIR programs for a total investment of over $50 million. SRI examined the last five years of OCAST award data. From the data presented in Table 1, one can see OCAST investment is heavily weighted toward particular fields, primarily medical/biotechnology research (206 awards) followed by plant science (46 awards), as required by Oklahoma legislation. To be strategic as it moves forward, SRI recommends OCAST and its stakeholders consider the types of economic impact outcomes that it hopes to support in the state. For example, if the economic development objective is to create world-class research universities with particular, noteworthy centers of excellence in medical/biotechnology and plant science, then directing OCAST investment toward these fields makes sense if the universities can leverage OCAST money to bring even larger federal research dollars to the state. The expansion of research universities has played a critical role in driving the growth and rejuvenation of cities, such as Pittsburgh, Atlanta, Raleigh, etc.

If the economic development objective is to support new company formation, then more work needs to be done to identify lingering constraints and how further investments can help to scale up existing entrepreneurial support and early-stage financing programs in the state. If the objective is to catalyze the growth of emerging industries or to enhance the competitiveness of existing industries, then a number of other programs may be appropriate based on an in-depth analysis of existing strengths and weaknesses and identification of key constraints to sector growth. Such programs might range from industry-community college collaboration on targeted workforce training programs to funding for collaborative university-industry R&D to a stakeholder roadmapping exercise to get industry stakeholder buy-in and ranking of investment priorities. These are policy questions for OCAST and its stakeholders to decide.

### Beyond clusters

SRI asked stakeholders if they could identify any gaps in the state's existing TBED ecosystem and if OCAST is the appropriate entity to attempt to fill those gaps. Most stakeholders said they see no gaps other than the need for more funding for OCAST programs. If OCAST were to receive more funding, stakeholders mentioned opportunities for other OCAST programs unrelated to previously mentioned cluster development, including a need to support major research equipment purchases that would be shared across the region. Another stakeholder would like to see more recruitment of high-tech minds to the state. Other stakeholders said OCAST should attract more federal dollars to the region by focusing seed funding on projects that have the greatest potential for leveraging federal funding.

## Recommendation: prepare and periodically update a strategic plan

SRI's stakeholder interviews showed that OCAST is regarded as a valuable asset to the Oklahoma TBED community. In addition, SRI's benchmarking analysis of TBED organizations found many OCAST practices are consistent with those of the comparison organizations. However, many OCAST stakeholders interviewed for this project suggested OCAST develop a more strategic vision for its funding allocation decisions. As one said, "Many of these programs are quite

traditional – since many of them were formed when OCAST was created 20+ years ago, but S&T, the economy, and the state are now in entirely different situations." This is echoed in calls for investment in existing Oklahoma industry clusters and in fields with the greatest prospect of federal grants – especially SBIR. A strategic plan should be based on an analysis of Oklahoma's existing science and technology skill set, information stakeholders told us was lacking. The brief industry cluster analysis above is a good start, but the data should be complemented with interviews with a much wider circle than could be classified under OCAST stakeholders.

## EVALUATE: HOW AND WHAT TO MEASURE

State and federal governments have widened their focus beyond what a program spends to what the program returns to the public, as well as how efficiently and effectively those funds are used.[14] The decision of which indicators or metrics to use to measure TBED program impact is challenging.[15] No one metric will tell the whole story, and while a collection of metrics will better reflect the many dimensions of a program's outputs and impacts, one must be thoughtful about which metrics to use. Indicators can send mixed signals – for example, the adoption of technologies that improve a company's competitiveness can lead to a net decrease in jobs in the short run, even if jobs are retained because the company remains operating in Oklahoma 20 years later. As is widely parroted, not everything that counts can be counted, and not everything that can be counted counts.

A fundamental requirement for developing a useful set of performance measures is that measures chosen are clearly linked to the program goals (intended outcomes).[16] It is also important to distinguish performance and impact measurement from program evaluation, because performance measures by themselves provide no information to managers or policymakers about what program features actually influenced the type and level of benefits measured.[17] It is especially important to relate performance and impact measures to what policymakers actually want to know and why they want to know it; different policymakers may seek different measures, and not all questions policymakers ask can be answered by performance measures.[18] Finally, in thinking about the merits of various impact or performance

[14] Voytek, K., et al., Developing Performance Metrics for Science and Technology Programs: The Case of the Manufacturing Extension Partnership Program, *Economic Development Quarterly* 18:174, 2004.

[15] We use the National Center for Science and Engineering Statistics' definitions of "metric" being a systematic measurement of data, and "data" being information in raw or unorganized form that represents conditions, ideas, or objects. From National Research Council, Panel on Developing Science, Technology, and Innovation Indicators for the Future, *Improving Measures of Science, Technology, and Innovation: Interim Report*, Washington, DC: The National Academies Press, 2012.

[16] Cozzens, S.E., The Knowledge Pool: Measurement Challenges in Evaluating Fundamental Research Programs, *Evaluation and Program Planning* 20(1):77-89, 1997.

[17] Georghiou, L. and D. Roessner, Evaluating Technology Programs: Tools and Methods, *Research Policy* 29(4-5):657-678, 2000; Roessner, J.D., Outcome Measurement in the USA: State of the Art, *Research Evaluation* 11(2):85-93, 2002.

[18] Feller, I, Appendix C: The Promises and Limitations of Performance Measures, in Olson S. and S. Merrill, eds., *Measuring the Impacts of Federal Investments in Research: A Workshop Summary,* Washington, DC: National Academies Press, 2011.

measures, it is important to distinguish between the *content* and *accuracy* of a metric set and the *credibility* or *effectiveness* of that metric set in the eyes of the policymakers it is intended to influence. All too often, a measure may be valid in the eyes of the evaluator, but not necessarily credible in the eyes of the policymaker, and vice versa.[19] Both matter considerably to OCAST, and as a result, SRI has attempted to address issues of both accuracy and effectiveness in our interviews and assessments of OCAST's impact measures.

Impact metrics are based largely on data collected from the organization's program participants. Most organizations collect data via surveys, but data are also collected though administrative records such as program registrations or information the company supplies to other organizations such as the unemployment office. Due to the limited resources most organizations devote to evaluation, participant surveys are usually the only source of evaluation data.[20] Though development and deployment of a survey instrument seems straightforward, one must balance the organization's need for information with the quality of the survey recipient's response. The psychology of survey response is widely studied, producing a few well-accepted conclusions that will improve every organization's survey practices. When designing a survey, one should keep in mind the following:

- Questions should be relevant to the survey objectives.
- Questions should be arranged in a logical flow to facilitate respondents' recall.
- Wording should be specific and precise.
- A shorter survey results in more accurate responses, since people may be willing to answer 10 questions more carefully than 20 or 30 questions.[21]

As demonstrated by this short discussion, decisions about what data to collect from participants and what metrics based on that data to present to stakeholders are complex. What data to collect depends on what impacts you want to measure, what measures of that impact are feasible to collect, and how credible and accurate they are. Many impacts of R&D projects are difficult to measure, especially in quantitative form or in the short term. In addition, the quality of any evaluation metric is highly dependent on the methods of data collection. Even a widely accepted metric is not valid if the collection instruments are not well-designed or the results misinterpreted.

[19] See, for example, Shapira, P. and J. Youtie, Evaluating Industrial Modernization: Methods, Results, and Insights from the Georgia Manufacturing Extension Alliance, *Journal of Technology Transfer* 23(1):17-27, 1998.

[20] This was confirmed by Dan Berglund who said, as far as he knows, every TBED organization surveys its clients. He also noted that very few states collect impact data on their TBED organizations. SRI International interview with Dan Berglund, President and CEO, State Science and Technology Institute, 2012.

[21] From Rea, L. and R. Parker, *Designing and Conducting Survey Research: A Comprehensive Guide*, Jossey-Bass (Public Administration Series), 2005; Tourangeau, R., L. Rips, et al., *The Psychology of Survey Response*, Cambridge University Press, 2000.

## TBED program metrics

Measuring program impacts is challenging, as illustrated by almost all respondents in a 2003 survey of directors of primarily state-sponsored science and technology organizations, which said developing appropriate measures was a problem.[22] Many reasons make measurement problematic. First and foremost, as noted above, the realization of benefits of an investment may take many years. The payoff may take 5-10 years to occur, many years after the initial state investment. In addition, many significant impacts such as improvements in human capital are very hard to measure. Finally, attribution of an impact to a particular investment is problematic, especially when many influences are at work (as in technology transfer and commercialization) and the time span from investment to impact measurement is lengthy. Measuring the impacts of OCAST programs is especially challenging due to the wide range of program types it supports, from fundamental and applied research to student internships to venture financing.

Performance metrics vary widely among different technology-based economic development programs largely because of the differences between the outputs, goals, and time frames of research and development programs vs. commercialization programs. Appendix A's Table 2 presents a long list of performance metrics as a function of stage of innovation. A total of 174 metrics are listed; however, many people, including the stakeholders and TBED officials SRI interviewed, say that very few metrics actually matter. In addition, different states define common terms such as return on investment (ROI) differently. Some, such as the Kentucky Science and Technology Corporation, define ROI only as the follow-on funding from federal and industrial investments per dollar invested by the state. Others, such as OCAST, include all measured benefits in the ROI. Leverage is also a common term to describe the strategy of using state dollars to fund seed projects that lead to much larger federal grants and/or industry support, but the definition also varies from state to state.

The National Governor's Association and the Pew Center on States recommend different types of measures along the continuum of innovation. Their recommendations are displayed in Figure 5. Though some of their metrics would be very hard to measure (such as old industry transformed), the chart communicates the fact that metrics are dependent on what stage the program supports. Dan Berglund of State Science & Technology Institute (SSTI) recommends a more precise list for early stage programs:

- Federal research funds leveraged by the state investment;
- The number of graduate students hired by collaborating companies; and
- The number of faculty hired by collaborating companies.

For later stage programs, he recommends measuring the following and reporting as a function of time:

- Jobs created;
- Sales revenues; and
- Capital raised, especially from outside the state.

[22] Melkers, J., Assessing the Outcomes of State Science and Technology Organizations, *Economic Development Quarterly* 18:186, 2004.

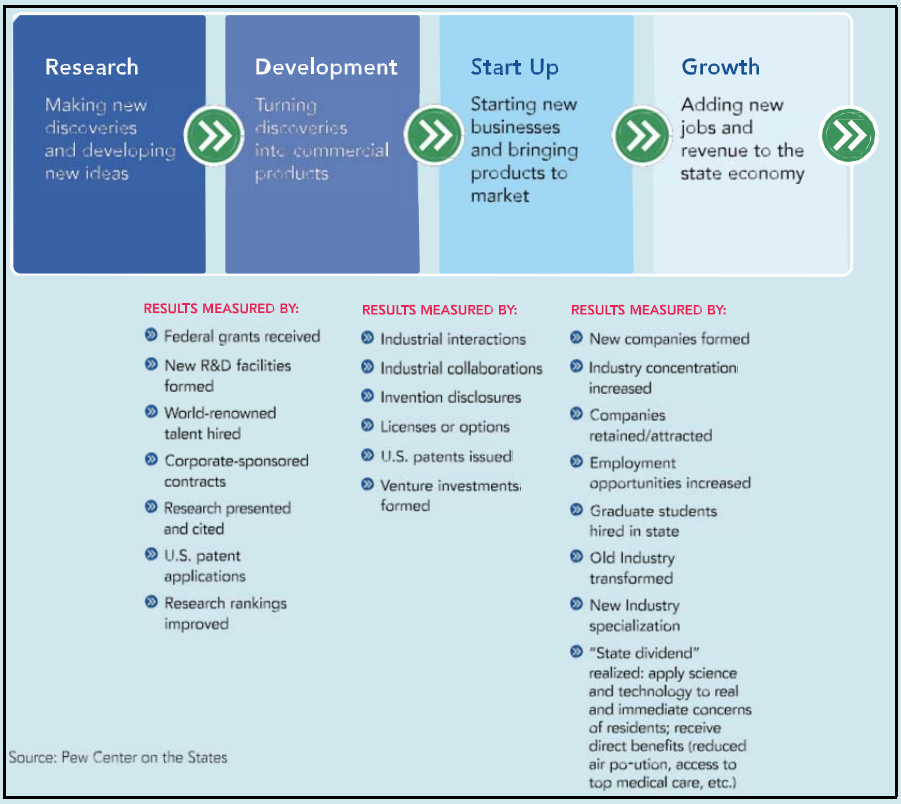


**Figure 5.** *Innovation America's* recommended metrics.

## OCAST impact data collection

OCAST collects impact data directly from awardees (typically principal investigators) in the Plant Science Research program, Applied Research Support (OARS) program, Small Business Research Assistance (SBRA), Nanotechnology Applications Project (ONAP) program, and R&D Intern Partnerships via mail surveys distributed to each recipient. The surveys are very similar across the programs and contain four pages of questions related to impacts. The surveys ask 6 questions on leverages/commercialization, 6 questions on workforce/outcomes, 8 questions on business financials, and 10 questions on human resources. (The Plant Science Research program survey does not ask about business financials.)

Many of the questions are clear and seek unambiguous information (such as *number of patent(s) awarded*); however, there are also many questions that ask for information that is by no means clear (such as the *dollar value of patents awarded*) when no definitions or guidance are provided. For example, for *jobs added as a result of this funding*, should the respondent include a job created and paid for by the OCAST money or just jobs created by follow-on funding? The surveys contain many questions that were unclear to SRI as to precisely what information was being sought and how that information was relevant to the program. As discussed later in the report, many other state TBED surveys provide very clear instructions and definitions for the measures they collect (for an example, please see the Ohio Third Frontier section).

OCAST staff reported these survey instruments have been in use in one form or another for many years. Over time, additional questions have been added in what appears to be an idiosyncratic fashion (i.e., at the whim of the staffer who happened to be responsible for managing the survey in a particular year). Staff confirmed survey instruments provide few or no explanations or definitions to recipients that would help them reliably estimate award impacts such as *estimated dollar impact on capital investments* and *number and dollar value of patent awards.*

Response rates for OCAST surveys are very high due to the requirement that surveys must be completed for the recipient to be eligible for future funding. Ninety percent of recipients return the survey. OCAST staff reports those who do not return the survey tend to be very busy, highly successful clients, or the recipients of relatively small awards such as $3,000 to support writing an SBIR Phase I grant application. If a survey is returned with unexpectedly high or low impact numbers, an OCAST staff member follows up with the respondent to verify the numbers. Beyond this, however, there is no systematic effort to verify the accuracy of the survey data.

Metrics for the programs managed by OCAST's partners i2E and the Oklahoma Manufacturing Alliance (OMA) are collected by the partners themselves. i2E and OMA analyze their own data and pass along their impact numbers to OCAST. Since i2E funds commercialization programs only, the impact information it seeks to collect is more easily measured than information on, say, R&D leverage attributable only to a specific project. i2E's survey questions generally are clear and precise and side-step the troublesome notion of attribution – the questions ask about the jobs added and follow-on funding received by the company as a whole instead of what could be attributed specifically to OCAST funding.

**Metrics that Matter**

**Capital/Commercialization Metrics**

- Jobs created
- Revenue from sales
- Capital raised
- Changes over time

**Research Metrics**

- Federal research money raised
- Number of students who work for collaborating companies
- Number of faculty members who work for collaborating companies

OMA uses a National Institute of Standards and Technology (NIST) survey form, as required by its funding agreement with NIST. In implementing this survey, the manufacturing extension agents sit down with each recipient to go through the survey and answer any questions the recipient may have about how to interpret the questions or define measures requested. The surveys are collected and analyzed by OMA and the results submitted to OCAST.

SRI interviewed a wide variety of stakeholders covering several topics, one of which was OCAST's evaluation process. Stakeholders had little to say about the evaluation process itself. The only substantive comment received on the evaluation process was a request that it be electronic.

## Evaluation findings

Themes concerning impact metrics heard in stakeholder interviews resonated throughout SRI's benchmarking process. Many interviewees acknowledged OCAST has a particularly hard job of communicating impacts due to the wide variety of programs it funds and recommended a different set of metrics for each type of program. Later stage programs return-on-investment numbers are legitimate measures; however, some felt very high ROI numbers raise eyebrows. Earlier stage programs should focus on follow-on funding and human capital measures. However, some people recommend against using publications or patent counts as impact measures since they are not meaningful from an economic development perspective. Many non-stakeholder interviewees agreed with the stakeholders that the most successful impact reports couple metrics like ROI with case studies.

The *Metrics that Matter* box summarizes the metrics SRI identified as effective and in common use by benchmark states. At first glance, these metrics seem clear and precise; however, each metric needs to be clearly defined in survey instruments and in impact publications. For example, in the case of job *creation* impact data, the survey instrument must clearly state if the data sought include jobs paid for by program money or only jobs created by follow-on funding.

Ultimately, collected metrics must fit with what impacts an organization wants to communicate. OCAST's 2011 *Impact Report* focused on case studies, jobs created annually, average salary, and leveraged private investment, federal grants, and business financials in relation to OCAST's investments. SRI analysis of the benchmarking states' TBED program evaluation reports underscored the uniqueness of Oklahoma's virtually one-agency approach to funding public support for the R&D/innovation cycle.[23] If state funding exists for research and development, programs in benchmark states usually are administered through an agency separate from later stage programs such as seed capital, technology transfer, etc. Dan Berglund's suggestion of different impact metrics be used for R&D funding and commercialization support is reflected in the practices of the benchmarking states. Figure 6 shows several recommended metrics along with the benchmark states that actually use each metric. Although nearly all benchmark states use federal money leveraged by state program support as an impact metric, apparently no benchmark states report the number of faculty members or students that go on to work for a company funded under a state-funded R&D program. However, most states use the recommended metrics for capital/commercialization programs.

Benchmark states do not present program specific return on investment numbers; however benchmark states use ROI measures occasionally. An aggregate ROI yields a single measure that can be used to argue one dollar of state investment in the TBED organization yields X dollars of impact on the state economy. This approach is generally considered effective in getting the attention of stakeholders, especially legislatures, and serves as a necessary element in the arsenal of arguments used by other state agencies competing for public funds.

[23] See Benchmark States section at end of report.

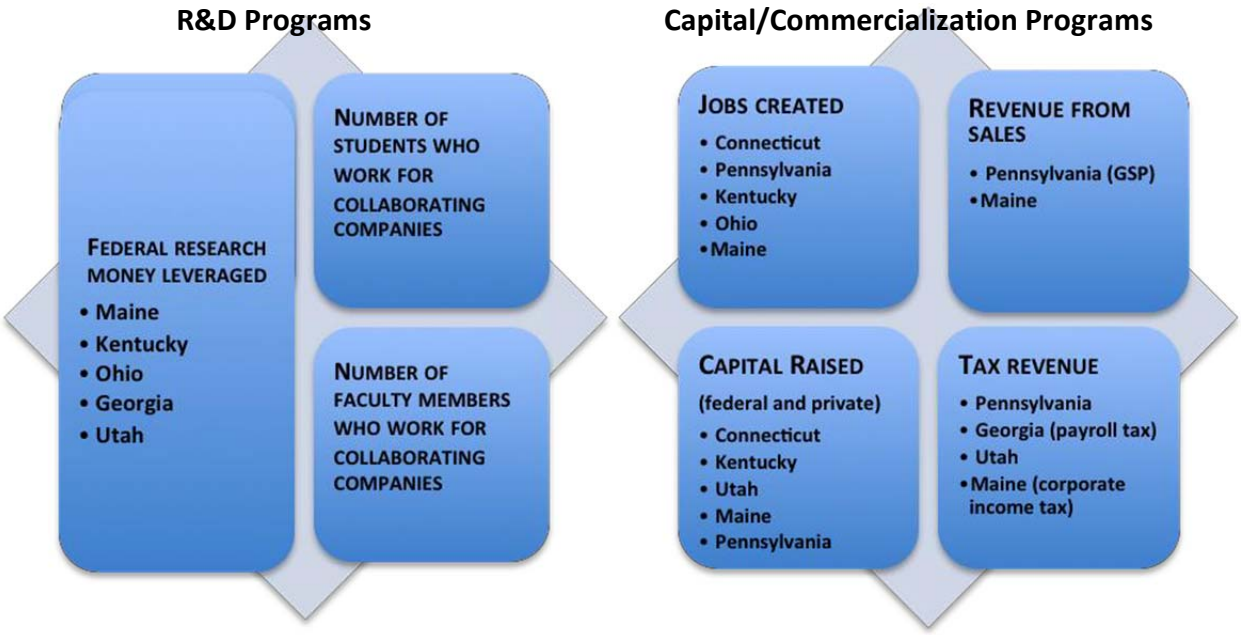


**Figure 6.** Recommended metrics grouped by programs across benchmark states.

Benchmark states usually supplement these ROI measures by more detailed, quantitative impact measures that are specific to the objectives of each program within the TBED agency's portfolio and, thereby, identify the basis for each ROI presented. Several states employ input-output (I-O) models of the state to generate information on the impact of the TBED agency's investments on employment, tax revenues, Gross State Product, change in personal income, and various other measures of economic development. Dan Berglund observes measures such as increased tax revenues can be compelling to stakeholders, but others such as Mike Cassidy of the Georgia Research Alliance argue the multipliers used in such models have little credibility in some quarters.

Despite the wide variety of metrics, there was widespread agreement in SRI's interviews that the most effective way to influence legislative bodies is a combination of single, "open the door" measures such as aggregate ROI or increased tax revenues with more detailed impact measures such as leverage on federal research funding, job creation (job retention data are viewed with some skepticism), and venture financing attracted from outside the state; and case studies of actual leverage and job creation.

Of course, what impact indicators are collected by TBED agencies is a different question from how such indicators are combined, analyzed, and reported to their stakeholders in annual reports or by other means. Communication strategies are obviously critical to getting an agency's message across, but their effectiveness is also bound to the metrics reported and to the accuracy of the information underlying those metrics.

Most of the states reviewed here have a two-part evaluation process. They survey their clients on a yearly basis to collect relatively accessible data such as jobs created due to the state's

investment or federal research funds leveraged. Then, every five years or so, TBED organizations commission a more in-depth impact analysis, which usually entails collection of impact data from a variety of sources (including clients and publicly available economic data) over a multi-year period. Formal verification of the survey data is rarely conducted, although less systematic methods such as informal knowledge of clients and scanning of results for unusually high or otherwise unexpected responses are widely used.

## Recommendations and implications for OCAST

While OCAST's emphasis on ROI measures may indeed open the door to further discussion of the agency's impact, it also may open the door to skepticism and greater scrutiny of the data and assumptions that underlie the final results. This is especially true for displays of separate ROI numbers for each program, which highlight both the large disparities between different program ROIs, as well as the very large ROI figures for some programs such as the 100-to-1 ROI of OCAST's investment in the OMA. A more balanced presentation that includes (1) a single, "reasonable" ROI for all of OCAST that matches similar numbers in benchmark states, (2) emphasis on the specific impact measures used (e.g., federal dollars leveraged; jobs created; out-of-state-financing obtained; university-industry collaborative research projects initiated; student internships with companies), and (3) case studies of high-payoff investments should further improve OCAST's already highly favorable perception among its stakeholders. To support these efforts, these metrics must be collected.

Of the benchmark state survey instruments obtained by SRI to this point, the benchmark instruments all were simpler than OCAST's survey, and they were similar to those used by i2E. OCAST's current surveys of its R&D-support and internship program contain many items that are repeated across all instruments, leading to clients facing items that are inapplicable, difficult to interpret, or time-consuming to respond to conscientiously. Examples include the R&D Intern Partnerships survey that requests estimated dollar impact on capital investments and jobs retained, with no guidance to clients about how to define or interpret these terms.

SRI recommends future surveys be tailored to the program surveyed and reflect the appropriate impact metrics OCAST has chosen. If OCAST will not be using jobs retained in its impact reports, for example, the survey should not ask about jobs retained. A shorter, more efficient survey will reduce the burden on respondents, increase response rates, and improve the accuracy of responses.

OCAST staff pointed out to us they are now designing an online evaluation survey, which we highly encourage. At least one stakeholder said if they could change one thing about OCAST, it would be to implement an online impact survey. An online impact survey can provide easily accessible guidance and some internal checks. Such surveys can provide definitions and examples of the impact measure requested through pop-up boxes. Also, the previous year's responses can be presented automatically to prevent double counting of impacts such as leveraged grants, and to discourage entering lasts year's numbers for this year's numbers.

Finally, augmenting OCAST's annual surveys with periodic – perhaps every five years – in-depth, multi-year assessments that incorporate a variety of data sources and offer a range of impact measures generated by different analytic methods (e.g., survey data, I-O analyses, interviews,

documented case studies, use of publicly available state economic data) would strengthen OCAST's overall evaluation efforts. The combination of periodic third-party assessments and a simplified and more reliable annual survey process would offer OCAST a strong mix of both credible and effective impact measures.

As reviewed above, there are some best practices widely cited in survey literature for survey instruments. In revising OCAST surveys, the following points should be considered:

- Questions should be relevant to the survey objectives;
- Wording should be specific and precise;
- A shorter survey results in more thoughtful and accurate answers.

OCAST surveys should collect data for both the metrics for presentation in its impact reports, metrics for internal project and portfolio analysis, and metrics that may be used in historical trends. Terms should be clearly defined, and the metrics should be directly and clearly relevant to the program.

Considering the impact report recommendations, the benchmarking states' surveys, OCAST's current surveys, interviews with OCAST stakeholders, and evaluation literature, SRI suggests three sets of survey questions – one for research and applied research programs, one for the small business research assistance program, and one for the R&D internship program. In addition, each survey should focus on balancing the desire for information with the burden on the data collector.

# COMMUNICATE: OCAST'S IMPACT COMMUNICATION STRATEGY

Following investment and impact evaluation, OCAST must communicate how Oklahoma's TBED programs serve the state and provide stakeholders with clear and convincing evidence of the value of public investment to achieve a set of specific objectives. Many OCAST stakeholders and leaders of TBED organizations in the benchmark states told SRI the most important objective of an impact communication strategy is to demonstrate to people across the state that OCAST can benefit them, even if they live in rural parts of the state or do not manage a leading high-tech company. Even if a taxpayer has never received an OCAST service, the perception he or she or his or her family could benefit from such services is key. The average taxpayer may not know or care that an OCAST grant helped a researcher win a follow-on federal grant five times larger in size than the original OCAST grant, but may well care that an Oklahoma student was supported by that grant, stayed in Oklahoma, and is employed in the local community today. The taxpayer may also care that early-stage seed capital or an applied technology grant created a high-tech job a son or daughter may someday fill. And the best way for OCAST to show stakeholders its programs can make their future better is to communicate clear and compelling evidence about OCAST's past performance.

## OCAST's current impact strategy

OCAST is a state agency that receives annual legislative appropriations to fund its programs. It is a small agency, with a budget of $19.2 million in FY 2011 compared to Oklahoma's total state budget of $6.7 billion in the same fiscal year.[24] Since OCAST's funding represents far less than one-half of 1% of the state budget, SRI was told the agency is not on many legislators' radars. This can be both good and bad – when times are good, OCAST gets funded without much attention; however, it also means if an individual legislator feels strongly about cutting OCAST, then the loudest voice wins. Therefore, it is important for OCAST to have a strong, coherent, defensible message to present not only to the legislature, but also to its stakeholders, the media, and the general public.

OCAST currently conveys its impact in a variety of ways that target different segments of stakeholders. Forms of communication include print, radio, and hosting and sponsoring events, including:

- OCAST's annual *Impact Report*;
- Weekly radio show (*Oklahoma Innovations*);
- Newspaper articles;
- Legislative testimony and visits;
- *Oklahoma Research Day;*
- Oklahoma Science and Technology Month activities, including recognition of more than 1,400 middle school and high school students each year for achievement in science and technology;

[24] See Legislative Issues Related to OCAST, http://www.ok.gov/ocast/Public_Information/Newsletter/Newsletter1105.html

- Rural Action Partnership program; and
- OCAST staff visits around the state.

OCAST publishes impact metrics at both the program level and the aggregate level in its impact reports. These impact reports are used to communicate with both the state legislature and the general public. Over the past five years, the length has varied from 32 pages to 6 pages. Some impact reports include many of the impact metrics mentioned above, some fewer. Reported metrics vary widely from average salary of an employee to the geographical distribution of projects. All reports contain case studies of award recipients. There is no consistent format from year to year, although dollar-based return on investment measures are presented along with a ratio of return to investment for each program and an aggregate for all OCAST programs (see Figure 7 for 2011 data and ratios overall and by program).

In addition to the OCAST *Impact Report*, OCAST's partners i2E and the Oklahoma Manufacturing Alliance publish their own impact reports that provide impact data on OCAST-funded programs. i2E's own impact report includes the following metrics:

- Amount of grant capital and equity raised;
- Annualized payroll;
- Average wage;
- Number of new products or services introduced into the market;
- Out-of-state revenues;
- Patent applications filed;
- New jobs.

It is notable that i2E does not generate ROI estimates based on these survey data, but OCAST uses the i2E data to generate its own ROI estimates.

The Oklahoma Manufacturing Alliance uses the following impact measures in its impact report:

- Number of manufacturers assisted;
- Number of projects;
- Total reported savings in labor, materials, energy and overhead;
- Amount of increased and retained sales reported by manufacturers;
- New capital investments made by companies assisted.

OMA's 2010-2011 *Impact Report* does not provide ROI ratios.

Stakeholders were shown OCAST's 2011 *Impact Report* and asked if it was an effective way to communicate OCAST's impacts. Responses varied widely. Some stakeholders who are more removed from the legislative environment felt the impact brochure was a good way for OCAST to communicate; however, most stakeholders felt the brochure focused too much on return on investment ratios. Two stakeholders pointed out the phrase return on investment or the acronym *ROI* are not concepts many non-business people are comfortable with – "They would rather hear what [OCAST is] doing for the cattle rancher or wheat farmer." In addition, as another stakeholder said, "When you get complicated it is harder for people to understand." Another stakeholder suggested the use of two indicators – "Something for involved audiences and something for the general audience. People want to know exactly where their tax money is going."

| Program | OCAST Award Amounts | Leveraged private investment, federal grants and business financials | Ratio |
|---|---|---|---|
| Applied Research | $3,526,517 | $70,957,362 | 20.12 |
| Intern Partnership | $309,729 | $13,606,992 | 43.93 |
| Health Research | $4,431,911 | $32,503,992 | 7.33 |
| Inventors Assistance Service | $165,205 | --- | --- |
| Manufacturing Alliance | $1,192,978 | $108,901,323 | 91.28 |
| Nanotechnology Applications Project | $1,140,557 | $29,582,916 | 25.94 |
| Plant Science Research | $1,090,528 | $10,094,347 | 9.25 |
| Seed Capital | $4,264,898 | $10,465,450 | 2.45 |
| Small Business Research Assistance | $220,202 | $7,950,273 | 36.1 |
| Technology Business Finance | $629,613 | $57,600,000 | 91.48 |
| Technology Commercialization Center | $1,803,055 | $137,400,000 | 76.2 |
| TOTALS | $18,775,193 | $479,062,655 | |
| LEVERAGE RATIO | | | 25.5 |

**Figure 7.** Leverage table reproduced from OCAST's 2011 *Impact Report.*

One stakeholder said when they look at the large ROI numbers, they question if OCAST is truly responsible for all of the return. However, other stakeholders said the large return on investment is there; it is just poorly communicated in a simple number. One stakeholder told us of an OCAST project that funded the finite element work on a company's product that resulted in a multi-million dollar procurement contract with the federal government. That finite element work would not have happened without OCAST funding, and so the stakeholder attributed the entire contract to OCAST funding. Context such as this is not being communicated with a single ROI number.

Stakeholders were asked about the effectiveness of OCAST's use of ROI estimates to communicate the impact of its programs both individually and as a whole. Some said it was a good starting point because it is simple, straightforward, people understand it, and it is a way to open the conversation about OCAST's impacts. However, almost all said there should be more to the story, especially since some of the ROIs reported are very large and could generate some skepticism. Many stakeholders, in fact, did say people do not believe the high ROI numbers OCAST publishes. This could be partly attributed to the fact many key stakeholders who, in SRI's opinion, should know exactly how these ROI estimates are generated (e.g., members of OCAST's Board of directors,

**IMPACTS NOT CAPTURED BY ROI**

- Collaborations
- Networking
- Training
- Retention of STEM graduates
- Long term impacts
- Geographic distribution

legislators, and the general public) in fact do not. They are unaware of what collected data are being used to calculate the ROIs, how the survey respondents interpret the requests for specific impact estimates, or how the survey data are combined and analyzed to yield ROI ratios. SRI's own review of OCAST's documentation on how the ROI numbers are calculated revealed a complex process, so the confusion is understandable.

Several stakeholders felt the major problem with ROI estimates is many important program impacts cannot be measured in dollar terms and/or occur long after an original award is made. Important impact measures not reflected in the ROI estimates are listed in the sidebar. Many stakeholders valued collaborations among companies, universities, and economic development agencies attributable to OCAST programs very highly. Programs requiring collaboration between faculty members and companies are sometimes faculty members' first introduction to the possibility and value of university-industry collaboration in research. OCAST facilitates these connections, and companies benefit from the faculty member's expertise. In the internship program, participating companies benefit from the training and mentoring of the intern by the faculty member. The intern learns from the experience and may accept a job at that company and stay in Oklahoma, thereby reducing brain drain. Several stakeholders agreed the tax collected by the state on funds brought into the state by OCAST would be very convincing to legislators.

Almost all the stakeholders SRI interviewed said anecdotal case examples are the most effective way to show impact – especially if the examples are from rural Oklahoma in addition to Oklahoma City and Tulsa. However, they also recognized this may be difficult because the number of OCAST awards is small and the geographic distribution of awards – especially research awards – is highly skewed toward urban areas and the top universities. At least one stakeholder said there is a perception OCAST only funds the same small group of people. A few stakeholders pointed out that many other state agencies report ROI, so OCAST's ROI can get lost in the plethora of numbers. This bolsters the argument for reporting impacts beyond the ROI numbers, augmenting them with anecdotal impact cases.

### Communication with the legislature

OCAST sees one of its roles as providing ongoing education for legislators about OCAST programs, and to achieve that goal, OCAST has a staff member responsible for government relations. This staffer "directs the design, development, and implementation of agency legislative goals and strategy for securing desired legislative and executive action and coordinates legislative activities with all OCAST divisions... Represents agency before and organizes and facilitates OCAST communication with public officials and local, state, and national organizations." [25] In addition, for its annual performance review the OCAST executive director provides a briefing to the Oklahoma House and Senate Subcommittees on Education. OCAST also frequently encourages its board members to communicate OCAST's benefits to their personal legislative representatives through letters and visits.

OCAST's *Impact Report* is another means of communicating with the legislature. As we noted above, the format of the report has changed from year to year, but all present at least six

[25] Oklahoma Center for the Advancement of Science and Technology, *Fiscal Year 2012 Business Plan*, 2011.

quantitative metrics such as return on investment ratios, jobs created or retained, and number of projects funded. In addition, at least one success story is profiled.

### Communication with the public

OCAST uses many avenues for communicating its program activities and impacts to the public. First, the annual impact reports describe programs in detail and are available both in print and electronically on the OCAST website. In addition, OCAST's website is user-friendly and provides information on each program and application procedures. OCAST also funds a science radio magazine called *Oklahoma Innovations* that airs in ten cities on 12 radio stations each weekend. (See inset map in Figure 8.) The radio show is archived on the OCAST website. Program managers from the radio stations included in the OCAST Radio Network collectively indicate the show currently reaches an estimated 42,500 listeners each week. In addition, the webpage of archived radio shows averages about 300 hits per month. *Oklahoma Innovations* features many OCAST recipients, giving them a spotlight to present their success stories. One stakeholder singled out the radio show as having provided good publicity for his product. Stakeholders also said that OCAST helps them with media coverage for their projects and cite this communication mode as an important OCAST service.

In addition to direct public communication, OCAST sponsors or hosts several public events through the year that serve to further OCAST's mission. OCAST co-sponsors *Oklahoma Research Day*, an annual event of poster presentations coordinated by Oklahoma's regional universities. At the 2010 *Oklahoma Research Day* event, more than 1200 students, faculty members, and guests attended more than 600 poster presentations and a banquet. One stakeholder stressed this event was an effective venue in which OCAST has fulfilled a TBED goal of highlighting research and development activities occurring in the state. OCAST also holds annual workshops on each funding program. The workshops' stated goal is to help with the application process, but they also serve to publicize OCAST's programs and how they can benefit people. In addition, one stakeholder valued these workshops' role in introducing faculty members to the possibility of collaborations with companies. Other OCAST-sponsored events have been credited with bringing together business owners, resulting in valuable connections and collaborations outside of OCAST's formal funding programs. Though these events are not designed specifically to communicate OCAST's impact *per se*, they do offer opportunities to communicate information about their services and the resulting impacts OCAST programs generate.

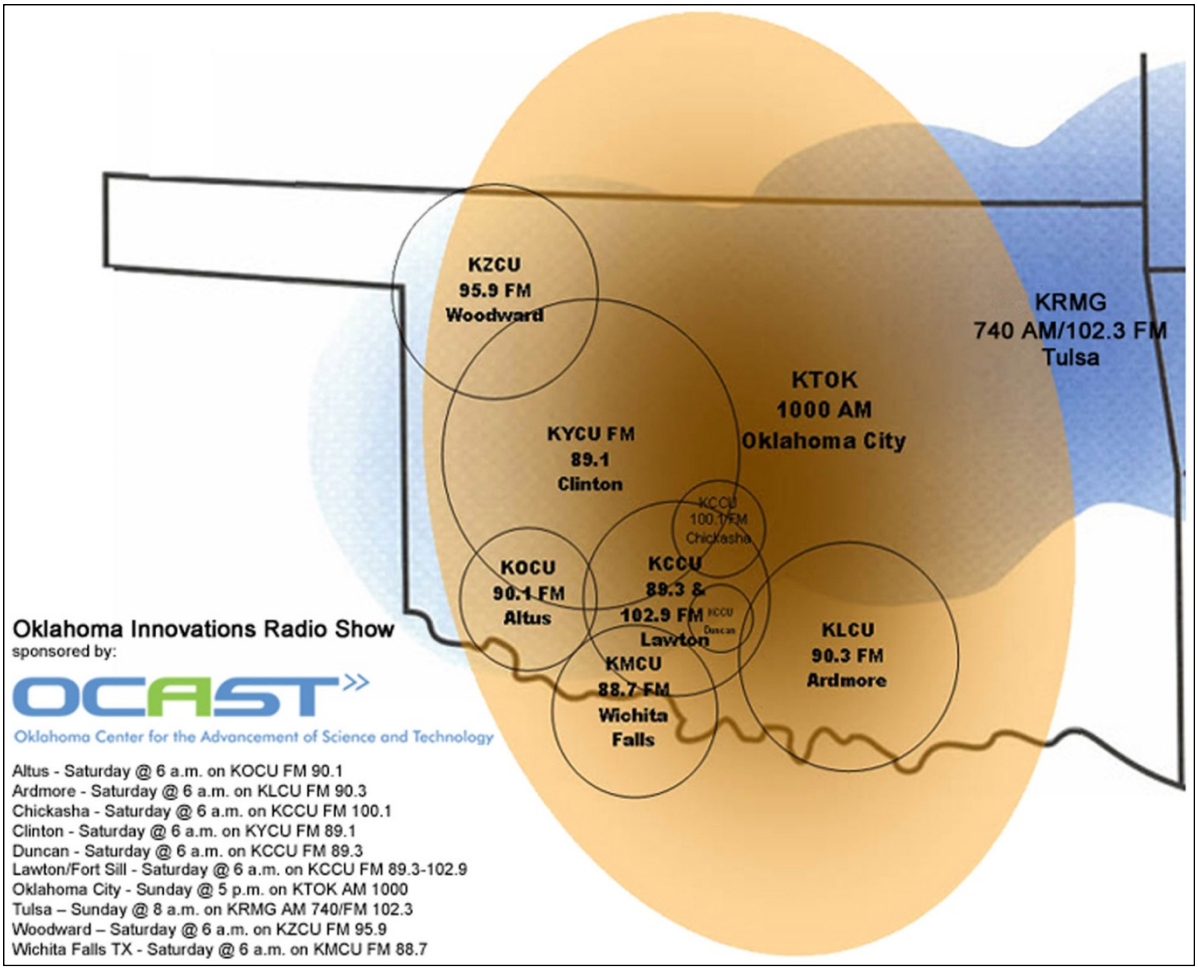


**Figure 8.** Coverage map of the *Oklahoma Innovations* radio show.

## Challenges to OCAST's impact message

### *Many Oklahomans lack an understanding of OCAST's goals.*

As discussed earlier in the report, the wide variety of OCAST programs makes communicating OCAST's goals and impacts challenging. Stakeholders who know OCAST's research and development programs may not know about OCAST's commercialization programs. In addition, even if someone is aware of the full array of OCAST's programs, he or she may not realize how these seemingly disparate programs work together in a synergistic way to accomplish broad economic development goals.

### *OCAST's partners are sometimes more visible than OCAST.*

Many stakeholders said some of OCAST's strategic partner organizations, notably i2E and the Oklahoma Manufacturing Alliance (OMA), have higher visibility than OCAST. The higher visibility is attributed by stakeholders to two factors: First, OMA and i2E are private (non-state) organizations whose funding sources include private money in addition to the state money they receive from OCAST. This important difference allows i2E and OMA to host receptions and do more marketing than OCAST. Second, OMA's grassroots network of manufacturing extension agents is a very effective way of communicating OMA's impact. OMA representatives live and work all over the state, providing many opportunities to communicate OMA's goals and successes.

In SRI's conversations with stakeholders and review of OCAST documents, it became apparent communication opportunities through OCAST's strategic partner organizations have been underutilized. As one stakeholder noted, "Most folks don't realize that the manufacturing alliance is a part of OCAST; this is a missed opportunity to make it clear that OCAST is helping rural Oklahomans." In addition, other stakeholders mentioned many people are unaware of the connection between i2E and OCAST.

### *Reporting return on investment ratios (ROI) for OCAST programs is problematic.*

Many OCAST stakeholders are unfamiliar with the concept of return on investment, especially when presented as a single quantitative ratio with little explanatory material explaining its basis. Moreover, large ROI numbers can invite skepticism and/or scrutiny, and a wide range of ROIs for different OCAST programs reported side-by-side can invite threats to cut out any activities with relatively low ratios. Furthermore, ROI ratios based on monetized data do not adequately communicate many important program impacts. The single ROI impact measure misses many important program outcomes that have major economic significance but are not easily quantified. These outcomes include strengthening Oklahoma's innovative capacity and networks by fostering collaboration, helping to match human capital talent with company needs through internships, and providing technical extension services to manufacturers that help them to be more competitive globally. While an ROI figure may have value for communicating with the legislature, it may not be meaningful to many Oklahomans and could fail to communicate OCAST's full impact to legislators if not accompanied by measures of specific program impacts. Examples of such specific impacts include federal research dollars attracted or jobs created. In any case, for a general audience, concrete examples of success stories and a concise definition of what OCAST seeks to do for Oklahoma are likely more compelling than ROI.

An aggregate ROI ratio also may be misinterpreted by the public as implying every OCAST project and every OCAST program is generating this type of return on investment. In fact, an aggregate ROI is an average figure with some OCAST projects returning very high ROIs and others returning very low ROIs. Providing more context and describing single project ROIs – when appropriate – can document some of the large ROI ratios stakeholders are accustomed to seeing, while providing a more transparent and credible basis for OCAST's impact message.

### *Job creation and retention numbers are hard to measure, controversial, and are lagging indicators.*

Many stakeholders said legislators care about jobs. OCAST currently collects and reports jobs created and retained; however, the goal of TBED investment is not to create jobs in the short term, but to catalyze development and to fill critical funding gaps private market incentives can fail to fill. Not all program investments will create jobs due to the very nature of TBED funding. In addition, if indeed jobs are created, they often emerge only years after the public investment. Some stakeholders said, although the common assumption is people want job creation, for the ordinary taxpayer that is not always the case. As one stakeholder said: "I don't know that the public cares about job [creation in general]. It doesn't matter unless you are the one getting the job or your neighbor is getting the job." Another stakeholder said he only cared about jobs created by private money, not jobs created with state money.

### *Oklahoma economic development agencies are not as well informed about OCAST programs as they could be.*

Multiple stakeholders said local economic development agencies are many entrepreneurs' and businesses' first call, and representatives of these agencies said they do not have a solid understanding of OCAST's core services and capabilities. Communication lines between OCAST and local economic development agencies can be strengthened by distributing OCAST materials to such agencies electronically and by inviting representatives of these organizations to OCAST meetings or events. OCAST could also design a one-page document that captures its core programs for a particular stakeholder group in a concise and compelling manner for distribution to other stakeholders.

## Benchmark states' impact messages

All seven of the benchmark states publish an annual report or annual impact report; however, the focus of each state's report is a function of the types of programs they employ, the relative size of the programs, their funding mechanisms, and their place in the state hierarchy.[26] These impact or annual reports vary from a collection of case studies, such as those produced by the Georgia Research Alliance, to full reports approximately 25 pages in length. States with bond-funded TBED programs do not have to advocate for their program funding each year, but do advocate when they need a new bond issue. Although they are not annually brought before the legislature, bond-funded programs submit an annual report. For example, the Ohio Department of Development, which oversees the Ohio Third Frontier, produces an annual impact report that includes quantitative metrics. In addition, the Ohio Third Frontier commissioned and published an in-depth impact analysis when it needed to request a bond renewal, as it did in 2010. In Pennsylvania, Ben Franklin Technology Partners (BFTP) is funded through a special tax authority.

[26] See Benchmark States section at the end of the report.

The agency does not testify before the legislature each year, but does publish an impact report. As expected, organizations funded directly by state appropriations publish an annual report and testify before some portion of their legislature.

Almost every stakeholder and TBED representative in the benchmark states said one of the most effective ways to communicate their impacts was through their clients. In an ideal world, clients would call their legislators to tell them about OCAST support, which would educate and engage their representatives. In the absence of grassroots assistance, OCAST should be proactive about capturing its clients' success stories from across the state and publicizing them to their respective representatives. In addition, publicizing OCAST's programs to a wide audience can lead to more communication between voters and legislators about OCAST.

### *Follow-on funding*

Every benchmark state reports follow-on funding (also referred to as "leverage"), and stakeholders and other interviewees agreed it is this impact metric everyone understands best because its source is clearly recognizable. Stakeholders said taxpayers and legislators respond positively to the message that $1 of state investment in a particular research program resulted in $3 of funding from federal agencies that support R&D or commercialization. It is straightforward to explain how the majority of this out-of-state money is subsequently spent within the state to pay salaries and purchase supplies and services from local vendors. In addition, though TBED programs have many goals and metrics, the validation provided by receipt of leveraged federal or private funding is a signal the TBED program is investing in worthy projects that pay off for the state.

### *Jobs*

Nearly all TBED representatives told us their state legislature cares about the number of jobs created by TBED programs. TBED programs create jobs directly by providing seed or grant funding that support positions in a company or a university. For example, if OCAST funds a company's R&D project, the money might go to support the salary of an engineer, a technician, or other R&D personnel for a certain period of time. Jobs are created when follow-on funding also directly supports the salary of a new job. States usually collect and report these job counts in aggregate as jobs directly created by the initial investment. The company or university might also purchase other goods and services locally in support of their projects, which generates additional economic impact of OCAST funding. Finally, when the individual whose position is supported by the OCAST-funded project spends money locally, this induces economic activity and thereby helps supports jobs across a wide variety of sectors from retail to restaurants to services. The induced jobs and economic activity supported by an initial expenditure of money in the local economy is known as the multiplier effect, and there are different multipliers related to different types of economic activity, e.g., construction, R&D services, retail services, etc.

Thus, a job creation indicator is not as straightforward as it would appear, and every TBED organization must ask itself the following questions:

- Should we report only jobs created or also jobs retained?
- Should we report only jobs directly created or also the induced jobs supported and calculated through the use of economic models and multipliers?
- Since multipliers are applied to total direct spending, which categories of funding or what share of this funding should be attributed to the TBED program?

- Should we report employment data aggregated over decades as *net* or *total* jobs created?
- How accurate are jobs retained data?

Most of the benchmark states do not focus on jobs retained because it is difficult to track, to obtain reliable data, and to make a solid case the program retained jobs that would have been lost otherwise. However, states with a historically large manufacturing base, such as Ohio and Pennsylvania, do report jobs retained. The continuous and dramatic decline in manufacturing employment in these states over the past four or five decades has resulted in a situation in which legislators view a reduction in job loss as positively as an increase in job creation. The downside is jobs retained is very difficult to measure and justify in aggregate terms; but, a case study or profile of a company that describes a clear causal path from program support to saved jobs can communicate the jobs retained impact far better than a single number.

Some states such as Connecticut, Utah, and Ohio report induced jobs in addition to direct jobs as part of estimates of the total economic impact of their TBED programs. These estimates are calculated through the use of multipliers in regional input-output models. The U.S. Bureau of Economic Analysis calculates multipliers for output, employment, and earnings. These multipliers can vary considerably depending on the characteristics of the industry that is experiencing the increased funding or investment. For example, industries with higher average wages and more linkages to other sectors in the local economy would have higher multipliers than industries that exhibit much lower average wages and import intensively from outside the region. Interviews revealed other state TBED organizations are moving toward reporting these types of calculations; however, many advise caution regarding the multiplier calculations.

Many states report aggregate data over the life of their programs using quantitative indicators such as jobs created. Most benchmark states that report aggregate data over decades do not subtract jobs from their aggregate program jobs created statistic when a company closes and/or jobs disappear. However, BFTP's third-party five-year impact report does calculate job-years created, defined as the number of years of full-time work the program creates. This is the only report SRI reviewed that accounted for the loss of jobs in addition to job gains. Interviews also revealed other TBED organizations are starting to think about accounting for the loss of those initially created jobs as their programs age past the decade and more mark.

### *State revenue impacts*

Many benchmark states report estimates of the increase in tax revenues generated by TBED programs. Some states, such as Utah and Georgia, calculate the state tax collected on expenditures of federal funds, such as payroll taxes and sales taxes on purchases of equipment and supplies from in-state businesses. Connecticut calculates the state taxes collected on equity and private funding raised using regional input-output models. Ohio calculates tax revenues from Ohio Third Frontier activity in three categories – income tax revenue generated from directly created jobs, sales tax revenue generated, and income tax revenue generated from induced jobs. Calculations of state taxes generated are typically done in one of two ways. One way is to estimate the amount of state payroll tax collected on jobs directly created. Alternatively, input-output models used to calculate induced jobs can also generate estimates of the tax impact of TBED program investments and of follow-on funding. However, such models are not routinely used in benchmark states' annual impact reporting and lack the transparency of simpler impact measurement methods.

### *Distribution of funding*

Many benchmark state TBED representatives and OCAST stakeholders stressed the need to communicate the distribution of funding both geographically and by other recipient characteristics (such as institutional affiliation or industry affiliation). Such statistics support the idea that TBED programs are available to a variety of entrepreneurs, companies, and researchers across the state by showing the historical distribution of funding geographically in the state and by type of recipient.

**Table 2**. Selected metrics presented in benchmark states annual or other impact reports.[27]

| Selected metrics presented in annual or other impact reports | | Connecticut | Pennsylvania | Maine | Kentucky | Ohio | Utah | Georgia |
|---|---|---|---|---|---|---|---|---|
| | Follow-on funding/ leverage | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ |
| Jobs | Direct jobs created | ◆ | ◆ | | | ◆ | | ◆ |
| Jobs | Jobs retained | | ◆ | | | ◆ | | |
| Jobs | Induced jobs | ◆ | ◆ | | | ◆ | | |
| Jobs | Average salaries | | ◆ | | | ◆ | | |
| Revenue | State tax revenue raised | ◆ | ◆ | | | ◆ | ◆ | ◆ |
| Revenue | Increased state GDP | ◆ | ◆ | | | ◆ | | |
| Award statistics | Award numbers/ funds awarded | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ |
| Award statistics | Types of Industries supported | ◆ | ◆ | ◆ | ◆ | ◆ | ◆ | |
| Award statistics | Geographical distribution | ◆ | | ◆ | | ◆ | ◆ | |
| | Case studies | ◆ | ◆ | ◆ | | ◆ | ◆ | ◆ |
| | Intellectual property statistics (patents, etc.) | ◆ | | ◆ | ◆ | ◆ | ◆ | |

[27] Indicators were included in the chart if two or more benchmark states published the indicator.

## Recommendations for communicating impact

### *Shift to a new set of metrics*

SRI recommends OCAST consider an approach that minimizes the use of single number return on investment indicators, especially at the aggregate agency level, but instead use them sparingly and cautiously for individual projects and programs for which there are clear and transparent underlying cost and impact data. OCAST's programs support a variety of TBED objectives whose full impacts cannot be represented, captured, or explained solely by a single ROI. OCAST could explain a shift away from emphasis on an aggregate ROI ratio to presenting a small set of impact metrics, arguing that doing so increases the transparency of its program impact measures, thereby improving its overall accountability to the legislature and the taxpayers. OCAST can also point to widespread use by the benchmark states of a suite of metrics to capture TBED program impacts and to the recommendations of the State Science and Technology Institute.

SRI advocates using leveraged, follow-on federal dollars attracted as the key impact metric for OCAST research investments; this shows clearly the causal link between the initial investment OCAST makes in a researcher or piece of equipment and the follow-on funding that researcher subsequently attracts. For internships and applied research grants, SRI recommends tracking the number of students receiving internships and faculty-company partnerships, the counties they are from, the number of students or faculty hired by the Oklahoma companies at which they interned or partnered, and the number who remain in state because of the job opportunities revealed or connections made during their internship experience.

For companies and entrepreneurs, SRI recommends using measures of follow-on private investment attracted and number of companies assisted (while also trying to keep track of companies that have ceased operations). SRI also suggests publicizing the number of companies assisted, the revenues of sales of products commercialized through these services, and the follow-on private and federal investment in product commercialization. In addition, if tax revenue impact estimates are used, SRI recommends presenting them in a very conservative, transparent way.

### *Communicate the value of R&D internships*

SRI recommends that OCAST send a letter to each internship recipient's legislator and hometown newspaper to let them know a student in their area has won an OCAST R&D internship. These interns come from all over the state, and state representatives should know which companies and students OCAST is using state money to support. Because the R&D Internship program is low-cost and its impact very hard to measure, its impact is not effectively communicated by quantitative metrics. However, simple notification letters can start a word-of-mouth chain, and notices in recipients' hometown papers can serve as an effective public communication tool.

### *Highlight partnerships with i2E and OMA*

OCAST's 2011 *Impact Report* describes the programs managed by i2E, but does not mention i2E by name and describes OMA as if it is another OCAST-supported stand-alone program like the research grant programs. Failing to emphasize clearly these partnerships (and the key role played by OCAST support) may result in some misunderstanding in the public and the legislators'

minds about the nature and importance of the relationships. OCAST should highlight the value of these partnerships in its impact reports and explain clearly how they generate public benefits.

### *Hold press events for awards*

One stakeholder suggested holding more press events when OCAST awards are made, which can be particularly valuable for programs managed directly by OCAST or its strategic partners, the Oklahoma Manufacturing Alliance (OMA) and i2E. Expanded OCAST press opportunities and events would highlight OCAST's role in all TBED activities and can be of greater benefit to legislators, OCAST, OMA, i2E, and awardees.

### *Provide context where possible*

SRI heard OCAST success stories in which a relatively small investment by OCAST supported a much larger return on investment. The New Product Development Center (NPDC) and the Manufacturing Extension Agents provide services such as product redesign with cutting edge technologies that result in a product that wins a large federal government contract or generates a significant increase in sales. These stories provide the basis for examples of large return on investment ratios for single awards. Focusing on single projects with easily verifiable high ROI ratios can provide continuity with OCAST's historical focus on large aggregate and program-specific ROIs, thus easing SRI's recommended transition to more transparent and nuanced use of ROI language and concepts.

### *Distribute the Impact Report and advertise programs widely*

Several representatives of regional economic development agencies told us they had not seen the OCAST *Impact Report*, and some were not familiar with the services OCAST offers. The annual impact brochure is easily distributed via email with no cost beyond the maintenance of an email list. In addition, OCAST may want to consider a one-page document it can distribute to stakeholders that succinctly captures its mission, range of programs, and highlights of some recent successes. The document should be focused on the intended audience.

# BENCHMARK STATES

For this project, Dan Berglund of the State Science and Technology Institute (SSTI) recommended the following seven states are doing an especially good job of measuring the impact of state TBED programs and communicating the results to key stakeholders, especially state legislatures: Connecticut, Utah, Pennsylvania, Maine, Kentucky, Ohio, and Georgia. The resources and services provided by these state technology-based economic development entities vary widely. Some state organizations, for example Connecticut Innovations, do not provide any grants for research or incentives for SBIR applications. Other organizations, such as Utah's USTAR and Georgia's GRA, focus mainly on attracting star researchers to the state's universities and funding researchers there. This section reviews what we learned from interviews with the presidents, CEOs, and the directors of communication of these benchmark agencies and from the publications they distribute to the general public and the legislature. Effective impact measures depend on the type of program, and so we summarize the types of programs supported by each agency to frame their evaluation and impact practices.

Many states administer their R&D funding programs through organizations separate from their organizations that fund commercialization programs. Where information was available, we describe program and evaluation processes for both organizations. For example, commercialization funding in Maine is administered by the Maine Technology Institute (MTI), the organization suggested by Dan Berglund as most similar to OCAST. However, we also include the evaluation process and impact measures for the Maine program that funds research and development, though outside MTI.

## Connecticut

### Connecticut Innovations

Connecticut Innovations (CI) was established by the Connecticut Legislature as a "body politic and instrumentality of the State of Connecticut." The legislature established CI to promote "technological innovation and application of technology within Connecticut and encourage the development of new products, innovations and inventions or markets in Connecticut by providing financial and technical assistance."[28] CI was initially funded through state bonds, but since 1995 it has been self-funded from the returns on past investments. Recently the state legislature passed some bonds that will be issued over the next five years to fund future and expanded CI programs.

[28] Connecticut Innovations, *Financial Statements: June 30, 2011 and 2010*, 2011.

CI's programs stretch from Knowledge Building to Business Expansion. CI has the following eight programs:

- The Pre-Seed Fund helps innovative, high tech entrepreneurs develop companies. The Connecticut Innovations team provides mentoring, coordination of services, and limited funding for business assistance to prepare a tech company for future investments.
- The Seed Investment Fund is for entrepreneurs growing Connecticut-based emerging technology and life science companies. Seed investments of up to $500,000 are structured as equity (preferred stock), convertible debt, or debt with warrants depending on the individual circumstances of the deals.
- The Eli Whitney Fund makes investments in some of Connecticut's fastest growing early-stage technology companies.
- The BioScience Facilities Fund helps qualified companies build wet laboratory and related space to propel Connecticut's bioscience industry.
- The Connecticut Clean Tech Fund creates opportunities for emerging, innovative technology companies that can address critical challenges with energy, environmental, and resource management.
- The Angel Investor Tax Credit allows angel investors to take a 25% credit against the Connecticut personal income tax for certain investments made in qualifying Connecticut businesses.
- The SBIR Office seeks to support Connecticut based innovators, entrepreneurs, and small business to commercialize new products. It provides services such as reviewing applications and helping them with the application process. There is no money geared toward incentives or a matching program.
- The TechStart Fund provides entrepreneurial or student teams with initial capital so they can determine whether a technology concept and business are viable and whether future funding can be obtained to launch a new business.

Connecticut Innovations does not support any research or applied research. According to Peter Longo, president and CEO of CI, there are no state-sponsored programs that support research and applied research.

CI collects financial data on a quarterly basis and job information on an annual basis. The reporting is required as part of the loan contract. If companies do not report, they are considered to be in default. In addition, because the vast majority of CI's activities involve equity stakes in companies, CI representatives sit on the boards of these companies, resulting in both a personal relationship to the company leaders and frequent updates on the financial and employment picture of a company. CI validates these numbers through its requirement for fully audited financial statements of each company and copies of the companies' unemployment filings with the state of Connecticut.

CI publishes an annual report that lists, in addition to the number of companies, the financial highlights of net assets statements and the results of operations statements. In addition, since Connecticut Innovations is a quasi-public entity, it reports to the Connecticut legislature's commerce committee every year.[29] This presentation lists many more impact metrics than CI's annual report, including the following impacts:

[29] Their presentation can be accessed at http://prezi.com/smqfxxbkjgvw/connecticut-innovations-2011-commerce-committee-presentation/

- Direct and indirect jobs created;
- ROI of state tax revenue, personal income, and a total leverage ratio;
- Case studies;
- Social impact;
- Number of successful exits;
- Internal rate of return.

Every three to five years Connecticut Innovations performs an impact assessment. In 2008, the Connecticut Department of Economic and Community Development (DECD) assessed CI's programs for FY95-FY08. The resulting report was published in January 2010. DECD sent a survey to 81 firms to supplement the employment and revenue data provided by CI. The survey is short (5 questions) and requests the following data elements:

- A short description of the company;
- The geographical location of purchased inputs;
- The CI effect and services used;
- An estimate of the employment and revenue with and without CI.

This survey was sent to the 81 firms that CI had invested in between FY95 and FY08. The survey response rate was 42%, reflecting the long period of analysis during which some business were not active, went out of business, were acquired, could not be contacted, or failed to respond. Using the reported changes in employment and funded activity for firms responding to the survey, DECD measured the total impact on the state economy including:

- State revenue from sales, income, excise, and property taxes and fees;
- Jobs created indirectly by the spending habits of the direct jobs that were created by companies supported by CI;
- Change in state gross domestic product;
- Change in personal income.

CI, like many of the benchmarking states, used a regional economic model of its state to calculate indirect impacts of investments. The increase in employment attributed to CI's investment and the economic activities such as construction and procurement attributed to CI's investment are inputted into the regional economic model, which DECD used to calculate the resulting economic impacts listed above.

According to Mr. Longo, the ROI numbers are an effective mechanism to communicate with the legislature. He thinks it is easy for them to understand that "for every $1 invested, $9 of private capital is attracted." He acknowledges that for some large firms, attributing all the benefits to CI's initial investment is a hard case to make, and they do get challenged by some economists in the legislature. However, he notes, most people accepted the ROI number at face value.

# Utah

### Utah Science Technology and Research Initiative (USTAR)

In 2006, the Utah legislature created Utah Science Technology and Research Initiative (USTAR) with the following goals:

- Recruit top-level researchers;
- Build state-of-the-art interdisciplinary research and development facilities;
- Form science, innovation, and commercialization teams across the state.

The majority of USTAR's funds support innovation teams at the University of Utah and Utah State University. The money goes to attract researchers from other states using USTAR funds for research support and to build research space. The buildings are funded through bonds and private donations, while the funds to attract and support researchers are appropriated by the Utah Legislature every year.

USTAR also runs the Technology Outreach Program, which supports commercialization activities across the state and includes SBIR application assistance and two business incubators. This program has 6 satellite offices throughout the state associated with non-research universities. This program is a resource for universities to commercialize innovations and to assist Utah entrepreneurs, businesses, and innovators by providing support in business development and SBIR/STTR editorial support.

USTAR reports many impact measures, including the following:

- Number of researchers recruited to University of Utah and Utah State University;
- Amount of money USTAR researchers won in direct federal and other funding;
- Total impact in dollars;
- A leverage number of 187% for 2006-2011;
- Number of invention disclosures;
- Number of provisional patents compared to national averages;
- Number of companies created by USTAR Researchers;
- Number of projects in a commercialization pipeline;
- Number of counties in the state where USTAR Technology Outreach staff supported companies, entrepreneurs, and researchers;
- Number of product prototypes, disclosures/patents filed, distribution agreements, follow-on investments, and jobs created by the Technology Outreach program;
- Many case studies on universities/researchers;
- Number of companies served by the SBIR-STTR Assistance Center;
- SBIR/STTR funding won in FY 2011;
- Commercialization grants based at universities;
- Quotes from recipients.

The University of Utah's Bureau of Economic and Business Research (BEBR) performs the analyses USTAR presents to the state legislature annually using its annual report as the base. However, USTAR's Marketing and Communication's director, Michael O'Malley, said the most effective strategy for communicating impacts to the state legislature is to get the business community to talk to the legislators in support of USTAR. Mr. O'Malley stated that economic

development organizations such as the Salt Lake Chamber of Commerce and The Technology Council have a large impact on the legislature. USTAR also highlights its regional initiatives to the regional legislators; as Mr. O'Malley pointed out, "Every legislator wants to know what have you done for me and what have you done for my district? Legislators are concerned that they are getting their fair share of USTAR's attention in their district or conversely that any of their constituents would have a fair shake at getting USTAR's support. The perception is just as important."[30]

## Pennsylvania

### Ben Franklin Technology Partners

The Pennsylvania General Assembly created the Ben Franklin Technology Partners (BFTP) in 1982. The organization has 4 regional offices located across the state. Each regional office is run independently; however, they speak as one voice to the legislature through their Managing Director of Statewide Initiatives. BFTP is funded mainly through the Department of Community and Economic Development (DCED) via a general appropriation, which is divided evenly between the offices.

While some BFTP funding goes to education and economic development organizations, BFTP mainly supports entrepreneurs and early-stage and established companies. In previous years it has supported some basic and translational research, but these programs have not been funded since 2007. Each BFTP office decides how to implement its program in the context of its region's strengths and needs. All offices provide both financial investments in companies as well as business mentoring in the form of networking, experts-in-residence, incubators, and SBIR/STTR editorial assistance and award matching.

BFTP has a long history of measuring program impacts. Based on the Pennsylvania DCED standard, BFTP surveys each client for up to 5 years to measure program impacts. In 2007, the Pennsylvania DECD's Technology Investment Office released a report outlining the short-term metrics that will "encourage great accountability for our investment of taxpayer dollars." The report informed the impact survey BFTP sends its clients. The survey requests information on the following data elements:

- Company revenue ;
- Total job data;
- Jobs created/retained as a result of BFTP support;
- New products or services introduced as a results of BFTP support;
- Amount spent on research, development, testing, and evaluation;
- Number of patents and licenses as well as revenues from both;
- Additional financial support obtained due to BFTP support.

The survey's response rate is 80%. BFTP does not directly validate the responses other than through a 3rd-party 5-year impact analysis described below. Like Connecticut Innovations, BFTP staff is very involved with their companies, and in many cases a BFTP staff member is a board

[30] SRI International, interview with Michael O'Malley, USTAR's Director of Marketing and Communications, 2012.

observer, which means they actively participate in board meetings, but do not get a vote. These personal relationships are considered to be a type of validation of the numbers since many times BFTP staff knows the employees by name.

BFTP produces a short annual report to communicate with the general public and with the legislature. The brochure reports the following metrics:

- Gross State Product (GSP);
- Additional taxes paid to Pennsylvania as a result of BFTP investment ;
- Number of jobs created/retained;
- Funds leveraged;
- Case studies of clients.

BFTP reports only one ROI ratio: "$3.50 of incremental tax revenue is returned for every dollar of state investment in the program."[31] The brochure is distributed to every legislator.

In addition to this survey, BFTP engages an outside firm every 5 years or so to perform an economic impact analysis of its programs. The most recent analysis was done in 2009 for the companies funded from 2002 to 2006.[32] The study uses a quasi-experimental approach in which the authors compare specific metrics from BFTP-supported companies and non-BFTP-supported companies. The study bases its analysis on the number of jobs created that can be attributed to BFTP programs. To measure job creation, the study matches each BFTP client with a similar (control) company in the same NAICS code and with the same pre-award employment. Using job and wage data supplied by the Quarterly Census of Employment and Wages, the analysis built an econometric regression model that estimated the increase in jobs due to BFTP support while controlling for average annual salaries and industry fixed effects. The regression model estimated that BFTP support resulted in an increase of an average of 4.6 jobs per year over the time period analyzed. According to John Sider, the BFTP Managing Director for Statewide Initiative, the goal was to have an independent measurement of jobs created to supplement the survey data. He echoed many people's concerns that it is hard, if not impossible, for most business owners to estimate how many jobs were created/retained due to program support results. The Pennsylvania Economy League study then uses a regional model to estimate the indirect effects of jobs created and products produced by BFTP-supported companies.

The Department of Community and Economic Development speaks to the legislature on behalf of BFTP; however, BFTP officials appear occasionally before the legislature as witnesses or experts. In addition, the heads of each regional office visit their state legislature delegations annually. Further, when a company is awarded a large BFTP award, the regional CEO engages their legislators for a public ceremony.[33]

[31] Ben Franklin Technology Partners, *2010 Annual Report: Catalyzing Innovation Throughout Pennsylvania,* 2010.

[32] Pennsylvania Economy League, *A Continuing Record of Achievement: The Economic Impact of Ben Franklin Technology Partners 2002-2006*, 2009.

[33] SRI International, interview with John Sider, Managing Director of Statewide Initiative for Ben Franklin Technology Partners, 2012.

# Maine

## Maine Technology Institute

The Maine State Legislature established the Maine Technology Institute (MTI) in 1999 to "encourage, promote, stimulate, and support research and development activity leading to the commercialization of new products and strengths in the State's technology-intensive industrial sectors." MTI is a private non-profit organization funded by the State of Maine with a Board of Directors appointed by Maine's Governor. MTI funds mainly technology development projects under the following programs:

- Business Innovation Program
  - TechStart Grants provide up to $5,000 for concept planning, market research, and tech transfer exploration.
  - Seed Grants provide up to $25,000 to support early-stage research and development activities for new products and services that lead to the market.
  - Development Loan provides up to $500,000 to support research and development of new and/or enhanced products, processes or services leading to commercialization.
  - Business Accelerator Grant provides grant funds to support commercialization and business development/capacity activities not eligible for SBIR or DL funding but required to advance the new technology to market and to firmly establish and increase the scope and sustainability of the business enterprise.
  - Equity Capital provides equity capital.
  - SBIR/STTR program provides editorial support for SBIR/STTR applications.
- Renewable Energy Technology – a program supported by utility fees that provides grants to support the development and commercialization of renewable energy technologies.
- Cluster Initiative Program – up to $50,000 for feasibility and planning and up to $500,000 for collaborative initiatives that boost the strength and scale of Maine's high-potential technology intensive clusters.
- Maine Technology Asset Fund – to fund capital and related expenditures supporting research, development and commercialization projects.

As indicated above, MTI's funding sources include Maine Legislative appropriations to the Department of Economic and Community Development and proceeds from bond issues. MTI publishes an annual report to the Maine State Legislature's Business, Research, and Economic Development Committee. The report includes the following metrics:

- Geographical location of applications and awards;
- Funding by industrial sector;
- Funding by MTI program;
- Case studies
- Select quotes from the impact report.

The annual report data are partly based on the surveys MTI requires its clients to submit annually to Maine's evaluator for the Comprehensive Research and Development Evaluation Report, which is submitted to the Maine Office of Innovation, Department of Economic and Community Development. The results are usually aggregated with other state R&D programs;

MTI accounts for 16% of the total state R&D investment.[34] This distributed survey includes the following questions:

- Geographic questions
- Year founded
- Number of employees
- Average wage
- Number of patents
- Revenues
- Revenue sources
- R&D expenditures
- Amount of money used to match MTI funds
- Other support organizations
- Corporate income tax paid/tax credit claimed
- Ratio of state dollars to total R&D performed by recipients
- People employed
- Customer locations
- Debt financing sources and amount (if applicable)
- Equity financing sources and amount
- Federal awards – sources and amount

In addition to the aggregate evaluation for the Maine DECD, MTI commissions its own impact study every 5 or so years. The last evaluation included awards ending in 2006-2008, and was done by a third-party evaluation team. The in-depth evaluation is based on the same survey data as the DECD report. The impact report includes MTI-specific data for the above subjects and also includes:

- Funds for R&D and production;
- New products resulting from development awards or seed grants;
- Firms where MTI support led to products for sale;
- Likelihood of marketing MTI-supported products;
- Employment change in MTI-support companies.

Betsy Biemann, President of the Maine Technology Institute, said the feature of MTI that has the greatest impact with the Maine Legislature, which has a lot of turn over due partly to term limits, was that MTI evaluates its programs every year; she said that reporting of impact data as a function of time is the most effective indicator of the agency's effect.

### Economic impacts of Maine R&D grants

Maine supports R&D through the following programs:

- University of Maine System;
- Maine Biomedical Research Fund;
- Maine Technology Institute;
- Marine Science and Technology Foundation;
- Applied Technology Development Center;
- Small Growth Enterprise Fund;
- Maine Marine Research Fund;
- Gulf of Maine Research Laboratory.

Twenty-two percent of R&D funding in Maine goes to the business development program (also know as technology-based economic development), while the rest of the funds (78%) go to

[34] PolicyOne Research, EntreWorks Consulting, and Scruggs & Associates, *Maine Comprehensive Research and Development Evaluation 2010,* 2011.

university, nonprofit, and research-based programs. All Maine-supported R&D programs are evaluated annually, and the impacts are published in the Maine Comprehensive Research and Development Evaluation report. The evaluation's data comes from surveys sent to each of the funding recipients. The surveys collect information on:

- Institutional capacity – number of STEM undergraduate and graduate students and degrees;
- Publications – number of peer-reviewed publications (journals and books) and white papers;
- Research proposals – number and dollar amount;
- Research awards – number, dollar amount, and source;
- Intellectual property – number of disclosures made, patents applied for, copyrights obtained, licensing agreements signed, and license income.

The portion of the report covering supported R&D research listed the following measured impacts:

- Total R&D spending;
- Total number and dollar amount of new federal grants and contracts;
- University peer reviewed publications;
- Licensing agreements;
- Number of new firm spin-offs.

## Kentucky

### Cabinet for Economic Development – Office of Commercialization and Innovation

The Office of Commercialization and Innovation (OCI) is part of the Cabinet for Economic Development, and "leads the state's technology-based economic development efforts." OCI strives to build and promote technology-driven and research-intensive industries with the goal of "creating high-tech job opportunities and developing cluster of innovation throughout the state." OCI is funded by the Kentucky Legislature and administers the following six commercialization programs focused on early stage funding:

- SBIR-STTIR Matching Funds Program matches phase 1 and phase 2 SBIR/STTR awards.
- Commonwealth Seed Capital makes debt or equity investments in early-stage Kentucky business entities to facilitate the commercialization of innovative ideas and technologies.
- Kentucky New Energy Venture Fund provides seed stage capital to support the development and commercialization of alternative fuel and renewable energy products, processes, and services.
- Innovation and Commercialization Centers Program provides a cohesive resource offering business development services and funding assistance.
- Kentucky Enterprise Fund makes seed-stage capital investments in Kentucky-based companies.
- Kentucky Commercialization Fund Program provides seed funds to Kentucky university faculty members for commercializing products, processes, or services develop R&D at universities.

OCI makes an annual report to the Kentucky Legislative Research Commission and the Kentucky Innovation Commission. The report contains the following data obtained by surveys of clients:

- Number of SBIR phase 1 grants applied for and awarded to Kentucky;
- Jobs created due to OCI support;
- Licensing agreements due to OCI support;
- Patents filed due to OCI support;
- Out-of-state firms creating Kentucky operations due to program;
- Total OCI support;
- Follow-on funding in venture funds supported by OCI;
- Descriptions of supported companies.

### Kentucky Science and Engineering Foundation

State support for R&D and very early stage seed capital is administered through the Kentucky Science and Engineering Foundation (KSEF). The Foundation manages the following programs:

- Research and Development Excellence Program – which awards up to $50,000 per year to Kentucky small businesses, and scientists and engineers in post-secondary institutions. The program targets specific areas established by the state, which are:
    - Biosciences;
    - Environmental and Energy Technologies;
    - Human Health and Development;
    - Information Technology and Communications ;
    - Materials Science and Advanced Manufacturing.
- Kentucky Commercialization Fund (described above)
- SBIR/STTR Phase Zero and Phase Double Zero grant program:
    - Phase Zero provides grants to assist small businesses and college and university faculty with the preparation of Phase I SBIR/STTR proposals;
    - Phase Double Zero provides grants to assist small businesses with the preparation of Phase II SBIR/STTR proposals.

KSEF publishes a one-page annual impact report that lists the following economic impact indicators:

- Amount and source of follow-on funding (funds leveraged);
- Number of young investigator awards from the National Science Foundation and the Department of Defense;
- Number of invention disclosures, and patent applications;
- Number of new business formed by awardees;
- ROI ratios for research and SBIR/STTR grants.

According to Dr. Maria Mabreveux, Program Director for Kentucky Science and Engineering Foundation, the data for the impact report is collected via a survey of each recipient, which is required as part of the award.

# Ohio

### Ohio Third Frontier

The Ohio legislature created the Ohio Third Frontier (OTF) program in 2002 to expand Ohio's technology-based research capabilities and to promote innovation and new company formation to create and retain high-wage jobs. It is Ohio's largest-ever investment in a technology-based economic development program and consists of the following programs:

- Wright Centers of Innovation and Wright MegaCenter funds university-based Centers of Excellent in target technologies.
- Research Commercialization Program provides awards for applied research in science and technology with excellent commercialization potential.
- Ohio Research Scholars Program endows chairs at Ohio universities in targeted technology platforms.
- Wright Projects provides awards for capital equipment purchases to build university and firm collaboration.
- Entrepreneurial Signature Program provides mentoring to entrepreneurs.
- Pre-seed Fund Capitalization provides grants to accelerate the growth of early-stage Ohio technology companies.
- Fuel Cell Program supports applied R&D that addresses technical and cost barrier to fuel cell commercialization.
- Advanced Energy Program supports applied R&D that addresses technical and cost barrier to commercialization and adaptation of advanced energy system components.
- Ohio Research Commercialization Grant Program provides support to improve the commercial viability of technologies development through SBIR, STTR, and Advanced Technology Program R&D projects.
- Targeted Industry Attraction Grant Program provides incentives for out-of-state companies in target industry sectors to locate new technology facilities in Ohio;
- Innovation Ohio Loan Fund provides subsidized debt financing to established companies.
- OTF Internship Program supports internship of science, engineering, technology, and mathematics students with Ohio companies.

Of the total funds awarded from 2003-2008, 76.2% went to improving university-industry-nonprofit research collaboration and creating a world-class R&D capacity in target technology platforms relevant to Ohio industry. Approximately 13.3% of awarded funds went to supporting technology entrepreneurs through investments in formal support programs, as well as investments in pre-seed funds. Close to 10% of awarded funds went to product development assistance – providing support to new or existing companies trying to commercialize products based on new technologies. Less than 1% of award funds during this period went toward incentives to attract out-of-state companies in target industry sectors and toward supporting the placement of science, engineering, technology and mathematics (STEM) students with Ohio technology-based companies.

OTF's funding initially came from Ohio legislature appropriations and Ohio's tobacco settlement payments. In 2005, Ohio passed a $500 million bond issue that was used to fund the vast majority of the programs listed above. In 2010, Ohio voters passed a $700 million renewal of the bond program for OTF.

The Ohio Department of Development writes and submits an annual report of OTF, and consists of the following metrics:

- Case studies
- National recognitions
- Total number of awards
- Direct jobs created
- Leverage ratio
- Number of companies starting in Ohio
- State funds awarded
- State funds expended
- Cost share expended
- Leverage received
- Jobs created/retained
- Companies created/attracted
- Cost per job created
- Average salary
- Geographical distribution of awardees
- Total awards by sector

The annual report is based on data from OTF surveys of the organizations that serve the clients. As part of the awards, OTF clients are required to fill out surveys requesting information about impact metrics. The numbers are not validated unless a response is unexpectedly high. In addition to the annual report, the impacts of OTF have been assessed by a third-party organization, most recently by SRI International in 2009. This study calculates and reports:

- Follow-on investments by private, federal, and other non-state government organizations;
- Direct job creation;
- Indirect job creation;
- Product sales as a result of involvement with OTF and resulting economic impacts;
- Construction as a result of OTF funding and resulting economic impact;
- Licensing income to Ohio universities;
- Interviews with stakeholders;
- Case studies.

Many of these impacts were compared with results of a counterfactual analysis that estimated the economic impacts of the alternative of returning the amount of money invested in OTF as a tax credit to Ohio citizens.

OTF is funded through bond measures, so it does not have to communicate directly with the legislature except when the bond issue goes on the ballot. However, every year it issues an annual report as described. Like Maine, the Director of the OTF, Norman Chagnon, said Ohio's legislature and the public value their annual evaluations that include a block of metrics that communicate their message.[35]

[35] SRI International, interview with Norm Chagnon, Deputy Chief of the Technology and Innovation Division, Ohio Department of Development, 2012.

## Georgia

The Georgia Research Alliance (GRA) is an independent nonprofit organization funded by state appropriations since 1993. Its operating budget is also supported by industry and foundation contributions. GRA's main activity is to recruit researchers to Georgia universities by "investing in university-based research opportunities." GRA published an annual report that lists the researchers attracted by the GRA, along with vignettes about their activities. The GRA website touts the additional federal and private investment leveraged by GRA researchers.

Mike Cassidy and Susan Shows of GRA said that data are collected on job creation – both the jobs created by this recruitment, but also the jobs created by the staff in the researchers' lab and by the additional federal research funds brought into the state. In addition, GRA estimates the state payroll tax collected due to the additional federal and private funds leveraged by the recruited academic "stars." All of the data are collected via a GRA-administered survey, but the data are not formally verified since GRA has close relationships with most of its clients and because the universities keep careful records of leveraged research funding.[36]

[36] SRI International, interview with Mike Cassidy, President and CEO, and Susan Shows, Senior Vice President, of the Georgia Research Alliance, 2012.

# CONCLUSION: OCAST 2000 – OCAST 2012

## OCAST 2000

In 1999, just over 10 years after OCAST was established as the state's lead agency for technology-based economic development, the Oklahoma legislature engaged SRI International to conduct an assessment of the current status and past performance of OCAST. The project called for SRI to rank Oklahoma's science and technology infrastructure against that of similar states; compare OCAST's program portfolio against other states; assess OCAST's role in the state's overall R&D structure; compare its evaluation methods with those of other states; and evaluate the appropriateness of OCAST's current activities in light of Oklahoma's national ranking. Now, following another 10-year period of continued support from the state and a significant expansion of OCAST's program portfolio, it is interesting to compare and contrast the findings from SRI's earlier study to those of the present one – recognizing the present study has focused on a more limited range of assessment questions.

In its report to the legislature in 2000, SRI noted OCAST's role in the state TBED infrastructure is atypical in that Oklahoma chose to consolidate almost all of the state's science and technology programs in one agency. SRI reported OCAST's range of programs was similar to that in most states that had sought to use science and technology to promote economic growth. At the same time, over most of its history OCAST had emphasized upstream funding of fundamental and applied research, including a short-lived university-based Centers of Excellence that had recently been cancelled. Although a proposed seed capital fund program had not been funded, by 1999 the Oklahoma Technology Commercialization Center (OTCC) had just begun operation, signaling a new emphasis on more downstream-oriented innovation activities. During its early years engaged in TBED policy, Oklahoma (like most other states) emphasized upstream support of pre-competitive, academic R&D programs such as eminent scholars, Centers of Excellence, and R&D centers. By 2000, Oklahoma and OCAST, as the flagship TBED agency, were moving rapidly toward applied R&D, product development, increased use of direct grants to private firms, and relatively less support for university-based R&D.

SRI's interviews with OCAST stakeholders suggested OCAST's mission was not well understood in Oklahoma's S&T community, yet members of the community held strong but varying opinions of what that mission was. Many stakeholders saw OCAST as beneficial to the state, but some viewed it as bureaucratic, turf conscious, protective of external review, and isolated from some related state efforts such as EPSCoR. There was strong support for the Health Research program, which was seen as critical to maintaining and renewing the state's health research system. The applied research program (OARS) was strongly supported by business, but the academic research community was more critical. Many stakeholders spoke positively of the discontinued Centers of Excellence program. Although the new OTCC had just begun operations, it was already the subject of some strong negative opinion among stakeholders. Still, many apparently supported the move toward increased emphasis on downstream innovation activities and continued to believe a seed capital funding program is critical to increased commercialization of technology.

SRI found OCAST's indicators of the impacts of its programs on state economic development were complete, detailed, and on a par with the best evaluation methodologies used by other states. Survey methods and analysis were gauged as conservative, perhaps leading to understatement of the magnitude of impacts to date. At the same time, SRI cautioned about interpretation of leveraged research funding and the tendency of survey respondents to assign full attribution of leveraged funds to OCAST seed research projects. SRI also found, although the overall evaluation methods OCAST used were sound, the agency was not as effective as desired in communicating these impact results to stakeholders. SRI recommended augmenting the survey-based impact data with individual success stories in impact reports to stakeholders. Among SRI's recommendations: "The pros and cons of a more targeted, strategic approach to strengthening Oklahoma's S&T infrastructure should be considered."

## OCAST 2012

It is quite interesting and revealing to compare OCAST's situation in 2000 (at least as reported by the SRI investigators) against some of the current study's findings and recommendations. The basic organization of this report – investment, evaluation, communication – serves as a useful framework to compare the differences and similarities between OCAST 2000 and OCAST 2012. With increased funding for OCAST has come a major expansion in the size and breadth of OCAST's investment portfolio of TBED support. Perhaps is it more accurate to put expansion first as a goal, a goal realized by subsequent increases in OCAST funding by the legislature. Among the most significant changes in OCAST's role has been the greatly increased funding of downstream innovation activities, as evidenced primarily by more than a doubling of the number of programs between 2000 and 2012. Additions include the Nanotechnology Applications and Nanotechnology Initiative, a greatly expanded OTCC, the Manufacturing Innovation Fund, the Oklahoma Seed Capital program, Small Business Research Assistance, R&D Intern Partnerships, and the Inventors Assistance Service. In contrast to most other states, which have also greatly expanded their TBED downstream investments, Oklahoma's expansion into downstream innovation support programs has taken place largely within OCAST rather than through the addition of new agencies (governmental or quasi-governmental) or through creation of new departments within existing state agencies. So OCAST remains the lead agency for TBED in the state, a reality that in large degree is understood and favorably regarded by stakeholders. SRI's sense is the role of TBED programs in state economic development, and thus the mission of OCAST, is better understood now than it was in 2000. Accompanying this (relatively) greater understanding is continued strong support for OCAST among stakeholder groups, notwithstanding the more general issue of increased concern over public spending in a time

In comparing OCAST's impact on Oklahoma's economic development in 2012 with SRI's findings in our similar study of OCAST completed in 2000, our overall impression is that the role of OCAST programs in state economic development, as well as its mission, are better understood by stakeholders now than in 2000. Accompanying this greater understanding is continued strong support for OCAST among stakeholder groups, who overwhelmingly agreed that OCAST is a key player in the state's economic development strategy and that the state's science and technology capabilities would be much weaker without OCAST.

of economic weakness.

While the 2000 report found OCAST's approach to impact analysis to be conservative, OCAST's 2011 metrics cover a more extensive portfolio of programs. Impact metrics themselves are subject to continuing improvement in the state of the art and so should be reviewed on a regular basis, especially when programs are added or changed. Although SRI's examination of OCAST's evaluation methods in 2000 was not as detailed as it was in 2012, our impression is there has not been sufficient attention paid to assessing and revising the basic evaluation process and the impact data collected. There is now need for a closer look at both the survey instruments used to collect impact data and at the way the resulting data are analyzed and presented. The basic survey method OCAST has used throughout its existence is sound, but the instruments have apparently been significantly modified without sufficient attention to the consequences of increasing the amount of information sought for each program and of using essentially the same instruments for all programs in OCAST's greatly expanded portfolio. And, as with all government programs, OCAST faces increased public scrutiny and calls for greater accountability than was the case in 2000, suggesting more care should be taken to ensure the impact data sought and actually collected accurately reflect the different goals of each program.

> "Over the years, OCAST has done a good job on both measuring and communicating its positive results."
>
> Dan Berglund, President and CEO
> State Science and Technology Institute (SSTI)
> Westerville, OH

Finally, effective communication of OCAST's impact on state economic development remains as much of an issue today as it did in 2000. The challenge is much greater now than then, as more public programs compete for limited funds and are subject to more probing questions about their costs and performance. Fortunately, the state-of-the-art in evaluation of public programs has advanced, as has our understanding of how best to communicate complex activities and their value to legislators and the public to which those programs are accountable. SRI recommends the experiences of the past decade and the advances in communication and evaluation methods be applied to the formulation of a new communication strategy based on multiple measures of impact closely matched to specific programs; nuanced use of return-on-investment concepts based on clearly understandable, reliable data; and liberal use of individual success stories.

# APPENDIX A

**Table A-1.** Oklahoma employment in high-tech industries as defined by Daniel Hecker. Data from EMSI.

| NAICS 2002 | Description | OK Jobs 2005 | OK Jobs 2011 | Compound aggregate growth rate OK 2005-2011 | Location Quotient 2011 |
|---|---|---|---|---|---|
| 3254 | Pharmaceutical and Medicine Manufacturing | 348 | 296 | -2.7% | 0.09 |
| 3341 | Computer and Peripheral Equipment Manufacturing | 865 | 961 | 1.8% | 0.48 |
| 3342 | Communications Equipment Manufacturing | 857 | 740 | -2.4% | 0.54 |
| 3344 | Semiconductor and Other Electronic Component Manufacturing | 1010 | 888 | -2.1% | 0.20 |
| 3345 | Navigational, Measuring, Electromedical, and Control Instruments Manufacturing | 2368 | 2568 | 1.4% | 0.53 |
| 3364 | Aerospace Product and Parts Manufacturing | 3800 | 5515 | 6.4% | 0.98 |
| 5112 | Software Publishers | 853 | 600 | -5.7% | 0.18 |
| 5191 | Other Information Services | 818 | 600 | -5.0% | 0.30 |
| 5179 | Other Telecommunications | 2037 | 1413 | -5.9% | 0.89 |
| 5182 | Data Processing, Hosting, and Related Services | 2093 | 2472 | 2.8% | 0.69 |
| 5413 | Architectural, Engineering, and Related Services | 14042 | 14149 | 0.1% | 0.76 |
| 5415 | Computer Systems Design and Related Services | 8601 | 9921 | 2.4% | 0.44 |
| 5417 | Scientific Research and Development Services | 2316 | 2005 | -2.4% | 0.25 |
| 1131 | Timber Tract Operations | 95 | 97 | 0.3% | 1.29 |
| 1132 | Forest Nurseries and Gathering of Forest Products | 115 | 76 | -6.7% | 1.43 |
| 2111 | Oil and Gas Extraction | 39827 | 71481 | 10.2% | 9.20 |
| 2211 | Electric Power Generation, Transmission and Distribution | 6304 | 6451 | 0.4% | 1.36 |
| 3251 | Basic Chemical Manufacturing | 601 | 521 | -2.4% | 0.32 |
| 3252 | Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing | 347 | 230 | -6.6% | 0.22 |
| 3332 | Industrial Machinery Manufacturing | 624 | 434 | -5.9% | 0.34 |
| 3333 | Commercial and Service Industry Machinery Manufacturing | 1362 | 1429 | 0.8% | 1.23 |
| 3343 | Audio and Video Equipment Manufacturing | 238 | 228 | -0.7% | 0.91 |
| 3346 | Manufacturing and Reproducing Magnetic and Optical Media | 249 | 182 | -5.1% | 0.58 |
| 4234 | Professional and Commercial Equipment and Supplies Merchant Wholesalers | 4570 | 5213 | 2.2% | 0.71 |
| 5416 | Management, Scientific, and Technical Consulting Services | 12797 | 14909 | 2.6% | 0.64 |

| | | | | | |
|---|---|---|---|---|---|
| 3241 | Petroleum and Coal Products Manufacturing | 2196 | 2464 | 1.9% | 1.90 |
| 3253 | Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing | 367 | 597 | 8.4% | 1.38 |
| 3255 | Paint, Coating, and Adhesive Manufacturing | 592 | 523 | -2.0% | 0.75 |
| 3259 | Other Chemical Product and Preparation Manufacturing | 701 | 564 | -3.6% | 0.54 |
| 3336 | Engine, Turbine, and Power Transmission Equipment Manufacturing | 1318 | 789 | -8.2% | 0.70 |
| 3339 | Other General Purpose Machinery Manufacturing | 7630 | 8340 | 1.5% | 2.91 |
| 3353 | Electrical Equipment Manufacturing | 1512 | 1699 | 2.0% | 1.02 |
| 3369 | Other Transportation Equipment Manufacturing | 103 | 79 | -4.3% | 0.18 |
| 4861 | Pipeline Transportation of Crude Oil | 259 | 272 | 0.8% | 2.58 |
| 4862 | Pipeline Transportation of Natural Gas | 1032 | 669 | -7.0% | 2.10 |
| 4869 | Other Pipeline Transportation | 426 | 1014 | 15.6% | 12.61 |
| 5171 | Wired Telecommunications Carriers | 10689 | 8079 | -4.6% | 1.04 |
| 5172 | Wireless Telecommunications Carriers (except Satellite) | 3459 | 3333 | -0.6% | 1.54 |
| 5174 | Satellite Telecommunications | 51 | 47 | -1.4% | 0.31 |
| 5211 | Monetary Authorities-Central Bank | 77 | <10 | NA | NA |
| 5232 | Securities and Commodity Exchanges | 74 | 164 | 14.2% | 0.56 |
| 5511 | Management of Companies and Enterprises | 13480 | 16956 | 3.9% | 0.71 |
| 5612 | Facilities Support Services | 3490 | 3771 | 1.3% | 1.84 |
| 8112 | Electronic and Precision Equipment Repair and Maintenance | 1895 | 1924 | 0.3% | 1.06 |

Source: Hecker, D., High-technology Employment: A NAICS-based Update, *Monthly Labor Review*, July 2005.

**Table A-2.** Types of Impact Metrics collected by TBED organizations.

| Capital Metrics | Research Metrics |
|---|---|
| Direct investment in firms (sorted by sector, geography, or goals)<br>Number of awards distributed<br>Number of deals closed<br>Percent of program expenditures that cover administration<br>Types of debt attained by assisted companies<br>Diversity of investment (by type, i.e. debt, equity)<br>Fund growth thru private contributions (tax credits to grow funds)<br>Leveraged non-state dollars (by source)<br>Federal grants won by sponsored projects Number of SBIR awards won by client companies Number of assisted companies that won SBIR awards Amount of venture funding provided by client firms (fund-of-funds)<br>Share client investment made in in-state companies (fund-of-funds)<br>Amount of follow-on funding (by source and type) | Number of awards distributed<br>Number of universities that received awards<br>Federal research funding – follow-on or matching<br>Institutional share of total/state's federal research funding<br>Share of federal research funding relative to share of eligible faculty<br>Research funding from state sources<br>Research funding from local sources – follow-on or matching<br>Research revenue from industrial sources – follow-on or matching<br>Institutional research funding – follow-on or matching<br>Foundation research funding – follow-on or matching<br>Total external research funding<br>Amount of SBIR/STTR awards attracted |

| | |
|---|---|
| Local investment by assisted companies | Number of SBIR/STTR awards attracted |
| Papers submitted | Aggregate required cost-share |
| Number of publications | Percentage of research funding from industrial sources |
| Number of presentations | |
| Research enabled that would not have otherwise been possible | Faculty salaries supported by external research funding |
| Number of citations in academic journals (sorted by impact ) | Number of federally sponsored research centers created |
| Formal invention disclosures (by subject type) | Number of state-funded research centers created |
| Number of new patent filings | |
| Licenses granted | Square footage of lab space |
| Licensing revenue | Number of new invention disclosures, sort by type |
| Number of new patents issued (U.S. and foreign, subject types) | Number of faculty presentations |
| Number of copyrights | Faculty honors |
| Number of trademarks | Third-party rankings of university research |
| Number of trade secrets | Number of academic publication by faculty |
| Licensing revenues per investment/expenditures | Number of citations in academic journals (sorted by impact factors) |
| Number of exclusive licenses | |
| Number of non-exclusive licenses | Ranking by number of publications and citations among peer institutions Number of books published by faculty Faculty publishing by prestigious and highly prestigious presses |
| Number of in-state companies reviewed by portfolio venture firms (for fund-of-funds) | |
| Number of proposals received | |
| Number of new research collaborations as a result of grants | Third-party bibliometric rankings of faculty (e.g., Web of Science) |
| Percent of regional venture deals assisted by organization | Publications from authors affiliated with university hospitals |
| Location of VC firms what have provided investment | Number of new licenses and options |
| Number of national awards won (non-monetary) | Number of new patent filings |
| Satisfaction surveys by industry partners | Number of new patents issued (U.S. and foreign) |
| Survey responses of research grant recipients | |
| Returns from loan repayment | Number of copyrights |
| Payroll tax revenue generated by portfolio companies | Number of trademarks |
| State and local tax revenue created (non-payroll) | Number of trade secrets |
| Internships and student employment as a result of funding | Number of licenses/options yielding income |
| Percentage of awards spent on in-state research | Number of submissions to a commons |
| Additional equity dollars attracted to region | Number of products introduced to market |
| Number of companies who received awards | Number of licenses/products developed or leveraged from open commons |
| Exit rate | |
| Reported revenue of client companies (including spinouts/startups) | Licensing revenues per research expenditure |
| | Total license revenue |
| Reported sales of client firms | Number of exclusive licenses |
| Number of surviving firms (total) | Number of non-exclusive licenses |
| Number of surviving firms with employment growth | Number of new spin-off companies/created based on university IP |
| Mergers and acquisitions of funded companies | |
| Number of successful IPOs | Number of active spin-off companies |
| Firms created after researchers received grant | Number of employees at spinoff firms |
| Total savings to client companies | Survey of faculty entrepreneurs (satisfaction) |
| Percent of jobs in high-tech industries (by sector) | Average time required to complete technology transfer agreements |
| Average wage of jobs created or retained | |
| Aggregate wages created or retained (by sector, relative to others) | Survey of licensee companies (satisfaction) |
| | Licensing revenues per TTO expenditure |

| | |
|---|---|
| Average wage of jobs in firms assisted<br>Average number of jobs created per award<br>Average number of jobs per funds expended<br>Export destinations by country for companies assisted<br>Sales location by sector (in state, in U.S. not state, outside of U.S.)<br>Percent purchasing raw materials/services within state<br>Net jobs created by surviving firms<br>Number of jobs projected (e.g. over next 10 years)<br>Number of indirect or secondary jobs created, full-time employees<br>Aggregate wages created or retained (annualized, adjusted, average annual, etc)<br>Jobs created (direct attribution)<br>Jobs retained<br>Total jobs at portfolio and former portfolio companies (all jobs)<br>Cost per job (funds expended/job)<br>Companies relocating to state because of investment<br>Energy savings incurred by grant recipients<br>Energy savings incurred by region as a result of investment<br>Impact on energy consumption<br>In-state construction spending by sponsored projects<br>Total economic benefits accrued to taxpayers Ratio of economic benefits to operational costs Value of company activities and employee spending Leverage Ratio (leveraged dollars – cost share)/state funds<br>Net economic impact on geographic location<br>Aggregate fiscal impact (direct and indirect)<br>Monetary returns to fund from investments | Capital Improvements plus Royalty and Licensing Income<br>Number of faculty entrepreneurs<br>Number of proposals received<br>Amount of funding sought by participating researchers<br>Number of researchers using equipment<br>Number of (external) grants sought by participating researchers<br>Number of new and active CRADAs and Space Act Agreements<br>Number of university researchers consulting with industry<br>Number of private firms using university research facilities<br>Number of collaborations (institutions, disciplines, countries)<br>Number of new/junior investigators funded<br>Number of faculty/students in exchange programs at firms<br>Number of graduates taking jobs in the technology sector<br>Completion of STEM degrees<br>Number of S&T students placed in federal laboratory internships<br>Number of doctoral student placements (total and prestige)<br>Number of undergraduates employed in research (total and by funding source)<br>Number of graduate students published as sole/first author in refereed journals<br>Number of graduate students published as co-author with program faculty<br>Number of graduate students delivering paper/presenting at scholarly meetings<br>Increase in regional skilled S&T labor force (number of skilled laborers)<br>Number of university STEM graduates living in state<br>Number of star scientists, researchers, and staff attracted<br>Underrepresented or targeted population involvement<br>Leverage ratio (follow-on dollars – required cost share)/grant amount<br>Sales revenue from new products using university technologies<br>Total salaries of employees at spinoff firms<br>Revenue of active spinoff companies<br>Cost savings at client firms (from productivity increases at client firms)<br>Local goods and services purchased to support research (university and industry sources) |

| | |
|---|---|
| | Total personal income attributable to university research<br>Total sales or products and services attributable to university research<br>Increase in gross state product attributable to university research<br>Increase in employment attributable to university research<br>Net impact in state tax revenue<br>Jobs directly and indirectly supported by university research expenditures<br>Total personal income of research employees<br>Net economic impact of non-payroll expenditures, by industry<br>Impact = Grant Funding Received + (Number of Jobs per Sector * Salary) + Revenue Impacts Generated + Cost Savings + Additional Funds Acquired + Capital Improvements + Royalty and Licensing Income |
| Source: Cummings and Skinner, 2011. | |