October 2008

Economic Impact Assessment of the Oregon Nanoscience and Microtechnologies Institute (ONAMI)

Final Report

Prepared for

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RTI International is a trade name of Research Triangle Institute

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A special word of thanks goes to Sheila Martin, author of a companion piece on lessons learned from ONAMI, with whom we collaborated on many of the interviews informing this analysis.

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Executive Summary

The Oregon Nanoscience and Microtechnologies Institute (ONAMI) is a novel economic development initiative that integrates the nanoscience and microtechnology programs at Oregon's major science and technology research institutions: Oregon State University (OSU), Portland State University (PSU), University of Oregon (UO), Pacific Northwest National Laboratories (PNNL), and, more recently, Oregon Health and Science University (OHSU).

Established in July 2003, ONAMI is Oregon's first signature research center. It was established pursuant to the philosophy and university administrators' and researchers' acknowledgement that the combined, coordinated efforts of Oregon's research universities would be able to acquire more funding, deliver greater economic potential, and offer better educational and employment opportunities for Oregonians than if each university launched individual initiatives.

Leveraging each university's strengths rather than competing for limited resources makes Oregon's research universities and their private-sector partners more competitive for public–private R&D centers, research grants, and other sought-after opportunities.

ONAMI's mechanisms - proposal matching funds, signature researcher recruitment, shared facilities support, and commercialization gap financing – are designed to build Oregon's research infrastructure in order to sustain and build Oregon's competitive advantage in nanoscience and microtechnologies. ONAMI supports university-based research initiatives in green chemistry, advanced materials, and micro/nanoelectronics that complement Oregon businesses' strengths, diversify activities, and invigorate innovation statewide.

In April 2008, the Oregon Economic and Community Development Department (OECDD) and the Oregon Innovation Council (Oregon InC) contracted with RTI International to conduct an economic impact assessment of ONAMI and measure the economic benefits that ONAMI has generated.

ES.1 PROJECT GOALS AND METHODOLOGY

The purpose of this assessment was to estimate the economic benefits accruing to the state that are attributable to ONAMI and its programs that would not have accrued had ONAMI not been created. In other words, had there been no ONAMI, how would Oregon's university and private-sector R&D activities have developed differently?

Our approach was to measure the return on Oregon's investment in ONAMI using a cash flow analysis; all benefits and costs incurred during the period of analysis were quantified in dollar terms.

RTI's researchers collected historical program and financial data from ONAMI, university affiliates, and industrial affiliates to determine the extent to which ONAMI impacted their research agenda and business opportunities. RTI conducted nearly 70 interviews with

- university researchers and administrators,
- signature researchers,
- matching-funds recipients,
- gap financing recipients,
- private-sector shared facilities' users, and
- Oregon business leaders.

In addition to semistructured interviews, RTI fielded surveys to ONAMI researchers, shared facilities' users, and commercialization gap-funded companies. These surveys included questions about affiliates' economic activities, near-future plans, research outcomes, and probabilities of success and of acquiring Oregon and non-Oregon research funding under scenarios in which ONAMI's resources were not available.

ES.2 RATIONALE FOR STATE INVESTMENT IN ONAMI

Higher education in Oregon is underfunded, relative to Oregon's peer states in micro/nano research. States with similar high-technology employment patterns are spending 43% more per student than Oregon.

Lower higher-education spending levels translate into fewer resources for university-based research and training opportunities, which, in turn, dampen competitiveness for applied research opportunities with federal agencies and foundations.

Oregon is at risk for falling behind, particularly as R&D activity and high-technology employment in the state is highly dependent on semiconductor research. Peer states' private-sector employers perform between 70% and 77% of their R&D, but that figure is 83% in Oregon. This high proportion coupled with a concentration in a small number of industries amplifies adverse industry trends in Oregon.

Given this context, Oregon's universities partnered with leaders in government and industry within the fields of nanoscience and microtechnology to devise a program that would

- competitively allocate scare resources,
- leverage state support to aggressively grow external funding,
- improve the quality and quantity of university-based research and deepen ties between industry and universities, and
- catalyze diversification and growth of Oregon's high-technology industry to offer greater economic opportunities and well-being for all Oregonians.

The state government contributed $12.75 million in operating funds and $20 million in capital funds to ONAMI between the start of fiscal year (FY) 2004 on July 1, 2003, and the close of FY 2008 on June 30, 2008.

ES.3 ONAMI'S MISSION AND SUCCESSES

The focus at ONAMI since 2004 has primarily been on building Oregon's research infrastructure. Efforts focused on establishing sophisticated laboratories (referred to as shared facilities), acquiring sophisticated analytical instruments and signature researchers, and growing Oregon's human capital with federally funded research initiatives.

ONAMI itself does not employ researchers, own or operate facilities, or have investments in the Oregon businesses it supports; rather it awards funding on a competitive basis to Oregon's researchers. Only about 10% of the state's annual support for ONAMI is allocated for administrative expenses. In brief:

- The proposal matching fund leveraged $2.5 million to secure $15.2 million, or for every $1 ONAMI invested Oregon received $6.08.

- Three shared facilities—Center for Advanced Materials Characterization in Oregon (CAMCOR), Center for Electron Microscopy and Nanofabrication (CEMN), and Microproducts Breakthrough Institute (MBI)—are of such high quality that users from outside of the Pacific Northwest travel to Oregon to use them, paying market rates that are used to defray the state's operating costs.
- ONAMI's researchers and the Oregon congressional delegation secured $65 million for R&D in strategic Oregon research areas.[1]
- ONAMI support also stimulated $11.8 million in cash inflows to Oregon businesses and to the universities from out-of-state donors.
- Shared facilities permitted Oregon's businesses to keep research activity in the state that otherwise would have been contracted out of state.

An additional $29.7 million was contributed to ONAMI by Oregon businesses that felt that its workforce development, economic diversification, and commercialization strategies were paramount to the state's economic vitality.

Several common themes emerged from our conversations with Oregon businesses:

- Emphasis on evaluating ONAMI's initial success should focus on ONAMI's role in supporting the innovation infrastructure—facilities, instruments, people—and not yet on employment gains, which are likely to accrue following some incubation period denominated in years.
- Research alliances across the state, both among universities and between universities and business, allow all of Oregon to better compete and provide greater "presence" on competitive research proposals.
- ONAMI is trying to close the divide between the business and university communities by rewarding collaboration and brokering relationships.
- ONAMI diversifies and provides greater opportunities for Oregon's labor talent pool, which will likely mitigate any brain drain should the semiconductor business "dry up."
- ONAMI incubates small businesses by providing commercialization support for university professors who have good ideas

[1] Following completion of this analysis additional federal funding of $10.4 million was announced for ONAMI's strategic research thrusts.

- Universities are likely to develop better talent, both at the undergraduate and graduate levels, which in turn enhances employers' competitiveness.
- ONAMI is raising the caliber of researchers, Oregon science, and infrastructure—all of which will enable success to happen now and in the future.

ES.4 SUMMARY ECONOMIC IMPACT MEASURES

ONAMI has been successful at growing nanoscience and microtechnology research activity at ONAMI's university affiliates and PNNL's Corvallis laboratory (see Figure 5-1 in Section 5). Between FY 2004 and FY 2008, ONAMI researchers

- submitted proposals worth more than $562 million, which corresponds to an annual growth rate of 57%;
- received project and grant awards worth $110 million, which corresponds to an annual growth rate of 65%; and
- accounted for $198 million in research activity, which corresponds to an annual growth rate of 78%.

Benefits were primarily defined as cash inflows to Oregon that likely would not have occurred had ONAMI not been created. These cash inflows secured by the end of FY 2008 from non-Oregon sources totaled $77 million, which translated into a net benefit of $39 million.

As stated above, Oregon businesses have invested a substantial amount of value in ONAMI, including donated services, analytical instruments, processing equipment, and office space. The significance of this investment indicates the imperative the business community places on growing and diversifying Oregon's technology sector and integrating Oregon's universities more closely with its industry. Inclusion of companies' contributions boosts net benefits by 76% from $39 million to $69 million.[2]

Assessing the economic benefits of ONAMI is akin to assessing the economic contributions of a star-performing stock in an investment portfolio: the annualized rate of return on the state government's investment from cash inflows from non-Oregon sources is 56% (see Table ES-1). A benefit-to-cost ratio of 1.72 means that for every $1 the state government invested, Oregon received $1.72 in return.

[2] Although donations and gifts from Oregon businesses to its universities are transfers of value between two parties, this analysis is from the ONAMI prospective, and therefore contributions from Oregon businesses, are a cash inflow into ONAMI.

Table ES-1. Summary Economic Impact Results

Measure	Value
All state costs, including one-time $20 million capital contribution	$38 million
Total economic benefits from **non-Oregon sources**	$77 million
Net economic benefits	$39 million
Net present value (2008$, 7% discount rate)	$25 million
Benefit-to-cost ratio	1.72
Internal rate of return	56%
Total economic benefits from **Oregon and non-Oregon sources**	$107 million
Net economic benefits	$69 million
Net present value (2008$, 7% discount rate)	$40 million
Benefit-to-cost ratio	2.15
Internal rate of return	76%

Inclusion of in-kind and cash contributions from Oregon businesses increases those impact metrics to a rate of return of 76% and a benefit-to-cost ratio of 2.15. The IRR on ONAMI is within a range observed for other successful technology policy initiatives (Tassey, 2003).

Cash inflows translate into economic opportunity. Business leaders cited ONAMI's extraordinary potential of increasing employment and educational opportunities for Oregonians. ONAMI's commercialization support program may yield between 1,360 and 2,100 new jobs by 2013. The employment gains are in addition to the jobs in Oregon's communities that are supported by ONAMI's ability to secure research funding.

Perhaps most notably, Oregon businesses matched the state government's contributions 75 cents on the dollar. Business leaders cited the need for statewide research alliances, the effectiveness and novelty of ONAMI's programs, and ONAMI's focus on developing Oregon's research infrastructure as the key attributes that catalyzed the more than nearly $30 million in state-of-the-art instruments, office space, and in-kind services they have donated to ONAMI since the program's inception.

One researcher commented to us that he was working on a business plan with a company that received an ONAMI gap grant to commercialize technology funded in part with an ONAMI proposal match and that was conducted in an ONAMI shared facility. This comment illustrated ONAMI's comprehensive strategy of building the research infrastructure that will support the development of new business and industries in the future.

The story of ONAMI is largely a story of infrastructure and human capital: ONAMI's mechanisms are designed to secure and procure the tools necessary for Oregon's university and private-sector researchers to further Oregon's goals to rank among the preeminent micro/nano research centers in the world.

1 Introduction

The Oregon Nanoscience and Microtechnologies Institute (ONAMI) is a novel economic development initiative that integrates the nanoscience and microtechnology programs at Oregon's major science and technology research institutions: Oregon State University (OSU), Portland State University (PSU), University of Oregon (UO), Pacific Northwest National Laboratories (PNNL), and, more recently, Oregon Health and Science University (OHSU).

Established in July 2003, ONAMI is Oregon's first signature research center. It was established pursuant to the philosophy, and university administrators' and researchers' acknowledgement, that the coordinated efforts of Oregon's research universities would be able to acquire more funding, deliver greater economic potential, and offer better educational and employment opportunities for Oregonians than if each university acted individually. Leveraging each university's strengths rather than competing for limited resources makes Oregon universities and their private-sector partners more competitive for public–private R&D centers, federal funding opportunities, and other sought-after opportunities.

In stark contrast to Oregon's position as a leading U.S. location for corporate semiconductor research and development (R&D), Oregon's research universities have a minor footprint on the national research stage. Oregon's peer states in the micro/nano research space have universities that are tightly integrated with their business communities. Strength in corporate R&D is not in itself a negative, but Oregon's overwhelming dependence on semiconductor R&D to drive innovation means that adverse industry trends are amplified in Oregon. These changes, in turn, impact state tax revenue, employment across the state, and the economic well-being of Oregonians.

ONAMI's goals are to aggressively grow and diversify academic and private-sector micro/nano research activity in the state, increase collaboration among private-sector and university researchers, and through this activity invigorate economic development and catalyze new sector development.

In the case of ONAMI, the overall performance measures include:

- Number of technologies or products developed in partnership with ONAMI affiliates that are commercialized by Oregon companies.
- Number of Oregon companies assisted by ONAMI to raise at least $20 million in private capital.

Key ONAMI milestones are:

- By July 2009, hire between four and six world class researchers leveraged with contributions from ONAMI affiliates.
- Raise at least $40 million in new federal and private funding by July 2009.
- Advance three to eight technologies, developed by companies assisted by ONAMI, to venture-ready stage by July 2009.
- Generate between $200,000 and $500,000 in technology licensing revenue and/or equity value growth in companies assisted by ONAMI by July 2009.

Anecdotal evidence and quarterly research activity data collected by ONAMI suggest that ONAMI has been successful in meeting its objectives. However, this study is the first that reviews ONAMI's impacts and compares them to what would have occurred had ONAMI not been created.

1.1 ECONOMIC IMPACT ASSESSMENT GOALS AND OBJECTIVES

In April 2008, the Oregon Economic and Community Development Department (OECDD) and the Oregon Innovation Council (Oregon InC) contracted with RTI International to conduct an economic impact assessment of ONAMI.

The state government contributed $12.75 million in operating funds and $20 million in capital funds to ONAMI between the start of fiscal year (FY) 2004 on July 1, 2003, and the close of FY 2008 on June 30, 2008.

The government has also committed $4.5 million for FY 2009, bringing the state's total investment in ONAMI to $37.25 million by the close of the current biennium in June 2009.

The purpose of this assessment was to estimate the benefits accruing to Oregon that are attributable to ONAMI and its programs that would not have accrued had ONAMI not been created. In other words, had there been no ONAMI, how would Oregon's university and private-sector R&D activities have developed?

OECDD and Oregon InC had five overarching objectives for the project:

- analysis of the economic impact of state investment in ONAMI,
- analysis of the underlying attractiveness of Oregon for business investment and retention,
- summary of noneconomic outputs (e.g., patents, invention disclosures),
- analysis of projects funded through ONAMI's commercialization gap program, and
- quantification of specific impacts on Oregon jobs and workforce development.

OECDD also indicated that, to the extent possible, all benefits should be expressed in dollar terms to enable comparison with the state investment. This document is the final report for the assessment.

1.2 ANALYSIS METHODOLOGY

Our approach was to review Oregon's investment in ONAMI using a cash flow analysis; all benefits and costs incurred during the period of analysis were quantified in dollar terms. Costs and benefits were assembled into a time series of cash flows and analyzed much like an investment portfolio would be, with the exception of employment impacts. Job gains from ONAMI were listed as the number of positions gained.

1.2.1 Primary and Secondary Data Sources

RTI's researchers collected historical program and financial data from ONAMI, university affiliates, and industry affiliates to determine the extent to which ONAMI affected their research agenda and business opportunities. RTI conducted nearly 70 interviews with

- university researchers and administrators,
- signature researchers,
- matching-funds recipients,

- gap financing recipients,
- private-sector shared facilities' users, and
- Oregon business leaders.

RTI complemented its interviews with brief surveys targeting university researchers, shared facilities' users, and gap-fund recipients. These surveys included questions about affiliates' economic activities, near-future business plans, research outcomes, probability of success, and probability of acquiring Oregon and non-Oregon research funding under scenarios in which ONAMI's resources were not available. These surveys are included as Appendix A.

1.2.2 Time Period of Analysis

ONAMI's origins can be traced to a number of programs and informal collaborations, including

- an interinstitutional internship program that paired students with companies,
- OSU and PNNL's decision to jointly launch the MBI, and
- the prevalence of interdisciplinary institutes at the University of Oregon in Eugene.

Furthermore, in the years just prior to ONAMI state and business leaders were discussing the potential for signature research centers. The convergence of university researchers, university administrators, and state and business leaders and the striking similarity in their proposed strategies led to ONAMI's creation.

This report's period of analysis is FY 2004 through FY 2008, which corresponds to July 1, 2003, through June 30, 2008. Although these extensive efforts had a cost component to them, this analysis necessarily focused on the moment funds were first appropriated for and distributed to ONAMI from the state government. The costs presented in the report are the actual costs the state government appropriated specifically for ONAMI through FY 2008 ($32.25 million).

It is important to note that benefits from research awards that leveraged state funds extend as far as FY 2013. Proposals are often funded over a multi-year period and funding organizations release money incrementally. Thus, a project awarded in 2008 may have funds coming in later years.

ONAMI's mechanisms are meant in part to secure research funding, which organizations like The Defense Advanced Research Projects

Agency (DARPA), National Institutes of Health (NIH), and the National Science Foundation (NSF) distribute to winning proposals over a period of time. A winning proposal may have a 5-year period of performance, with funds being distributed to the proposal winner in five annual "awards." Thus, although is this analysis is largely retrospective, future cash flows secured by past efforts are included.

1.2.3 Definitions of Economic Benefits, Costs, and Transfers

Economic benefits were defined as cash inflows into Oregon from federal agencies, foundations, and private-sector companies. These inflows may be research funding for proposal wins, federal funding for ONAMI and its affiliates, or other economic resources that did not originate from the state government. These funds were largely from federal sources, such as DARPA, NIH, NSF, the Department of Defense, and other groups that fund the majority of science and technology research in the United States. The study also differentiates between Oregon and non-Oregon cash flows because of the sizable investment Oregon's businesses have made to enable ONAMI to be successful.

Costs were defined as the state government investment in ONAMI, including those start-up costs that were borne by OSU, PSU, and UO during ONAMI's early stages.

Care was taken to measure only the incremental impact associated with ONAMI to avoid overstating benefits and thereby overestimate measures of economic return. The legislature's appropriations for ONAMI were channeled through ONAMI, Inc., a not-for-profit entity, that distributed awards and funds to university researchers on a competitive basis.[1]

Because Oregon's universities had research programs before ONAMI—indeed, the concept of ONAMI is rooted in partner universities' desire to be more competitive for research funding—it was important to identify only benefits that would not otherwise have occurred. ONAMI's grants to organizations were not counted as a benefit or a cost because they were included in the state appropriation to ONAMI. Similarly, funds that were awarded from in-state sources, such as ONAMI, a state agency, or another state university, were treated as transfers of value within ONAMI. These adjustments were made to avoid double-counting benefits.

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[1] ONAMI, Inc. was incorporated as a not-for-profit, 501(3)(c) organization in March 2005.

For the purposes of this study, if a multimillion dollar proposal would have been awarded in the absence of ONAMI, then the proposal was not considered a benefit attributable to ONAMI and, therefore, was excluded from the time series of economic benefits.

Further methodological detail accompanies the analysis of each of ONAMI's mechanisms in the sections that make up the main body of this report.

1.3 REPORT ORGANIZATION

The balance of this report is organized as follows:

- Section 2 reviews the rationale for Oregon's investment in ONAMI, including a discussion of the state's ranking on several key R&D performance indicators.
- Section 3 discusses and analyzes ONAMI's programs and their economic significance.
- Section 4 analyses the impacts ONAMI has had on the Oregon business community.
- Section 5 analyses the impacts ONAMI has had on university-based R&D.
- Section 6 reviews summary economic impact data, calculates measures of economic return on the state government investment, and offers concluding remarks on ONAMI and its economic significance.

2 Rationale for State Investment in ONAMI

***Synopsis**: ONAMI's creation is rooted in the recognition that coordinated research and proposal ventures will enable the Oregon University System (OUS) to be more successful than if each constituent university acted alone. Furthermore, because financial resources are more constrained in Oregon than in other states, a competitive, interinstitutional mechanism was viewed as being more effective at leveraging state dollars. Growing research activity in the university and private sectors—and collaboration between them—would yield long-term benefits for the state.*

Oregon's preeminence in private semiconductor R&D is not historically matched by equivalent preeminence in university-based R&D. As competition for research opportunities that align with Oregon's high-technology sector increases, Oregon's research universities must develop strategies for keeping pace.

Higher education in Oregon is underfunded, relative to Oregon's competitor states in micro/nano research. States with similar high-technology employment patterns are spending 43% more per student than Oregon. Lower higher-education spending levels translate into fewer resources for university-based research and training opportunities, which, in turn, dampen competitiveness for applied research opportunities with federal agencies and foundations.

Oregon is at risk for falling behind, particularly because R&D activity and high-technology employment in the state is highly dependent on the semiconductor industry. Peer states' private-sector employers perform between 70% and 77% of their R&D, but that figure is 83% in Oregon. This high proportion coupled with an R&D concentration in a small *number of industries suggests that adverse industry trends would be amplified in Oregon.*

Although the purpose of this report is not to analyze the competitive landscape Oregon faces for private and university R&D, an overview is needed to contextualize the rationale for the state government's investment in ONAMI.

2.1 RESEARCH ACTIVITY IN OREGON COMPARED TO OTHER STATES

Oregon competes with other regions for research funding, employers, labor, and capital. RTI selected seven states for comparison with Oregon that have significant micro- and nanoscale R&D clusters similar to those in Oregon: Arizona, California, Massachusetts, New York, North Carolina, Texas, and Washington.

The data in Tables 2-1 through 2-3 illustrate that Oregon compares favorably with other states on the amount of R&D activity relative to the size of the state economy, as measured in research spending. Yet, although the ratio of R&D to gross state product (GSP) is favorable overall, Oregon's R&D activity is highly concentrated in the private sector. Other states rely on their universities to diversify and support innovation, but Oregon relies on a small number of large employers concentrated in comparatively few industries.

2.1.1 High-Technology Industry Employment Concentration

Relative to the seven states selected by RTI, in 2004, Oregon's economy was smaller in both absolute and per capita terms, but had a comparable concentration of its workforce employed in high-technology businesses (see Table 2-1).[1] The data in Tables 2-1 through 2-3 are for 2004, the last year for which equivalent data for all states and measures were available.

[1] In this study, businesses were defined as being "high-technology" if they employed a proportion of employees in technology-oriented occupations that is at least twice the average proportion for all industries. This approach to defining high-tech employment was first developed by Daniel Hecker at the Bureau of Labor Statistics and has recently been used by NSF in its 2008 Science & Engineering Indicators Report (Hecker, 2005; NSF, 2008).

Table 2-1. Comparison of State Technology Competitiveness Metrics, 2004: Economic and Employment Characteristics

Competitiveness Metric	Oregon	Arizona	California	Massachusetts	New York	North Carolina	Texas	Washington
State population (millions)	**3.58**	5.74	35.72	6.43	19.26	8.54	22.45	6.19
Gross state product ($billions)	**132.8**	193.4	1,519.4	306.9	896.4	324.4	901.7	253.2
Gross state product per capita ($/person)	**37,073**	33,676	42,535	47,691	46,547	37,991	40,155	40,913
Total state employment (thousands)	**1,356**	2,044	13,265	2,980	7,434	3,366	8,118	2,269
Employment in high technology establishments	**147**	228	1,765	447	795	324	1,100	279
% of total employment in high technology establishments	**10.8%**	11.1%	13.3%	15.0%	10.7%	9.6%	13.5%	12.3%
% of total employment in semiconductors	**0.8%**	0.9%	0.6%	0.6%	0.4%	0.3%	0.5%	0.3%
Unemployment rate (%)	**7.3%**	4.9%	6.2%	5.2%	5.8%	5.5%	6.0%	6.2%

Sources: U.S. Department of Commerce, Bureau of Economic Analysis (BEA) (2004); U.S. Department of Commerce, Bureau of the Census (2004, 2008); and U.S. Department of Labor, Bureau of Labor Statistics (BLS) (2008).

In 2004, 146,500 workers were employed in Oregon's high-tech industries—approximately 11% of total employment. This percentage is similar to those of competitor states, where employment in high-tech industries accounts for an average of 12% of total employment. But apart from Arizona, Oregon had the greatest concentration of employment in semiconductor manufacturing at 0.8% of the work force, or between 7% and 8% of total high-tech employment in the state. The other states had concentrations at 0.6% or less.

2.1.2 Industry and University Research Activity Volumes

Investing in R&D is critical to creating improved products, markets, methods of production, and business practices. As a result, the amount of R&D activity in a state will significantly impact its prospects for future growth and economic diversification.

Table 2-2. Comparison of State Technology Competitiveness Metrics, 2004: Research and Development Activities

Competitiveness Metric	Oregon	Arizona	California	Massachusetts	New York	North Carolina	Texas	Washington
Total state R&D performance ($millions)	**3,664**	3,544	59,607	15,987	13,113	6,491	14,266	10,936
per $1,000 of GSP	**27.58**	18.32	39.23	52.10	14.63	20.01	15.82	43.18
Industry R&D performance ($millions)	**3,057**	2,570	46,614	11,819	8,793	4,565	10,992	8,840
per $1,000 of GSP	**23.01**	13.29	30.68	38.52	9.81	14.07	12.19	34.91
% of total R&D	**83%**	73%	78%	74%	67%	70%	77%	81%
Academic R&D performance ($millions)	**437**	618	5,363	1,822	3,090	1,395	2,766	870
per $1,000 of GSP	**3.29**	3.19	3.53	5.94	3.45	4.30	3.07	3.43
% of total R&D	**12%**	17%	9%	11%	24%	21%	19%	8%
Unclassified R&D performance ($millions)	**170**	356	7,630	2,346	1,230	531	508	1,226
per $1,000 of GSP	**1.28**	1.84	5.02	7.65	1.37	1.64	0.56	4.84
% of total R&D	**5%**	10%	13%	15%	9%	8%	4%	11%
Federal R&D obligations	**449**	2,216	18,041	5,325	4,034	1,677	5,026	2,071

Source: National Science Foundation (NSF) (2006, 2007).

Per $1,000 of GSP, Oregon's total state R&D performance outranks Arizona, New York, North Carolina, and Texas, but is surpassed by California and Massachusetts. In 2004, over $3.7 billion of R&D was performed in Oregon, which corresponds to approximately $28 per $1,000 of GSP (see Table 2-2). Massachusetts has less than twice Oregon's population, but has nearly four times the amount of research activity in absolute terms. Per $1,000 of GSP, Massachusetts invests $52.10 in R&D.

States rely on their universities to educate their workforce, develop and commercialize technologies, and stimulate economic development. Among its peers, Oregon is the most reliant on its private-sector firms for its R&D activity.

Table 2-3. Comparison of State Technology Competitiveness Metrics, 2004: State Appropriations for Higher Education

Competitiveness Metric	Oregon	Arizona	California	Massachusetts	New York	North Carolina	Texas	Washington
Total fall enrollment in degree-granting institutions (thousands)	**200.0**	490.9	2,374.0	439.2	1,141.5	472.7	1,229.2	343.5
In public institutions (thousands)	**165.4**	318.0	1,987.3	187.8	623.2	389.1	1,071.9	293.1
State appropriations for higher education ($millions)	**586.6**	913.9	9,091.4	880.6	4,048.9	2,628.5	4,882.2	1,427.6
Higher education appropriations per 1,000 public students ($millions)	**3.5**	2.9	4.6	4.7	6.5	6.8	4.6	4.9

Sources: National Center for Education Statistics (NCES) (2008) and Fischer (2006).

Over 83% of Oregon's R&D was performed by industry; academic and other institutions (such as federal research labs and federally funded nonprofit research institutions) accounted for only 12% and 5% of total R&D expenditures, respectively. While Massachusetts and California have relative proportions of academic R&D that are smaller than Oregon's, in absolute terms they still outrank Oregon.

The balance between private, academic, and federal R&D in Oregon is different than what is typically found in competitor states, where private companies account for 74% of total R&D expenditures on average, and R&D in academic and other institutions accounts for 16% and 10%, respectively.

The reliance on private industry, particularly semiconductors, for R&D activity is not a negative; however, it does suggest that changes in firm location or industry trends would more adversely impact Oregon's R&D activity than other states'.

2.1.3 State Spending on Higher Education

State spending on higher education largely corresponds to the quality and level of preparedness of the local workforce. Oregon, like other states, also relies on labor importation – attracting skilled and highly-educated people from outside the state. Yet, the amount of resources a state devotes to developing human capital today will potentially affect worker productivity and economic growth in the future.

According to the *Chronicle of Higher Education*, Oregon's state appropriations to institutions of higher education were approximately $587 million in 2004 (or $3.5 million per 1,000 students enrolled in a public 4-year institution) (see Table 2-3).

By comparison, the state governments of the seven comparison states appropriated an average of approximately $3.4 billion ($5 million per 1,000 students enrolled in public 4-year institutions). This means that comparison states spend $1.5 million per 1,000 students (or 43%) more on higher education than Oregon spends.

2.2 UNIVERSITY COMPETITION FOR SCIENCE AND TECHNOLOGY RESEARCH FUNDING

Academic research that complements Oregon's private-sector R&D strengths requires investments in human capital, research equipment, and facilities denominated in the millions of dollars. In addition, funding organizations like the Department of Energy increasingly include matching funds requirements in their solicitations. Proposal teams that are unable to meet these requirements are essentially precluded from submitting a proposal; they must walk away from the opportunity.

2.2.1 Applied versus Basic Research Funding

Universities' research funding is predominantly funded by the U.S. federal government, with private companies, and nonprofit research foundations comprising the other most significant external funding groups. The state government supports universities, which pay faculty salaries. Universities expect faculty members to perform research and therefore there is some research without external funding from endowments and institutional funds, but the majority of research funding is from external sources.

This funding can be broadly categorized into two "types" of research: basic research and applied research. The distinction between applied and basic research is important because funding organizations are loosely segmented into these categories, and so are universities' research opportunities.

Simply put, basic research expands and deepens the body of research and thought that is foundational to society's understanding of the physical and life sciences. NSF and NIH, for example, principally fund basic research. While basic and applied research both are explorations in science, applied research seeks to further a stated goal, develop a technology, or enable a specific application. The Department of Defense, Department of Energy, and other organizations tasked with specific, objective-oriented missions principally fund applied research.

Research funding is not in unlimited supply; universities are forced to compete against one another to receive it. Whereas NSF and NIH funding has been relatively stable, applied research funding is growing. Applied research is also more likely to include matching funds requirements and research objectives may span disciplines. Applied research opportunities generally favor proposals that integrate multiple research fields.

ONAMI makes partner universities more competitive in this environment by rewarding coordination of research efforts across institutions and interdisciplinary research and providing matching-fund grants for successful proposal teams.

2.2.2 Research Activity at ONAMI University Affiliates Compared to Other Science and Technology Research Universities

RTI selected 12 science and technology universities against which to compare Oregon's research universities to illustrate Oregon's research universities' competitive position in the competition for research funding. The selected 12 science and technology universities, including MIT, Stanford, Cal Tech, and Carnegie Mellon, are also active in nanoscience and microtechnology research and have researchers that compete with OUS researchers on funding proposals and grants. A summary of how these universities compare along several research and tech-transfer metrics is provided in Table 2-4.[2]

Excluding OHSU, Oregon's largest research university and state-supported medical school, which only recently joined ONAMI, the data illustrate that separately UO, OSU, and PSU are much smaller than the 12 comparison universities. They have lower R&D expenditures and fewer cumulative patent applications, invention disclosures, and start-up

[2] RTI used data collected by the Association of University Technology Managers (AUTM) during its annual licensing survey to review Oregon's research universities in general and to compare them with large research universities in the next section. The AUTM surveys are administered each year to AUTM's broad membership base that includes over 350 universities, research institutions, government agencies, and private companies.

Table 2-4. Comparison of Oregon Universities and Major Science and Technology Universities

University	2006 Total Research Expenditures ($)	Cumulative Patent Applications 1996–2006	Cumulative Invention Disclosures 1996–2006	2006 Licensing Income ($)	Cumulative Startups 1996–2006
University of California System	3,035,949,000	5,208	10,576	193,499,879	215
Massachusetts Institute of Technology	1,212,800,000	2,485	4,792	43,500,000	220
University of Washington and Washington Research Foundation	936,360,325	426	1,380	36,199,485	30
Stanford University	699,211,807	2,324	2,971	61,310,739	112
Penn State University	656,634,000	1,568	1,933	1,348,400	45
Harvard University	623,958,100	845	1,580	20,849,993	37
University of Texas at Austin	446,686,000	500	960	8,431,700	49
California Institute of Technology	411,126,907	2,816	4,393	13,234,236	121
Northwestern University	348,439,588	763	1,206	29,990,550	32
ONAMI University Affiliates (pre-OHSU)	**325,374,776**	**310**	**729**	**6,198,203**	**24**
Oregon State University	189,606,000	187	413	1,879,542	9
University of Oregon	95,732,891	80	268	4,318,661	13
Portland State University	40,035,885	43	48	0	2
Case Western Reserve University	290,530,274	389	952	10,794,377	21
Oregon Health & Science University	257,302,253	280	738	719,786	20
Carnegie Mellon University	243,259,000	331	1,140	6,045,618	51
North Carolina State University	207,000,000	612	1,703	TBD	51

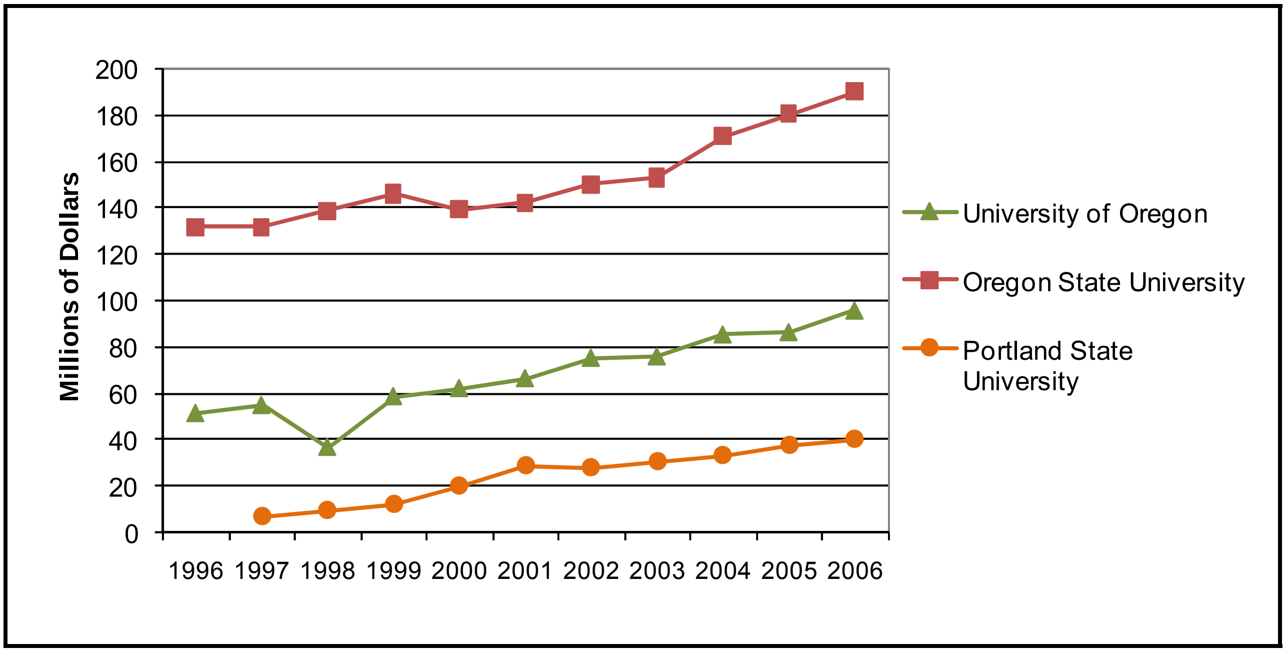
Source: Association for University Technology Managers.

companies. Thus, although ONAMI affiliate universities have been successful in their endeavors (see Figure 2-1), the scale of their research is dwarfed by larger institutions (see Figure 2-2).

Coordination offers Oregon the scale required to improve its competitive position relative to major research universities. The universities included in the comparison tables have research expenditures sufficient to absorb the high costs of laboratory equipment and materials, and this enables them, in part, to attract star scientists and top graduate students.

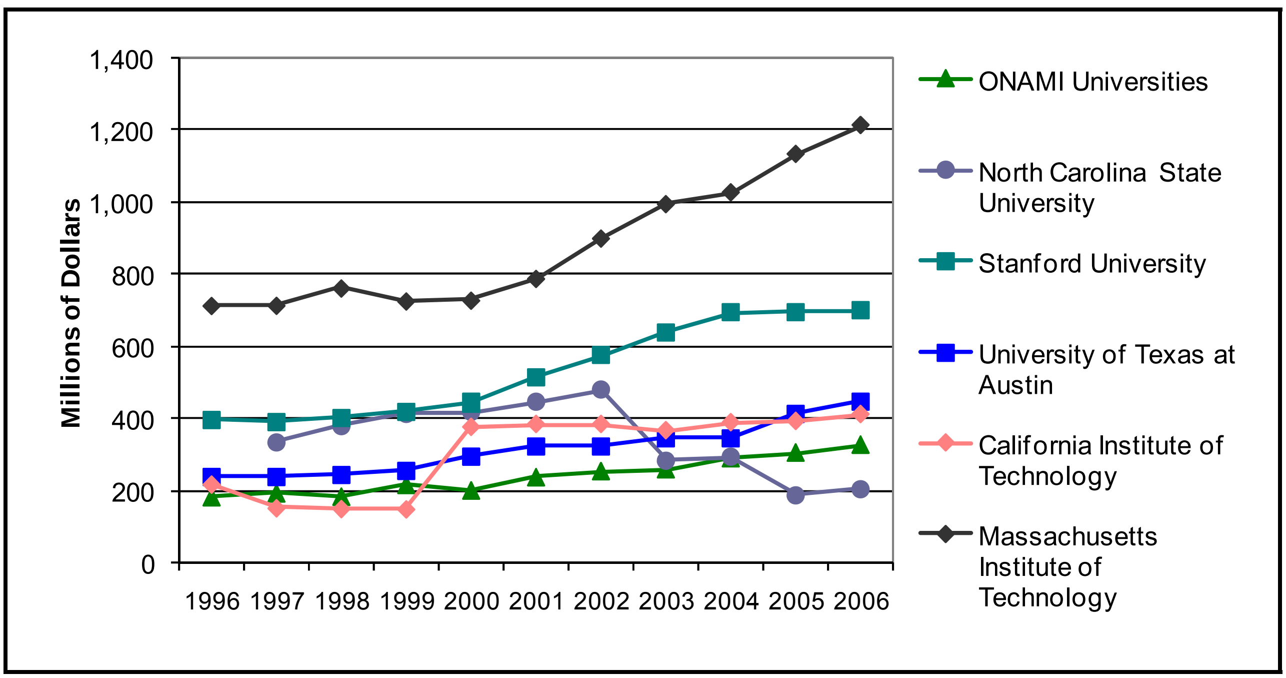
Given that large amounts of capital expenditures, research funding, and operational support are needed to sustain and grow micro and nanotechnology research, the ultimate rationale for the state and Oregon's universities is to cooperate on research ventures through

Figure 2-1. R&D Expenditures at ONAMI University Affiliates, 1996 to 2006



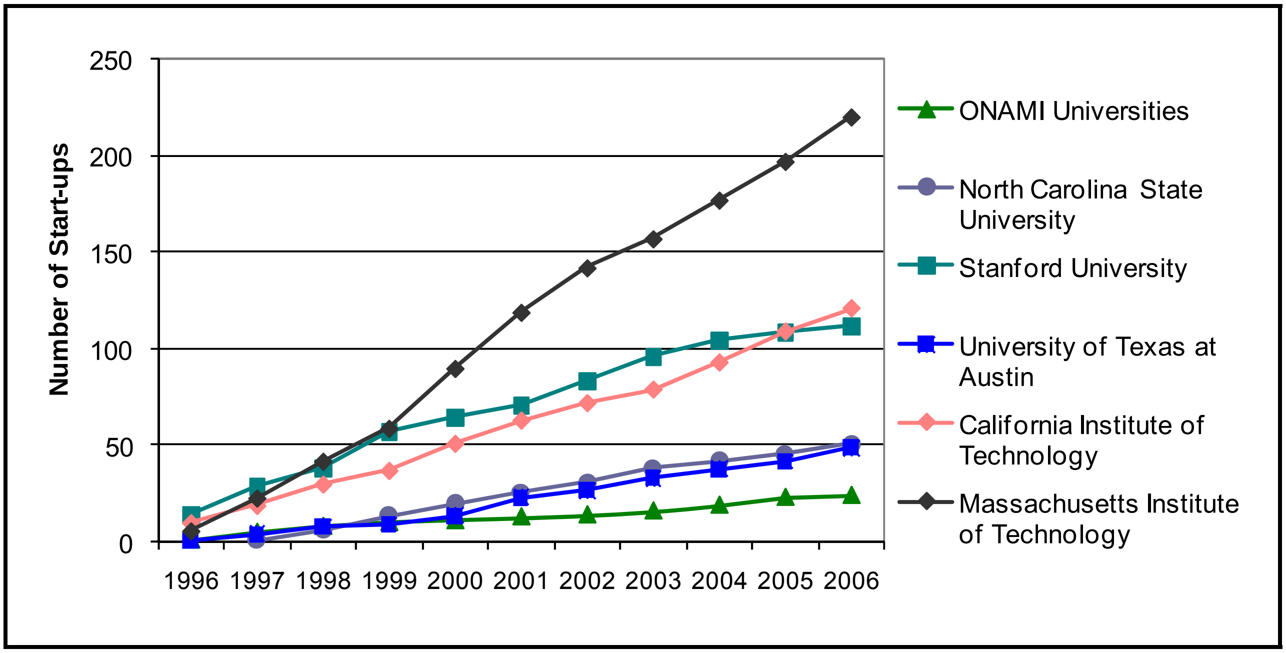
Source: Association for University Technology Managers.

Figure 2-2. Comparison of R&D Expenditures at Selected Science and Technology Research Universities, 1996 to 2006



Source: Association for University Technology Managers.

Figure 2-3. Comparison of University Spin-offs at Selected Science and Technology Research Universities, 1996 to 2006



Source: Association for University Technology Managers.

ONAMI. The framework seeks to pool resources and better compete for funding, invigorating economic, workforce, and social development.

3 ONAMI Program Mechanisms

Synopsis*: ONAMI pools science and engineering departments from Oregon's universities to efficiently allocate limited resources in the pursuit of research opportunities that complement and grow Oregon's science and engineering R&D activity in both the university and private sectors.*

The focus at ONAMI since 2004 has primarily been on building Oregon's micro/nano research infrastructure. Efforts focused on establishing sophisticated laboratories (referred to as shared facilities), acquiring sophisticated analytical instruments and signature researchers, and growing Oregon's human capital with federally funded research initiatives.

ONAMI itself does not employ researchers, own or operate facilities, or have investments in the Oregon businesses it supports; rather it awards funding on a competitive basis to Oregon's researchers, start-ups, and universities. Only about 10% of the state government's annual support for ONAMI is allocated for administrative expenses. In brief:

- *The proposal matching fund leveraged $2.5 million to secure $15.2 million, or for every $1 ONAMI invested the state received $6.08.*
- *Three shared facilities—CAMCOR, CEMN, and MBI—are of such high quality that users from outside of the Pacific Northwest travel to Oregon to use them, paying market rates that are used to defray the state's operating costs.*
- *ONAMI's researchers and the Oregon congressional delegation secured $65 million for R&D in strategic Oregon research areas.*

3.1 ONAMI MANAGEMENT AND OPERATIONS

While ONAMI spans and collects university faculties in one institute, ONAMI itself does not employ researchers, own or operate facilities, or have investments in the Oregon businesses it supports. Rather, ONAMI, Inc. is a non-profit that coordinates and supports researchers in their endeavors. OUS universities and Oregon businesses are tasked with implementing ONAMI's initiatives.

ONAMI, Inc., manages, directs, and strategizes program activities and distributes funds, employing only two people (about 1.6 full-time equivalents). In addition to ONAMI's executive director and vice president, senior administrators and executives from Oregon's universities and large businesses, including FEI, HP, Intel, and Invitrogen, volunteer their time to ONAMI's management.

A light administrative structure is intentional: rather than burden limited financial resources with overhead and other expenses, ONAMI's leadership awards state appropriations competitively among researchers through a proposal process. ONAMI, Inc.'s operating expenses are largely limited to staff salaries and marketing activities. ONAMI, Inc. also sponsors conferences and travels to market Oregon as place for micro and nanoscale research.

ONAMI members—almost entirely researchers at university campuses—submit proposals to ONAMI for matching funds to complement external research and infrastructure grants (i.e., instruments, signature researcher hires, laboratories). Funding is awarded competitively according to proposals' technical merit and strategic alignment with ONAMI research thrust areas, without regard to any minimum distribution levels among OSU, PSU, or UO. This arrangement permits researchers to go after strategic and highly competitive research grants while ensuring that state funds are prudently invested.

In addition to technical merit, proposals are also evaluated based on the extent to which they leverage strengths from multiple disciplines and/or universities, the potential for enriching university graduate and undergraduate students' educational opportunities, and commercialization potential. Commercialization gap grants are vetted by professional business development consultants and money managers in addition to ONAMI's leadership council.

Table 3-1. State and University ONAMI Program Investment through FY 2008

	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
General operations support		$500,000			
University contributions[a]	$2,502,890	2,783,593			
Subtotal of early start-up expenses	3,002,890	3,283,593			
Signature researcher recruiting			$748,000	$1,512,000	$1,250,000
Proposal matching funds			615,000	1,035,000	1,000,000
Shared facilities program			735,000	840,000	500,000
Intellectual property (IP) and proof of concept			230,000	470,000	1,250,000
Center start-up expenses			25,000	—	—
SRF grant			125,000	125,000	—
State contract fee revenue			395,000	395,000	500,000[b]
Subtotal of state disbursements			2,873,000	4,377,000	4,500,000
Total Operating Support	**3,002,890**	**3,283,593**	**2,873,000**	**4,377,000**	**4,500,000**
One-Time Capital Contribution		**20,000,000**			

[a] PSU, OSU, UO, and now OHSU incur ongoing expenses for participating in ONAMI; however, these expenses are considered business-as-usual operating expenses beyond the early start-up period. Savings from coordinated program administration are assumed to balance out the costs of participation at a minimum, if not outweigh them.

[b] The 2008/2009 Grant Agreement with the State of Oregon does not include fee revenue, but allocates funds for ONAMI programs (e.g., public relations, outreach, technical conferences) and administration.

Oregon's investment in ONAMI can be divided into two periods: early start-up expenses and ongoing program support (see Table 3-1). Early start-up expenses were appropriated for ONAMI in the 2003–2005 biennium. The state provided $1 million in operating support and agreed to make $20 million in capital funds available at the end of the biennium.

PSU, OSU, and UO agreed to shoulder the financial burden of launching ONAMI, providing nearly $5.3 million in support. University support included salaries, equipment, early proposal funds, and financial support for launching the program. HP, FEI, and other businesses offered in-kind contributions to defray start-up expenses and support the initiative, including space at Building 11 on the HP campus in Corvallis to house ONAMI's administrative offices and MBI. The universities also agreed that funds from ONAMI would not be subject to overhead and other indirect costs.

For the period FY 2004 through FY 2008, the state contributed $12.75 million in operating funds and $20 million in capital funds. Given the critical role the universities played in launching ONAMI, their $5.3 million start-up contribution was counted in the start-up cost component of total ONAMI program costs. Thus, the total public cost through FY 2008 amounts to $38.0 million. Furthermore, the state has appropriated an additional $4.5 million for ONAMI for FY 2009.

ONAMI has five principal mechanisms through which it acts:

- proposal matching funds,
- shared facilities support,
- signature researcher recruiting,
- commercialization gap grants, and
- federal funding for strategic thrusts.

3.2 PROPOSAL MATCHING FUND PROGRAM

Competitive research proposals often require or strongly encourage matching funds. The magnitude of cost share requirements may be as high as 50% of the total project cost. Most universities generate proposal matching funds through indirect cost recovery, in-kind contributions (such as providing laboratory time or equipment to a project at no cost), and private or endowment funds. Large universities have a competitive advantage on proposals because they are better able to distribute costs over large project bases or have endowments.

As ONAMI notes, these sources are comparable to working capital, and their limited availability at Oregon universities can become a significant barrier to research growth in competition with other institutions nationally. ONAMI has an opportunity to significantly influence the funding of its research priorities and automatically leverage its investment of state-appropriated dollars by committing matching funds.

Once an award has been made, funds are distributed to and managed by the proposal winner's university. Notably, universities are prohibited from applying overhead charges to ONAMI project accounts. Overhead charges are usually added to labor expenses to recoup costs such as buildings, administrative support, and utilities. These charges vary by institution and can be 50% or more of a researcher's hourly rate. If a researcher were to charge $50 per hour, the cost to the project would therefore amount to $75 per hour. Thus, ONAMI awards allow researchers to do more with less.

On a recent winning proposal for a hydrogen fuel center, noted OSU researcher Kevin Drost pointed to the availability of proposal matching funds from ONAMI as what enabled OSU and PNNL to submit its proposal. The project is valued at $2.4 million over 5 years, but the U.S. Department of Energy required a 20% proposal match. OSU was only in a position to provide 10%. If ONAMI proposal matching funds were not available, Drost would have had to walk away from the opportunity and not submit a proposal.

ONAMI will match

- up to 10% of a proposal value for competitive proposals if there is only one ONAMI-affiliated institution on the proposal,
- up to 15% of a proposal value if the proposal is being submitted by two or more ONAMI-affiliated institutions,
- up to 33% of a proposal value to acquire research equipment that will subsequently be available for use by all ONAMI institutions and Oregon businesses, and
- up to 33% of a donated piece of equipment's value to facilitate installation and set-up if the equipment will subsequently be available for use by all ONAMI institutions and Oregon businesses.

ONAMI's match is cash match, which is viewed favorably by funding organizations. In-kind donations, such as no-cost labor or laboratory time, is viewed less favorably because it is more difficult to audit the contribution to ensure that the matching requirement has been met.

If a proposal to the external (non-OUS) funding organization is unsuccessful, ONAMI's commitment to provide funds is released. ONAMI's leadership council weighs its commitments against the probability of success to manage the proposal matching budget.

For every $1 ONAMI has leveraged, $6.08 has flowed into the state. ONAMI has made $2.5 million in matching fund awards since the onset of FY 2006. These funds enabled Oregon universities to acquire $15.2 million in projects, workforce development grants, and research equipment (see Table 3-2). Equipment purchased using ONAMI matching funds are subsequently available for use by all Oregon researchers, including those in the private sector.

Table 3-2. ONAMI Proposal Matches through August 2008

Project	PI	Primary Purpose	Funding Organization	ONAMI Match	External Funds
Strada 237 Dual-Beam FIB for the Center for Electron Microscopy and Nanofabrication	J. Jiao	Equipment Purchase	NSF	$190,000	$500,000
Enriching Workforce Training through the Research Experience for Undergraduates (REU) Program	J. Jiao	Workforce Development	NSF, Intel	30,000	480,000
Installation of ENTEK Extruder	K. Li	Equipment Purchase	ENTEK	4,000	180,000
IGERT Grant Matching Funds: Accelerating the Transition from Student to Scientist	D.C. Johnson	Workforce Development	NSF	345,000	3,200,000
Shared Facilities Infrastructure: Web-based Scheduling, Remote Access, and Camera Installations for ONAMI Instruments	D.C. Johnson	Shared User Facilities	NSF	125,000	(see above)
Multiple Source Sputter Deposition System	D.C. Johnson	Equipment Purchase	NSF	71,225	213,680
Variable pressure SEM/Electron Backscatter Diffraction System (EBSD) for CAMCOR	D.C. Johnson	Equipment Purchase	Murdock, NSF	100,259	352,330
Acquisition of Pulsed Electron Deposition System	D. Keszler	Equipment Purchase	HP, DARPA	139,500	2,400,000
Purchase and Installation of Sputter System for Undergraduate Capstone Research Projects	M. Koretsky	Equipment Purchase	Intel	24,000	50,000
Matching Funds for NSF Career Proposal (Dhagat)	P. Dhagat	Research Funds	NSF	48,500	435,000
Acquisition of a MALDI-TOF Mass Spectrometer and Cyber-Enhancement of CAMCOR Facilities	D.W. Johnson	Hired staff	NSF	180,000	402,695
Implementation of the Oregon Technology Entrepreneurship Consortium (OTEC)	A. Meyer	Workforce Development	NSF	45,000	435,000
Set-up of Donated NMR Spectrometer Systems for University of Oregon CAMCOR NMR Facility	M. Strain	Installation of Equipment	Invitrogen and Bend Research	48,000	118,500
Development of Metal-Oxide Channel Layer TFTs for large-Area and Flexible Displays	J. Wager	Research Funds	USDC	25,000	225,000
Acquisition of TEM Instrumentation—Keck Proposal: Biological Interactions of Precision Engineered Nanoparticles	J. Hutchinson	Equipment Purchase	Keck Foundation	200,000	1,600,000

(continued)

Table 3-2. ONAMI Proposal Matches through August 2008 (continued)

Project	PI	Purpose	Funding Organization	ONAMI Match	External Funds
STEM and SAXS for CAMCOR—Acquisition of Nanoscience Research Equipment for Investigation of Interfacial Phenomena in Nanoscale Materials, Biological Tissue, and at the Bio/Nano Interface	J. Hutchinson	Equipment Purchase	Murdock Foundation	$200,000	$513,540
Strategies for Designing Mixed-Valent Transition Metal Oxides for Multiferroic Applications	M. Subramanian	Research Funds	NSF	48,000	478,363
Acquisition of an X-Ray Photoelectron Spectrometer	J. Hutchinson	Equipment Purchase	NSF	228,000	458,000
HP-OSU Collaboration on the Development of Lead-Free Piezoelectric Materials and Devices	M. Subramanian	Research Funds	OMI, HP	7,500	150,000
Installation and Start-up of Atomic Layer Deposition (ALD) Tool	R. Adams	Installation of Equipment	Confidential donor	59,500	210,200
Matching Fund Support of NSF Funded “Novel Dielectrics for Transparent Electronics”	J. Conley	Research Funds	NSF	32,826	328,256
NIH Awards: Critical Instrumentation Matching Funds	Mingdi Yan	Equipment Purchase	NIH	182,000	1,616,858
NSF Career Award	A. Yokochi	Research Funds	NSF	50,000	527,094
Installation of Agilent Semiconductor Parameter Analyzer	P. Dhagat	Equipment Purchase	Tektronix	11,000	110,000
Matching Funds for NSF MRI grant to purchase Laser Lithography Tool	P. Dhagat	Equipment Purchase	NSF	105,000	210,000
Total				**$2,499,310**	**$15,194,516**

3.3 SHARED FACILITY SUPPORT PROGRAM

ONAMI supports three shared facilities that are open to all users:

- CAMCOR, located at UO in Eugene;
- CEMN, located at PSU in Portland; and
- MBI, located at Building 11 on the HP campus in Corvallis.

The shared facility program is designed to increase collaboration among Oregon’s researchers and institutions while maximizing the impact of capital expenditures. Shared facilities reduce duplication of capital expenditures and encourage researchers to draw on and align with the research strengths of partner institutions: CAMCOR on UO’s Materials

Sciences Institute, CEMN on PSU's metrology and imaging strengths, and MBI on OSU and PNNL's microtechnology science and engineering.

The tools for advanced science and engineering are expensive to purchase, are expensive to maintain, and require expertise to operate. ONAMI has helped bring about three shared equipment facilities in Oregon filled with state-of-the-art instruments and nano/micro-technology tools.

Researchers are able to gain access to both sophisticated equipment and expertise in one location. Oftentimes, a single tool alone is insufficient for a job, but a suite of tools is needed for a researcher to obtain the answers needed or to engineer a desired structure or device. Colocating equipment in one facility expedites work and/or provides for measurements or fabrication abilities that otherwise would not have been available.

ONAMI's financial support took two forms. The first component was an initial start-up to upgrade existing facilities, acquire needed equipment, and/or perform a similar service (see Table 3-3). The second mode of support was initially through 1:1 matching grants for "external" billings and usage. Each university was rewarded for making its facilities and equipment available to other ONAMI universities and private businesses.

After success in implementing interuniversity use of shared facilities, ONAMI's leadership changed the external billing match to be only for private-sector usage to continue to encourage the universities to promote the facilities' availability to small businesses and high-tech firms.

Table 3-3. ONAMI Financial Support for Shared Facilities through FY 2008

Facility	Start-Up Grants	Usage Matches	Total
CAMCOR	$300,000	$215,000	$515,000
CEMN	305,000	205,000	510,000
MBI	385,000	190,000	575,000

3.3.1 Center for Advanced Materials Characterization in Oregon (CAMCOR)

Located in a new, ultra-quiet underground facility in Eugene, ONAMI's CAMCOR is one of the premier materials characterization laboratories in the U.S The CAMCOR facility in UO's Lokey Science Complex includes over 20 instruments offering a comprehensive suite of tools for chemistry, materials, and biology/medicine characterization. The facility's extraordinary utility attracted Voxtel and Sony Corporation. Sony's tenancy is the Japanese conglomerate's first R&D satellite office located outside of Japan.

The CAMCOR tool set is extensive and contains instruments for surface analysis, materials characterization, chemistry research, and nano-fabrication.[1] New materials development and green routes to nano-structured materials are common themes at CAMCOR, where researchers use the tools in surface analysis, electron microscopy, UV and light spectroscopy, and ion mass spectroscopy to study the composition and structure of the new materials they make. The materials studied have implications for energy use and generation, medicine, the environment, national security, electronics, and the basic sciences.

The facility's location and engineering make measurements of nanometer and subnanometer structures clearer and easier than could be performed elsewhere. Quiet buildings increase the ability to make more precise measurements. The bedrock the building sits on and advanced building engineering combine to make the quieter than the Advanced Measurement Laboratory at the National Institute for Standards and Technology (NIST) in Gaithersburg, MD, previously one of the quietest measurement facilities in the world.

Examples of pioneering research with great economic potential for Oregon include nanomaterials for light detection and conversion. Nanometer-sized crystals of semiconductors, called quantum dots, can be used to make light detectors or possibly photovoltaics (conversion of light into electrical energy). Voxtel uses CAMCOR to study their nanotechnology-based light sensor and photovoltaics. Interestingly, quantum dots are also being used in research of biology and medicine; CAMCOR's instruments are being applied to development of smart color tags for studying cell processes.

Another topic in the area of energy is thermoelectric devices that convert between heat and electrical energy. For example, waste heat from an engine could be used to drive thermoelectric devices, which in turn, generate electricity used to recharge a battery. Alternately, a thermoelectric device could be used to cool the chips in a computer,

[1] Instrumentation includes scanning electron microscope (SEM), TEM, nuclear magnetic resonance (NMR), UV and visible spectroscopy, x-ray spectroscopy, atomic force microscopy (AFM), thermogravimetric analyzer (TGA), electron microprobes, optical microscopes, sample preparation tools, and other tools of the trade.

allowing the processor to be smaller and run faster. ONAMI researches are able to make novel materials that could lead to new high-efficiency thermoelectric devices.

3.3.2 Center for Electron Microscopy and Nanofabrication (CEMN)

CEMN provides a suite of electron microscopy that enable the study of nano and micro structures, elemental composition, depth profiling/3-D imaging of micro structures, and more.[2] The facility is heavily used by semiconductor researchers in the Portland area because the lab houses sophisticated, high-power microscopes that are not publicly accessible elsewhere in the Pacific Northwest. Small, high-technology companies lack the capital to obtain and maintain sophisticated instruments but are happy to pay to use such tools made available by ONAMI's CEMN and thus generate new economic opportunities.

Nature has many examples of ways to produce detailed nano and microstructures that could be beneficial to humans as well as provide environmentally safe ways to obtain nanostructures. The instruments at CEMN permit imaging of viruses infecting a cell, thus possibly shedding light on infectious diseases and ways to fight them.

Nanotechnology also offers the potential to improve health and safety. One tool at CEMN (a dual-beam scanning electron and focused ion beam microscope) provided for detailed cross sectioning of the structure and preparation of transmission electron microscope samples. Preparation of samples via more traditional methods would not have so easily provided such high-quality samples.

3.3.3 Microproducts Breakthrough Institute (MBI)

Micro and nano-engineering promise to solve many problems in medicine, energy, security, and other advanced-technology areas. MBI's purpose is to help transition technologies developed at Oregon's universities into new companies with commercially viable technologies, products, and services. The lab has a comprehensive suite of tools for

[2] CEMN has a comprehensive set of electron beam-based microscopes such as SEM, TEM, scanning transmission electron microscope (STEM), dual-beam SEM with focused ion beam for sectioning samples, and many sample preparation tools. The center also features education programs on the use of the tool sets.

prototyping, fabricating, and measuring; a one-stop shop to design, build, and test a concept in micro devices.[3]

Several ONAMI researchers leverage MBI to produce microchannel devices to solve critical problems, including those in health care and energy production. An example in medicine is kidney dialysis. Well over 300,000 people in the United States require kidney dialysis, a process that removes toxins from the blood but is time consuming, occurs frequently, and is hard on the patient. ONAMI researchers have developed a quarter-sized dialyzer that is more efficient, less stressful on patients, and can be operated frequently.

An example in the area of energy is fuel production. The changing energy market suggests that distributed energy generation will be more effective and reliable. ONAMI researchers have developed a micro-reactor for producing biodiesel, enabling efficient, fast, and portable point-of-use production of fuel.

3.4 SIGNATURE RESEARCHER RECRUITMENT PROGRAM

The goal of ONAMI's signature researcher recruiting grants is to enable Oregon universities to compete more effectively for top talent. Signature researcher recruitment grants allow Oregon universities to acquire talent that they would not be able to acquire. New hires in micro/nano R&D require substantial investments in laboratories, support staff, and materials in addition to salaries and benefits. What is true of most researchers is doubly so for preeminent and up and coming researchers. Salaries are often complemented with $1 million investments to establish the necessary infrastructure for the researcher to be productive.

ONAMI has enabled the attraction of five signature researchers to Oregon, as of August 2008:

- Mas Subramanian, OSU
- Landis Kannberg, OSU and PNNL
- John Conley, OSU

[3] MBI has over 20 tools, instruments, and work stations for designing, fabricating, measuring, and testing nano and micro-based technologies and devices: micro-milling and machining of metals and polymers with feature sizes down to 5 microns, including state-of-the-art laser cutters and electro discharge machining; photolithography, soft lithography, embossing, and imprinting of polymers with feature sizes down to 10 microns; bonding and pressing of polymers; furnaces and vacuum ovens for sintering, annealing, and heat treatment of materials including ceramics; atomic and thin layer deposition of ceramics and chemicals; optical and mechanical measurement and imaging; and other tools of the trade.

- Andrea Goforth, PSU
- Drake Mitchell, PSU

In addition, four active searches are underway for signature hires in green chemistry at UO, green nanoscience at UO, thermal science at OSU, and microreaction chemistry at UO.

Signature researchers are expected to attract significant research funding to Oregon and complement universities' strengths while building new ones. As of this writing, ONAMI has made $3.3 million in recruitment grants for the five filled positions and three open ones.

Subramanian and Conley alone have submitted more than $5 million in proposals to competitive funding sources through the close of FY 2008. Several proposals are outstanding, however their current awards amount to nearly $800,000.

3.5 COMMERCIALIZATION GAP GRANT PROGRAM

The commercialization gap funding program's stated purpose is to commercialize nanoscience and microtechnology intellectual property, leading to the creation of high-wage jobs in Oregon. Gap grants are "proof of concept" grants made to university researchers to take research results to the next level (e.g., a more product-like prototype and/or demonstration of cost-effective fabrication methods).

ONAMI invests in a small number of projects that have the greatest chance of meeting the following goal:

> *"Successful ONAMI gap-funded projects will enable, within 12–18 months, significant (at least 3x the ONAMI grant amount) private funding for commercialization of the demonstrated technology in Oregon by an Oregon small business with significant potential to create high-wage jobs."*

Funding decisions are made by the ONAMI Operations Council, relying heavily on recommendations from the ONAMI Commercialization Advisory Council of active private equity investors and technology management consultants.

Gap grants also deepen connections between university researchers and private-sector entrepreneurs. Awards for successful gap-fund proposals are made to university-led teams or shared user facilities and in collaboration with a private-sector small business/entrepreneurial team. Commercialization gap financing supports collaborations between university-based research teams and small technology start-up companies. The start-ups are usually preexisting companies that have licensed or optioned university technology.

Commercialization gap funds were first available for distribution in FY 2006, and of the $2.6 million available for distribution, ONAMI has committed $2.3 million. Twelve projects have been funded at 10 start-up companies. In addition, the state appropriation for gap funds is used to compensate a professional technology manager under contract to ONAMI to vet proposals, market university researcher's start-up concepts, and provide gap-fund recipients with ongoing business plan and technology strategy support.

Section 4 includes a more in-depth discussion of ONAMI's commercialization gap fund recipients in detail. An analysis of potential employment gains from gap-funded companies accompanies the analysis results in Section 6.

3.6 FEDERAL FUNDING AGENDA

The unprecedented coordination of a unified, interuniversity research strategy enabled the Oregon congressional delegation to secure federal funding for key strategic research thrusts (see Table 3-4). These research thrusts align with Oregon's economic development strategy for maintaining and expanding the state's competitive advantage in nanoscience and microtechnologies.

3.6.1 Tactical Energy Systems (Microtechnology-Based Energy and Chemical Systems)

ONAMI researchers are fabricating microsystems that accelerate, miniaturize and distribute energy, chemical and biomedical processes. This work is based on the principle that mass and heat transfer are best accomplished in microchannels. These potentially revolutionary results can be applied to military energy, medical devices and other specialty chemical products. Dr. Kevin Drost, Associate Professor of Mechanical Engineering at Oregon State University, and Dr. Landis Kannberg of the Pacific Northwest National Laboratory jointly direct this team.

Table 3-4. Federal Appropriations for Strategic Thrusts through FY 2008

	FY 2005 ($thousand)	FY 2006 ($thousand)	FY 2007 ($thousand)	FY 2008 ($thousand)	FY 2009 ($thousand)
Tactical Energy Systems (Microtechnology-Based Energy and Chemical Systems)	$2,500	$2,500	$1,000	$2,500	(a)
Safer Nanomaterials and Nanomanufacturing	2,500	1,700	2,300	3,200	(a)
Nanoscale Metrology and Nanoelectronics	—	2,500	2,500	2,000	(a)
Nanoarchitectures for Advanced Performance (Nanolaminates and Transparent Electronics)	—	800	1,750	2,500	$2,500
ONAMI Department of Energy Grant	—	1,870	—	—	—
Total	**5,000**	**9,370**	**7,550**	**10,200**	**2,500**

(a) Following completion of this analysis, federal funding for these initiatives was announced at $2.4 million, $4 million, and $4 million, respectively.

3.6.2 Safer Nanomaterials and Nanomanufacturing Initiative

The goals of the Safer Nanomaterials and Nanomanufacturing Initiative (SNNI) are to develop new nanomaterials and nanomanufacturing approaches that offer a high level of performance, yet pose minimal harm to human health or the environment. Research under the Initiative will merge the principles of green chemistry and nanoscience to produce safer nanomaterials and more efficient nanomanufacturing processes in the context of producing nanoparticles and nanostructured materials for applications in fields such as in photovoltaics, nanoelectronics and sensing. Dr. Jim Hutchison, Professor of Chemistry at the University of Oregon, leads this initiative that is bringing together key scientists in the life sciences, materials sciences and engineering, including eight National Young Investigator award winners.

3.6.3 Nanoscale Metrology and Nanoelectronics

ONAMI's strong industrial and academic experience in microscopy, analytical tools, and test and measurement comes together to meet the challenges of accurate measurement at the nanoscale. The challenges of nanoscale metrology are particularly important for future generations of semiconductor electronics. Research projects include breakthrough advances in field-enhanced microscopy, electron optics and high-resolution quantitative materials characterization. Dr. John Carruthers, Distinguished Professor of Physics at Portland State University and former director of components R&D at Intel, directs this research collaboration.

3.6.4 Nanolaminates and Transparent Electronics

In the field of nanolaminates and transparent electronics, ONAMI researchers are pursuing cutting-edge materials chemistry applications in optics, electronics, sensors, thermoelectrics, magnetics and metrology standards. Transparent electronics for flat panel displays, for example, will enable brighter, lower power and less expensive displays—an important industry sector in Oregon. By applying atomic-precision synthesis using both low-temperature solution chemistry and gas-phase assembly techniques, scientists have created functionally graded materials from modulated elemental reactants, and composite electronic materials. Professors Dave Johnson of UO and Doug Keszler at OSU lead this research initiative. This work has direct implications for

- transparent and printed electronics,
- semiconductor processing,
- high-performance thermoelectric cooling,
- high-performance and reliability deep UV lasers, and
- advanced photovoltaics.

4 Private-Sector Activity and Growth

Synopsis: *ONAMI seeks to deepen ties between Oregon's universities and industry by making shared facilities open to all users, supporting commercialization efforts, and encouraging university-based R&D of relevance to Oregon businesses.*

ONAMI's efforts to commercialize university intellectual property are best evidenced by the commercialization gap program. Given that the most challenging period for a technology-based start-up company is the period between developing a technology and having the first proof-of-concept, ONAMI provides gap grants to small businesses that demonstrate viable technologies and have business plans that will secure further funding in 12 to 18 months. Ten companies have been supported since 2006, and several applications were pending as of this writing.

Leveraging the shared facilities allows Oregon businesses to conduct research that otherwise would not have been performed in Oregon. In essence, survey data and interviews suggest that open access to shared facilities keeps economic activity in Oregon that otherwise would have gone out of state or would not have occurred: 68% of Oregon businesses using shared facilities said they would have sent the R&D activity out of state had it not been for the shared facility.

ONAMI support stimulated $11.8 million in cash inflows to Oregon businesses and to the universities from out-of-state donors. An additional $29.7 million was contributed to ONAMI by Oregon businesses that felt that its workforce development, economic diversification, and commercialization strategies were paramount to Oregon's economic vitality.

4.1 TECHNOLOGY COMMERCIALIZATION AND START-UP COMPANY SUPPORT

Commercialization gap financing is perhaps the most critical component for ONAMI, given the program's mission to drive high-technology sector development through research growth and activity. ONAMI's stated focus is "on developing commercial capabilities for sustainable, clean, green, and efficient manufacturing technologies."

The most significant challenge for inventors and entrepreneurs is moving their idea from the proof-of-technology stage in which their technology was developed to a functioning, marketable proof-of-concept in which the technology is embodied. Without a prototype, professional investors such as venture capitalists are less likely to invest in a small business. Functioning prototypes evidence that the technology is sufficiently mature to warrant the financial risk. Yet prototype development is a costly endeavor, and many ideas never make it to the prototype stage for want of financing.

ONAMI's commercialization gap fund helps transition technologies to prototypes by supporting entrepreneurs and their university partners during this perilous development stage. As discussed in Section 3, gap funding decisions are made by the ONAMI Operations Council, relying heavily on recommendations from the ONAMI Commercialization Advisory Council of active private equity investors and technology management consultants.

ONAMI, Inc. takes an active role in the companies' development: introducing companies to business leaders, assisting with business planning, monitoring progress toward milestones, and helping entrepreneurs brainstorm their companies' direction.

Nine gap funded companies are in operation; one funded company is no longer operating (see Table 4-1). Most gap fund projects are in process—this ONAMI program is the youngest, having only started in 2006. At present, economic gains are less tangible than with the other ONAMI programs.[1]

When RTI interviewed gap fund recipients they indicated that ONAMI

- assisted them in their ventures,

[1] The commercialization gap component of the economic impact analysis differs from other components because only costs are included in the cash flow analysis. Thus, RTI forecasted future job creation gains under multiple scenarios to complement the inclusion of gap financing in the cash flow analysis. These results are in Section 6.

Table 4-1. Commercialization Gap Fund Recipients and Projects through FY 2008

Gap-Funded Company	Project Goal	University Partner	Gap Fund Amount
Home Dialysis Plus	Commercialize a microchannel dialyzer for hemodialysis. The dialyzer permits continuous flow treatment that more closely simulates natural kidney function. The system damages blood less and reduces the volume of blood outside the body at a given moment	OSU	$250,000
Crystal Clear Technologies	Remove heavy metals from water to the worldwide market for water purification to dramatically improve the cost and quality of water around the globe	UO	219,440
Nanobits	Nanobits and Oregon State University are working to advance microreactor systems for high-value fine chemicals and nanomaterials. The team has developed a stainless steel microreactor and heat exchanger platform that seeks to enhance synthetic efficiency in many specialty chemical and nanoparticle synthesis processes	OSU	162,221
Mtek	Mtek Energy Solutions and Oregon State University have designed and demonstrated a feasibility prototype biodiesel microchannel-based reactor. The three-stage, three-step prototype produces biodiesel and glycerol on a continuous basis, using virgin vegetable oil, methanol, and a liquid catalyst.	OSU	191,809
Inpria	Demonstrate application of a new technology that provides highly efficient deposition and patterning of functional materials for device applications at all length scales. The most promising application of the platform is to enable printed electronics via inorganic materials, which are expected to have much higher performance at far lower cost than organic approaches.	OSU	249,725
Dune Sciences	Assemble nanoscale building blocks into functional materials and coatings, including for antimicrobial coatings	UO	237,131
CNXLs	Determine the advantages of and develop proof of concept for incorporating novel nanoparticles into battery separators for use in lithium ion batteries	OSU	50,074
Trillium Fiber Fuels	Develop a microfiber isomerization reactor and system to create ethanol from agricultural residues, such as wheat or grass straw, avoiding use of the edible portion of these plants which have other commercial uses.	UO	248,000
Peregine Power	Develop methods to fabricate advanced, high temperature packaging for power semiconductors using components made of ceramic materials, shaped by powder injection molding. This novel means for package fabrication strives to apply this cost-effective, precision manufacturing process for electronics packaging in extreme environments, such as found in aerospace, military, automotive, and nuclear power devices.	OSU	201,000
ABP Biodiesel	Develop microreactor system for creating biodiesel from beef processing byproducts.	OSU	174,994

- lent a “halo effect” to their research projects and business plans,
- made their technologies more commercially viable, and
- improved their probability of success.

In May and June of 2008, RTI interviewed representatives from all 10 companies to explore how their ONAMI gap funding affected their business plans and research agenda. Companies completed a brief survey following their interviews, and this section reviews the aggregated results from those surveys.

Among the goals of the survey RTI administered was to obtain a deeper sense of the role that gap funding played in a company’s development. (Two recipients did not complete the survey: one that is no longer operating and another that felt it was too early in its formative stages to complete the survey meaningfully.)

Six of the eight responding gap-funded companies were started by experienced entrepreneurs who had also founded other companies. The same percentage initially founded the gap-funded company to commercialize a technology that was rooted in research supported by ONAMI (see Table 4-2).

Table 4-2. Gap-Funded Company Characteristics and Impact of ONAMI

	Yes (%)	No (%)
Company Characteristics		
Was this the first business that the company’s principal founded?	25	75
Is the gap-funded company rooted in research either directly or indirectly supported by ONAMI?	75	25
Role of Gap Grant in Company Development		
Would the gap-funded company have been created in the absence of the commercialization gap grant?	75	25
Would the gap-funded company have been able to sustain itself in the absence of the commercialization gap grant?	25	75
Did the gap grant accelerate the company’s development?	100	—
Did the gap grant strengthen the company’s IP position or technical foundations?	100	—

Note: Two of a total of 10 possible respondents did not complete the survey: one was no longer an ongoing concern and the other felt it was too early in its formative stages to complete the survey meaningfully.

With regard to whether the company would have started without gap funding, companies fell into two broad categories. Six of 8 respondents reported that their company would have been founded without the commercialization gap grant. Yet they also said that their company would not have been able to sustain itself in the absence of the commercialization gap grant and that the gap grant helped accelerate company development and improved the company's IP position or technical foundations. As one entrepreneur put it, "[the ONAMI grant] accelerated our technology, and we are more complete and on better footing as a consequence."

The second group consisted of 2 companies that would not have been founded at all. A representative opinion was "Our idea would likely have died, as many do. The challenge with being a researcher is that one must put food on the table, and if there is no money for a good idea, after a while it usually dies."

By program design, gap-funded companies take technologies out of the universities and endeavor to create profitable, sustainable ventures and high-tech jobs. Table 4-3 provides a more detailed look at the IP profile and funding sources of the eight responding gap-funded companies. Together, these companies license 10 patents from universities, jointly hold 3 patents, and fully own 9 patents.

Companies derive much, if not most, of their financing from non-ONAMI sources. Half are self-funded, meaning that entrepreneurs are using their own personal funds to sustain the company. In addition, 3 of 8 are funded by federal grants or other sources, and 2 of 8 are funded by angel investment or contract revenue. Crystal Clear Technologies, Dune Sciences, and Trillium Fiberfuels have received federal small business innovation research (SBIR) grants based on the technical merit of their research agendas. SBIR grants are included in the time series of benefits in Section 4.3.

Gap-funded companies have a broad level of involvement from both the academic and the private communities, from private entrepreneurs to undergraduate students (see Table 4-4). In all, the 8 companies benefited from the direct involvement of 62 people, slightly more than half of whom are not otherwise affiliated with a university.

Table 4-3. Characteristics of IP Portfolio and Funding Sources of Gap-Funded Companies

Source of Company IP	**Number of Patents**
Licensed from university	10
Jointly owned by university and company	3
Owned by company	9
Source of Company Funding	**Number of Companies**
Angel investment	2
Federal grants	3
Self funded	4
Contract revenue	2
Professional venture capital	0
Other	3

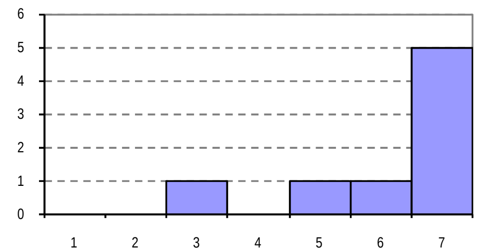
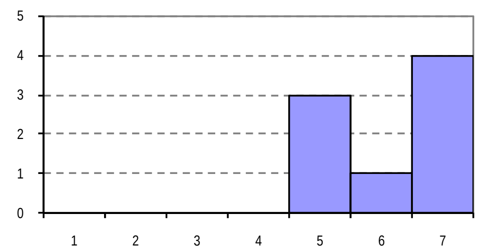
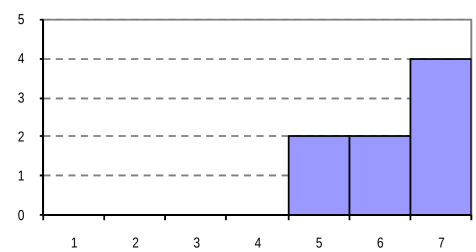
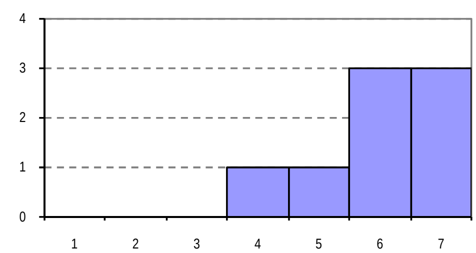
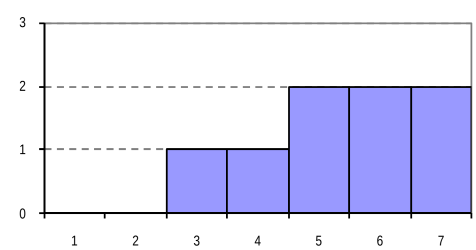
Table 4-4. Number of Persons Engaged in Gap-Funded Companies

Labor Category	Number of Persons
Full-time, nonuniversity staff	18
Part-time, nonuniversity staff	16
University faculty/staff	12
University post-docs	3
University graduate students	8
University undergraduate students	5
Total	**62**

Note: Two of a total of 10 possible respondents did not complete the survey: one was no longer an ongoing concern and the other felt it was too early in its formative stages to complete the survey meaningfully.

ONAMI's impacts on these small businesses expand beyond financing; benefits included introductions to Oregon's financiers and business leaders (see Table 4-5). Companies also stated that ONAMI helped coordinate and support a joint technical and business community where they had previously lacked integration. Companies felt that ONAMI was also bringing national recognition to Oregon's broader high-technology sector beyond that associated with large high-tech companies.

Table 4-5. Gap-Funded Companies' Perception of ONAMI's Impacts and Influence

	Average Agreement Score	Median Agreement Score	Range of Responses (1 = strongly disagree, 7 = strongly agree)
ONAMI-sponsored events connected me with researchers at Oregon universities.	6.1	7.0	
ONAMI has catalyzed greater professional interaction between Oregon universities and businesses active in micro- and nanoscale research.	6.1	6.5	
ONAMI has brought national recognition to Oregon's micro- and nanotechnology sectors.	6.3	6.5	
The gap-funded company is more likely to remain a viable, on-going concern because of the credibility lent to it by the receipt of an ONAMI gap grant.	6.0	6.0	
ONAMI-sponsored events connected me with researchers, executives, and entrepreneurs at other Oregon-based technology businesses.	5.4	5.5	

4.2 OPEN ACCESS TO ONAMI'S SHARED RESEARCH FACILITIES

ONAMI encourages open access to the facilities that are supported by state funds. The same barriers that university-based researchers face in regard to the expense of capital equipment and laboratories are also faced by Oregon's businesses. ONAMI's facilities use matching program includes a component that matches private-sector billings, up to a predetermined amount.

Leveraging the shared facilities while paying market rates enables Oregon businesses to conduct research that otherwise would not have been performed in Oregon. In essence, survey data and interviews suggest that open access to shared facilities keeps economic activity in Oregon that otherwise would have gone out of state or would not have occurred (see Table 4-6).

Table 4-6. Private-Sector Users' Alternative to Shared Facilities Usage

	Percentage of Respondents
Contracted with a non-Oregon laboratory, university, or service provider	68%
Performed research at a non-Oregon facility owned by our company or university	44%
Would not have conducted the research	16%
Purchased needed instruments and infrastructure	—
Waited until instruments at Oregon-based facility were available for use	4%
Contracted with private vendor in Oregon	—

As discussed in Section 3, ONAMI's matching programs also specify that equipment grants matched by ONAMI funds be available to all users. The combined efforts of ONAMI's investment in advanced laboratories, researchers' equipment proposal wins, and donations from several major instrument manufacturers—many of whom are headquartered in Oregon—has translated into an equipment quality that is likely not replicated elsewhere in an open-access format.

Indeed, private-sector shared facilities users cited the quality of the equipment and their availability as being a key factor in their decision to use the facility. One respondent with an Oregon company outside of the high-tech sector noted that “the shared facilities are a great program that should be continued. My research would suffer without it.”

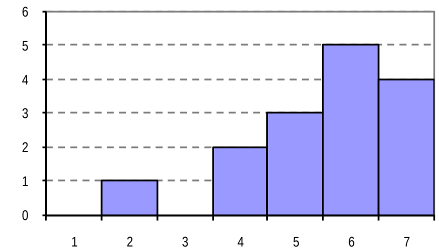
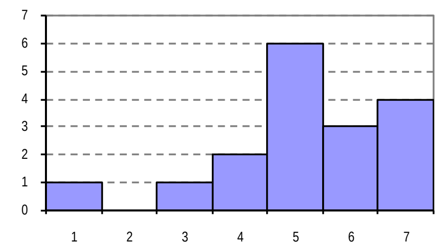
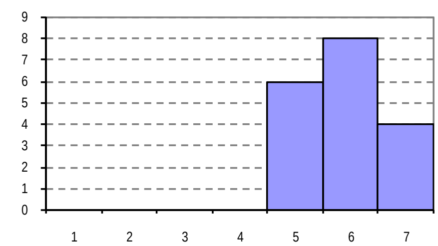
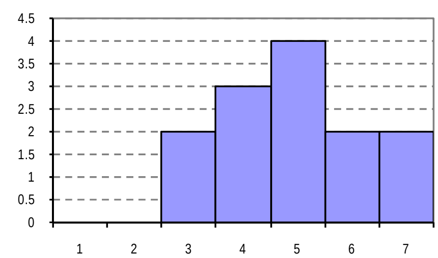
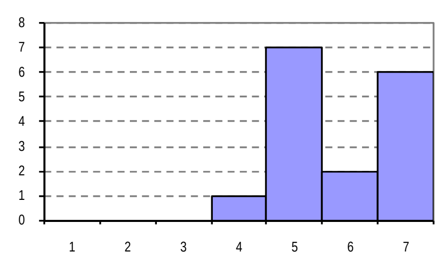
In addition, users cited the quality of the training delivered by lab staff and their availability and willingness to assist with technical issues and offer research insights (see Table 4-7). Another respondent noted: “The CAMCOR facilities are first rate. Access to equipment and staff is timely.” Similar sentiments were expressed about CEMN, particularly given its location in the Portland metropolitan area. CAMCOR, however, is unique among the shared facilities in that it attracts researchers from around the United States and abroad.

Table 4-7. Private-Sector Users’ Decision Factors for Using Shared Facilities

	Percentage of Respondents
Availability of laboratory instruments	100%
Quality and power of laboratory instruments	88%
Ease of access	80%
Proximity to primary place of work/research	72%
On-site technical staff and management	64%
Acceptable cost	60%
Training provided by on-site staff	36%
Self-directed research (i.e., “do it yourself”)	32%
Collaboration with university researcher(s)	28%
Privacy and information security	16%
Availability of real-time Webstreaming	0%
Don’t know or unsure	0%

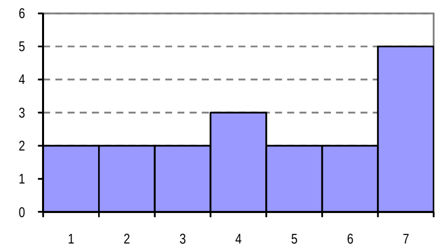
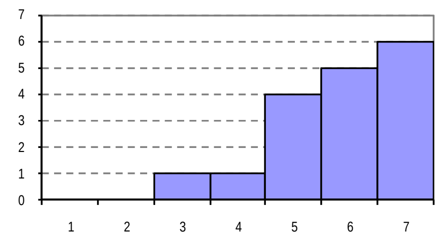
The shared facilities have an impact on Oregon’s competitiveness: on average, shared facility users view the state-supported labs as extensions of their corporate R&D infrastructure (see Table 4-8). The facilities create a competitive advantage, making users’ products and services more competitive while enhancing Oregon’s reputation as an attractive place for micro- and nanoscale research.

Table 4-8. Private-Sector Users' Perceptions of Facilities' and ONAMI's Impacts and Influence

	Average	Median	Range of Responses (1 = strongly disagree, 7 = strongly agree)
Our organization views the ONAMI shared facilities (CAMCOR, CEMN, and MBI/NMF) as extensions of our corporate research and development infrastructure.	5.5	6.0	
Our products, services, and research are of a higher quality and/or are more technologically sophisticated because of the research performed at the ONAMI shared facility.	5.2	5.0	
The availability of and ease of access to the ONAMI shared facilities and their instruments and technical staff offers my organization a competitive advantage.	5.9	6.0	
ONAMI has brought national and international attention and recognition to Oregon's micro- and nanotechnology sectors and advanced-technology industries.	4.9	5.0	
The ONAMI shared facilities make Oregon a more attractive place for micro- and nanoscale research and development.	5.8	5.5	

(continued)

Table 4-8. Perceptions of Facilities' and ONAMI's Impacts and Influence (continued)

	Average	Median	Range of Responses (1 = strongly disagree, 7 = strongly agree)
The specific research performed at the shared facility (i.e., CAMCOR, CEMN, and MBI) could not have been performed as effectively elsewhere.	4.5	4.5	
The specific research performed at the shared facility could not have been performed as timely elsewhere.	5.8	6.0	

4.3 TIME SERIES OF ONAMI-ENABLED INDUSTRY CASH INFLOWS

ONAMI's impacts outside of OUS have been less pronounced; however, this is expected given that ONAMI has been formally active for only 5 fiscal years. Yet, despite the brevity of its existence, ONAMI has supported small, nonuniversity start-ups in their funding endeavors. These start-ups have come to rely on shared facilities and connections forged through ONAMI's leadership and events such as the Micro Nano Breakthrough Conference ONAMI co-sponsors with the Washington Technology Center.

In addition, ONAMI's potential was sufficient to catalyze interest from funding organizations, federal agencies, and private-sector investors such that external investment flowed into Oregon outside of the traditional proposal channels.

Table 4-9 includes a time series of cash inflows from non-Oregon sources to Oregon businesses that were induced by or enabled by firms' affiliation with ONAMI. The data include private-sector donations to ONAMI from outside of Oregon. The last component of these data is sales revenue that accrued because of a connection ONAMI forged between an Oregon business and a non-Oregon entity. (ONAMI support from Oregon's business community is treated differently in the analysis, and is presented in Section 4.4.) Data are presented in the aggregate to avoid disclosing any one organization's response, with the exception of shared facilities whose total non-Oregon sources of revenue can be made available.

Table 4-9. Time Series of Industry Cash Inflows and Shared Facilities' Non-OUS Revenue

Fiscal Year	Cash Inflows to Oregon to/from Companies ($thousands)	Shared Facilities—Non-OUS Revenue ($thousands)
2004	$524	—
2005	8,521	$207
2006	1,340	369
2007	938	252
2008	75	96[a]
2009[b]	100	—
2010[b]	100	—
2011[b]	100	—
2012[b]	100	—
2013 and later[b]	524	—
Total	**11,798**	**923**

[a] Full-year data for all shared facilities was not available for 2008 as of this writing.

[b] Values for 2009 and later reflect cash flows that were secured as of August 2008. Data in this table represent actual past or future cash flows and are not projections.

In general sources of cash included

- sales revenue, investments and other sources of private funds;
- private donations from non-Oregon sources to support ONAMI and its initiatives, including Lorry Lokey's multimillion dollar donation to support the construction of CAMCOR's underground research facility in Eugene;
- SBIR grants and small business technology transfer research (STTR) grants; and
- other federal project and grants funds, including from the Department of Energy and NSF.

These estimates are conservative because future cash flows may occur from past activities and because it is also likely that we did not capture all economic benefits.

4.4 OREGON BUSINESSES' INVESTMENT IN ONAMI

We interviewed many of Oregon's high technology companies to inquire about their willingness to invest in ONAMI. Several common themes emerged:

- Emphasis should focus on reviewing and supporting the innovation infrastructure—facilities, instruments, people—and not yet on employment gains, which are likely to accrue following some incubation period denominated in years.
- Research alliances across the state, both between universities and between universities and business, allow all of Oregon to better compete and provides greater "presence" on applications for federal funding opportunities.
- ONAMI is trying to close the divide between the business and university communities by rewarding collaboration and brokering relationships.
- ONAMI provides greater opportunities for Oregon's labor talent pool, which will likely mitigate any brain drain should the semiconductor business "dry up."
- ONAMI incubates small businesses by providing commercialization support for university professors who have good ideas.
- Universities are likely to develop better talent, both at the undergraduate and graduate levels, which, in turn, enhances employers' competitiveness.
- ONAMI is raising the caliber of researchers, Oregon science, and infrastructure—all of which will enable success to happen now and in the future.

In dollar terms, the state's investment in ONAMI has been nearly matched dollar for dollar by Oregon's businesses. HP, FEI, Invitrogen, Bend Research, and ENTEK, among others, have donated state-of-the-art analytical instruments and processing equipment to ONAMI's shared facilities and programs valued at nearly $3.7 million between 2004 and 2008.

The single largest gift was HP's 25-year lease on Building 11 in Corvallis to house ONAMI, Inc. and MBI as well as to provide office, lab, and processing space for gap-funded companies and researchers from OSU and PNNL. HP had previously donated a leased of a portion of Building

11 to ONAMI and MBI for their use between 2004 and 2008. In 2008, HP donated a 20-year lease on Building 11 to ONAMI, MBI, and OSU. The total value of the donation is approximately $25 million over 25 years.

The balance of the $30 million Oregon's businesses have contributed encompasses in-kind services from small businesses and consultants, the majority of which occurred during ONAMI's early start-up years (see Table 4-10). This figure is conservative because ONAMI's board of directors and leadership council donate their time and expertise to oversee, strategize, and direct the initiative.

Table 4-10. Time Series of Oregon Businesses' Investment in ONAMI

Fiscal Year	Contributions to ONAMI from Oregon Businesses ($thousands)	Description
2004	$602	Equipment, services, office space
2005	1,393	Equipment, services, office space
2006	1,839	Equipment, office space
2007	567	Equipment, office space
2008	3,314	Equipment, office space
2009[a]	1,100	Office space
2010v	1,100	Office space
2011[a]	1,100	Office space
2012[a]	1,100	Office space
2013 and beyond[a]	17,600	Office space
Total	**29,715**	

[a] The values for 2009 and later extend to 2028 and reflect HP's donation of an extended lease of Building 11 to OSU, MBI, and ONAMI through 2028.

On a methodological note: this analysis is of contributions stimulated by or secured by ONAMI. Because contributions from Oregon's businesses represent a significant piece of ONAMI's economic impact, this analysis will later present two sets of economic performance measures. One set treats Oregon business' contributions as transfers, meaning an exchange of value between two Oregon stakeholders, business and ONAMI. The second set of performance measures accounts for business' investment as a cash inflow to ONAMI. This second set of performance measures will be understandably higher because, from the state's perspective, business' $30 million contribution generated additional value, similar to the federal funding agenda.

5 Influence of ONAMI on University Research Activity

***Synopsis**: ONAMI catalyzed a tremendous growth in micro/nano research activity in Oregon. Between 2004 and 2008, the dollar value of proposals grew at an annual rate of 57% and awards grew by 65%. A rate of growth in awards greater than the rate of growth in proposals indicates that not only were ONAMI university affiliates growing their proposal volume but they were also more successful at winning them.*

ONAMI's programs created a research infrastructure of higher quality than if the same funds had been distributed to the universities individually. Members that completed our surveys credited ONAMI's efforts to increase collaboration, generate national attention and stature, and secure research funding and analytical instruments for strategic research thrusts. The net effect of these efforts was to provide researchers with the tools required to succeed in an ever more competitive environment.

Researchers also noted that because of ONAMI

- *proposals are more competitive,*
- *the novelty and quality of research conducted at ONAMI university affiliates are greater, and*
- *Oregon's undergraduate and graduate students are better trained and likely enjoy better educational and employment opportunities.*

ONAMI increased competitive research funding by a total of $65 million. Notable among survey data from ONAMI researchers was that 18% of respondents cited winning proposals that they would not have or could not have submitted without ONAMI's resources.

5.1 GROWTH IN MICRO/NANO RESEARCH ACTIVITY AT ONAMI UNIVERSITY AFFILIATES

ONAMI has been successful at growing nanoscience and microtechnology research activity at ONAMI's university affiliates and PNNL's Oregon laboratory (see Figure 5-1). Between 2002 and 2008, ONAMI researchers

- submitted proposals worth more than $562 million, which corresponds to a compound annual growth rate of 57%;
- received project and grant awards worth $110 million, which corresponds to a annual growth rate of 65%; and
- accounted for $91 million in research activity, which corresponds to an annual growth rate of 78% between 2002 and 2008.[1]

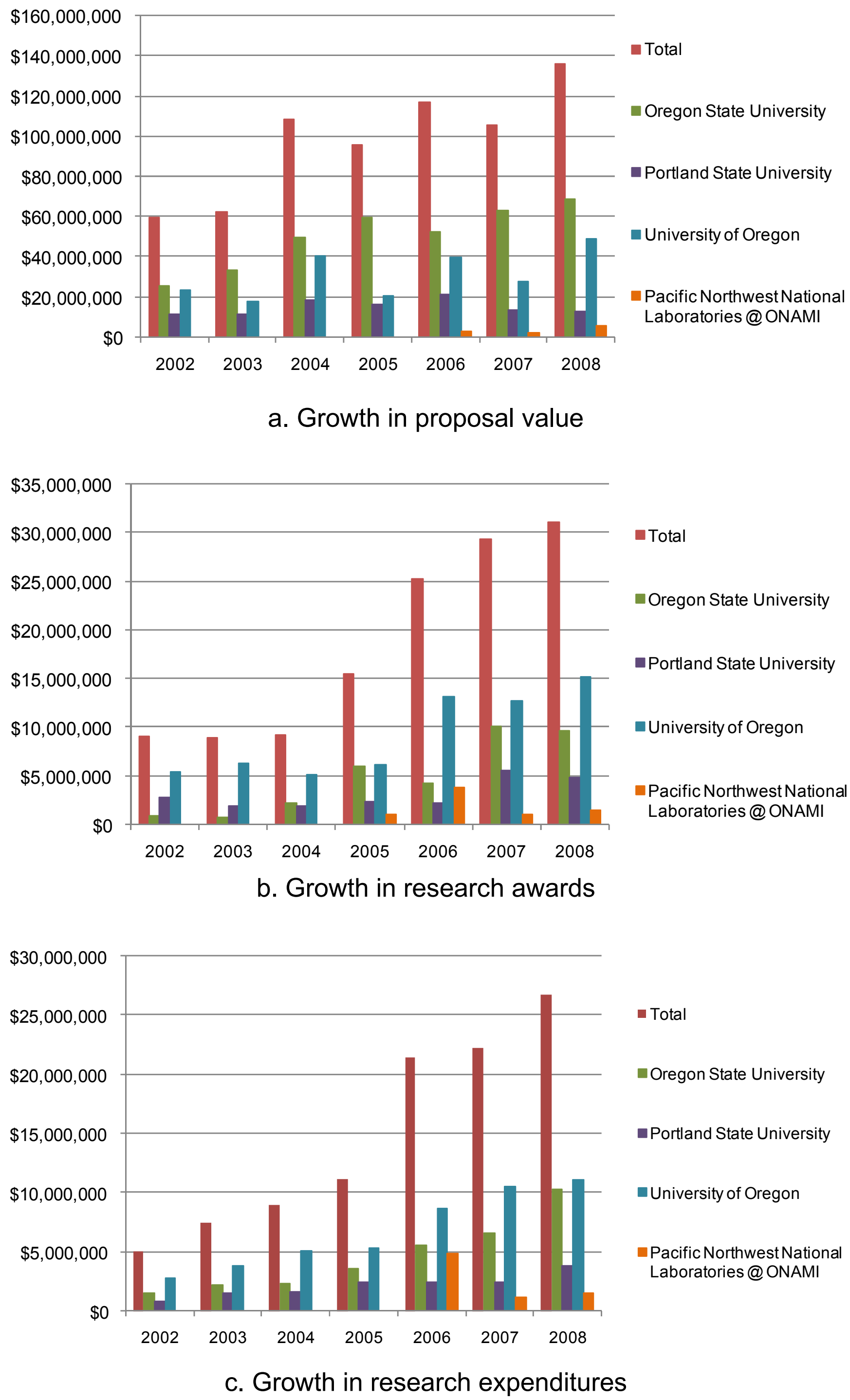
Nearly all of our interviews with university researchers and administrators indicated that ONAMI has had a far-ranging effect. One senior faculty member characterized ONAMI's mechanisms as "catalytic investments in people and facilities… structured to enable people to succeed, helping with upfront costs and then matching the funds you are able to secure."

RTI's task was to analyze ONAMI research activity to measure the effects the program has had on the state beyond proposal matching funds and the federal funding agenda. RTI examined ONAMI-funded infrastructure and the extent to which this infrastructure was leveraged to win proposals that did not have a direct ONAMI cash contribution. Interviewees indicated that these impacts stem from use of shared facilities, interdisciplinary collaboration, and the halo effect ONAMI lends their proposals.

RTI performed this analysis by examining how research would have been grown in the absence of ONAMI's programs. The data to perform the analysis included surveys from ONAMI members, research activity data from university affiliates, and financial databases maintained by NSF, NIH, and other federal agencies.

[1] ONAMI's affiliates are required submit quarterly briefings that illustrate the dollar value of proposals, awards, and research expenditures at both the summary and the project level. These data are used to monitor progress and provide ONAMI the opportunity to monitor progress on ONAMI-matched proposals and other initiatives.

Figure 5-1. Growth in Micro/Nano Research Activity at ONAMI University Affiliates



5.2 ONAMI MEMBERSHIP SURVEY RESULTS

RTI surveyed ONAMI members to determine

- the proportion of research activity growth that was attributable to ONAMI's programs, including the exact dollar value of that proportion;
- the extent to which ONAMI deepened connections, research, and resource sharing among OUS universities; and
- the extent to which university–industry interaction is greater and more productive than the years before ONAMI.

RTI used survey data to model research funding with and without ONAMI, enabling us to answer the question: how does what *actually* occurred compare with what *would have* occurred under a business-as-usual scenario without ONAMI?

Fifty-nine ONAMI researchers at OSU, PSU, UO, and PNNL completed RTI's survey, a response rate of 40% (see Table 5-1). Respondents had the opportunity to respond confidentially or identify themselves as willing to participate in a follow-on telephone conversation. A review of those who indicated that they were open to participating in telephone interviews suggests that ONAMI members with greater than 40% of ONAMI-related research activity participated in the survey.[2]

Table 5-1. ONAMI Membership Survey Response Rate

Institutional Affiliation	Number of Respondents	Estimated Number of ONAMI Members	Response Rate
Oregon State University	34	62	55%
Portland State University	8	36	22%
University of Oregon	10	33	30%
Pacific Northwest National Laboratories	7	15	47%
Total response rate	**59**	**146**	**40%**

ONAMI members that were with OUS prior to ONAMI's launch felt that ONAMI improved collaboration across OUS (see Table 5-2). Forty-one percent of respondents felt that collaboration was greater or much greater than it was 4 years ago; 44% had been with OUS for fewer than 4 years and thus may not have had firsthand historical perspectives on the pervasiveness of collaboration across OUS.

[2] It is possible that there is, therefore, selection bias in the survey results, yet this possibility is also counterbalanced with the fact that RTI is reasonably assured that research activity impacts are adequately captured, despite the lack or response from nearly two-thirds of ONAMI members.

Table 5-2. ONAMI Membership's Perceptions of Change in University Collaboration

Change in Collaboration (if with OUS >4 yrs)	
Much greater	22 %
Greater	19%
Comparable	15%
Less or much less	—
With university fewer than 4 years	44%

Members offered insights into how ONAMI affected their research opportunities (see also Table 5-3):

"As a young faculty member at OSU, ONAMI has been incredibly helpful in getting my research program started and recognized. I honestly believe that without ONAMI, I would not have the support and infrastructure that I need for my research program to survive and thrive here. Investments such as these are essential to keeping Oregon part of the nanotech revolution."

"I feel very fortunate to have joined [my institution] *in conjunction with the formation of ONAMI and its programs. It has positively impacted my career growth and has generated opportunities that may have been a lot harder to realize in its absence."*

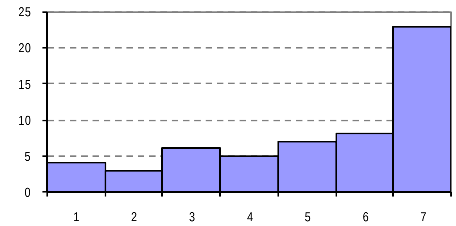
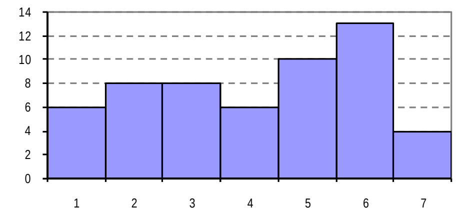
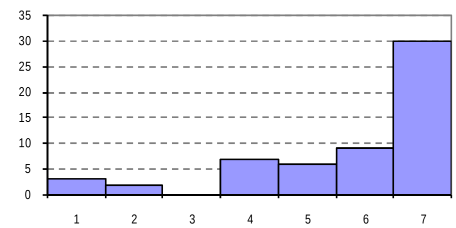
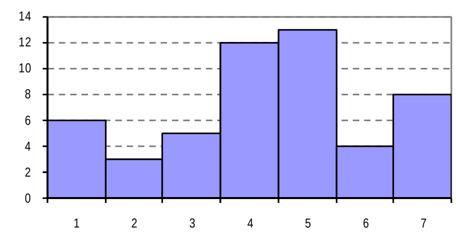
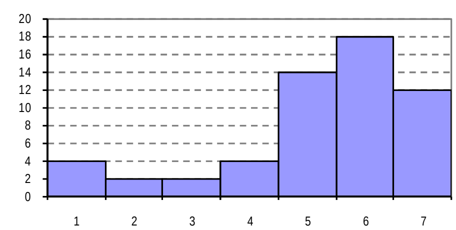
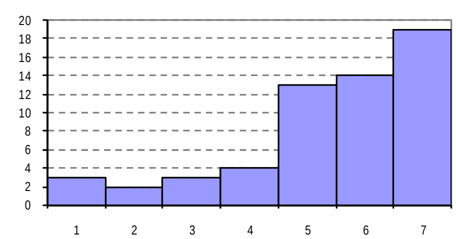
"Overall, I think that ONAMI is doing an excellent job in their critical mission to stimulate new science and fundamental research, new technology, new spin-out companies, and new collaborations among OSU, UO, PSU, PNNL, and companies in this region. They are helping to make Oregon an exciting and productive place for cutting edge research and development of micro- and nanoelectronic devices and materials."

"ONAMI has made an important impact on my career, I have received many grants … as a result of ONAMI, I owe them quite a lot of thanks. The connections I have made with other universities and people doing research have been immense, I would not have made such an effort to seek collaborations had ONAMI not been involved."

"I believe there will be many small businesses spun off as a result of ONAMI investment—some of which will grow and provide stable employment opportunities for Oregonians."

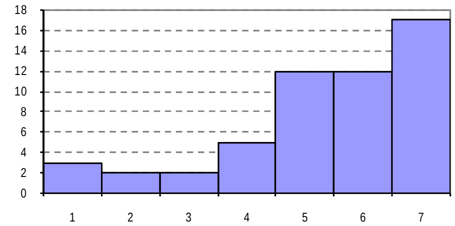
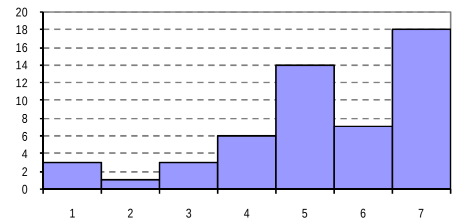
"In a nutshell, the ONAMI initiative has had a strikingly positive impact on my research program and continues to benefit my students: current students and recent graduates alike. ONAMI is well aligned with Oregon industry, which has translated to better opportunities for licensing of OUS IP and for commercialization of OUS-developed technologies. Perhaps most importantly, this is resulting in job creation where the new jobs are often filled by graduates of OUS institutions—keeping our intellectual investment at home."

Table 5-3. ONAMI Membership's Perceptions of ONAMI's Impacts and Influence

	Avg	Median	Range of Responses (1 = strongly disagree, 7 = strongly agree)
ONAMI-sponsored events connected me with researchers at other OUS institutions.	5.2	6.0	
ONAMI-sponsored events connected me with researchers in the private sector.	4.1	4.0	
ONAMI and its initiatives have been a catalyst for collaboration across OUS institutions.	5.8	7.0	
ONAMI's commercialization support programs have invigorated my interest in private sector collaboration.	4.3	4.0	
ONAMI and its initiatives likely lend greater credibility to my grant, research, and consulting proposals, in the eyes of my non-OUS collaborators and grant application reviewers.	5.2	6.0	
The novelty and quality of research conducted at my university is greater than it otherwise would have been because of ONAMI's shared facilities support and signature researcher programs.	5.4	6.0	

(continued)

Table 5-3. ONAMI Membership's Perceptions of ONAMI's Impacts and Influence (continued)

	Avg	Median	Range of Responses (1 = strongly disagree, 7 = strongly agree)
My students have better educational opportunities because of ONAMI's shared facilities, matching funds for training initiatives, and other programs.	5.4	6.0	
My students likely have better professional opportunities because of ONAMI's shared facilities, matching funds for training initiatives, and other programs.	5.3	5.0	

5.3 MICRO/NANO RESEARCH PROJECT AWARDS ATTRIBUTABLE TO ONAMI

Fifty-five percent of the researchers that responded to RTI's survey indicated that they were involved in proposals that would not have been possible in the absence of ONAMI.

Of the $684 million proposals in nanoscience and microtechnology submitted between FY 2002 and FY 2008, survey respondents indicated that approximately $77 million of these were made more competitive because of ONAMI-funded infrastructure. Notably, 18% of respondents indicated that they were involved in winning competitive proposals that would otherwise not have been submitted (see Table 5-4).

Researchers provided project information that RTI was able to cross-check against project and federal funding databases to acquire actual historical awards and to estimate future awards from proposals researchers have won. These "ONAMI-enabled" awards joined the time series of matched external funding, signature researcher, and federal agenda awards in the annual time series of total awards attributable to ONAMI (see Table 5-5 in addition to tables and text in Section 3).

Table 5-4. ONAMI Membership's Perceptions of ONAMI's Influence on Proposal Submissions and Awards

Percentage of respondents indicating that they were involved in proposals that would not have been submitted, or that would not have been possible, without ONAMI	55%
Percentage of respondents indicating that they believed that ONAMI enabled them to win proposals they otherwise would not have won	47%
Percentage of respondents indicating that they were awarded at least 1 non-OUS competitive proposal that they would not have submitted in the absence of ONAMI	18%

Table 5-5. Proposal Awards Attributable to ONAMI

Fiscal Year	Matched External Funding Awards ($thousands)	Signature Researcher Awards ($thousands)	Federal Agenda Awards ($thousands)	ONAMI-Enabled Awards ($thousands)	Total Awards Attributable to ONAMI ($thousands)
2004	—	—	—	—	—
2005	—	—	$5,000	$2,198	$7,198
2006	$1,746	—	9,370	1,548	12,664
2007	3,076	—	7,550	1,590	12,216
2008	5,805	$261	10,200	3,105	19,371
2009[a]	2,713	535	2,500	3,521	9,269
2010[a]	1,113			1,767	2,879
2011[a]	741			462	1,203
2012[a]				462	462
Total	**15,195**	**795**	**34,620**	**14,653**	**65,262**

[a] Project awards from FY 2009 and beyond represent funding secured by proposals won in 2008 or earlier; it was not possible to forecast future award wins.

ONAMI's contributions to research funding total $65 million that would not have otherwise accrued to Oregon, of which

- $15 million are external funding awards with an ONAMI cash match from the proposal matching fund,
- $0.8 million were won by ONAMI's signature researchers,
- $35 million were secured by ONAMI and Oregon's congressional delegation for strategic research thrusts, and
- $15 million were enabled through ONAMI's provision of shared facilities, university collaboration, and exploitation of synergies across OUS research institutes and programs.

If it were not for ONAMI, research awards would have been 47% or more *less* than they actually were between FY 2005 and FY 2008. Table 5-6 illustrates how proposal awards would have accrued for FY 2002 through FY 2008 without ONAMI, given the data RTI collected from researchers, ONAMI, and university administrators.

Table 5-6. ONAMI's Impact on Proposal Awards to Universities

Fiscal Year	Actual Awards ($thousands)	Less Awards *from* ONAMI ($thousands)	Less Awards *Attributable to* ONAMI ($thousands)	Equals Retrospective Awards *without* ONAMI ($thousands)	Percentage Attributable to ONAMI
2002	$9,007	—	—	$9,007	—
2003	8,842	—	—	8,842	—
2004	9,162	—	—	9,162	—
2005	15,433	—	$7,198	8,235	47%
2006	25,201	$1,886	12,664	10,650	58%
2007	29,245	3,187	12,216	13,842	53%
2008[a]	31,033	3,084	19,371	8,578	72%
2009[a]		1,079	9,269		—
2010[a]		66	2,879		—
2011[a]			1,203		—
2012[a]			462		—

[a] Values for 2009 and later reflect cash flows that were secured as of August 2008. Data in this table represent actual past or future cash flows and are not projections.

5.4 GROWTH IN MICRO/NANO TECHNOLOGY TRANSFER METRICS

Another measure apart from increased research activity and collaboration that may be used to evaluate ONAMI's effectiveness is the growth in technology transfer metrics, also known as commercialization measures (see Table 5-7). These measures are used to evaluate the extent to which research is generating IP that is of commercial value. According to data collected quarterly by ONAMI, Inc., since FY 2004

- 135 invention disclosures were submitted by researchers to their university technology transfer offices;
- 120 patent applications were submitted, and while some may still be pending, 13 patents had been issued by the end of FY 2008;

Table 5-7. Growth in Micro/Nano Technology Transfer Metrics

Fiscal Year	Number of Invention Disclosures	Number of Patent Applications	Number of Patents Issued	Expenses for IP Protection ($)	Number of License Agreements	License Revenue ($)	Number of Companies Started
2002	16	9	—	$75,191	—	$53,930	—
2003	20	19	1	233,520	1	91,676	1
2004	21	21	4	281,566	8	69,922	2
2005	23	20	3	211,126	3	51,028	2
2006	34	26	2	262,987	5	230,895	—
2007	27	19	1	211,290	1	38,477	1
2008	30	34	3	266,307	2	17,749	2
Since 2004	**135**	**120**	**13**	**1,233,276**	**19**	**408,071**	**7**

- $1.2 million was expended to protect IP;
- 19 license agreements for ONAMI technologies were executed, and over $400,000 in licensing income accrued to the universities; and
- 7 start-up companies were created.

6 Summary Results and Conclusions

***Synopsis**: Assessing the economic benefits of ONAMI are akin to assessing the economic contributions of a star-performing stock in an investment portfolio: the annualized rate of return on the state government's investment from cash inflows from non-Oregon sources is 56%.*

Economic benefits in this analysis were defined as cash inflows to Oregon, which amounted to $77 million. Costs were approximately $18 million in operating funds and a one-time $20 million capital contribution, bringing the net economic benefit to $39 million.

Perhaps most notably, Oregon businesses matched the state government's contributions 75 cents on the dollar. Business leaders cited the need for statewide research alliances, the effectiveness and novelty of ONAMI's programs, and ONAMI's focus on developing Oregon's research infrastructure as the key attributes that catalyzed the more than nearly $30 million in state-of-the-art instruments, office space, and in-kind services they have donated to ONAMI since the program's inception.

Including Oregon business' contributions boosts the rate of return to 76% and generates a benefit-to-cost ratio of 2.15. This means that for every $1 Oregon invested, it received $2.15 in benefit.

Cash inflows translate into economic opportunity. Business leaders cited ONAMI's extraordinary potential of increasing employment and educational opportunities for Oregonians. ONAMI's commercialization support program may yield between 1,360 and 2,100 new jobs by 2013. The employment gains are in addition to the jobs in Oregon's *communities that are supported by ONAMI's ability to secure research funding.*

6.1 SUMMARY TIME SERIES OF COSTS AND BENEFITS

Recall that in this analysis benefits were primarily defined as cash inflows to the state that likely would not have occurred had ONAMI not been created. Table 6-1 summarizes the benefits that were quantified in the preceding chapters. Total cash inflows secured by the end of FY 2008 from non-Oregon sources total $77 million (see Table 6-1), of which

- $65 million are project awards that had either an ONAMI proposal match, were won by ONAMI signature researchers, were part of a strategic thrust initiative, or were enabled by ONAMI's programs;
- $11 million were cash inflows to Oregon businesses or inflows to universities from non-Oregon companies or private donors; and
- $0.9 million were non-OUS revenues at ONAMI shared facilities.

Net benefits are calculated by reducing total benefits by program costs. Recall that program costs consist of $5.3 in program start-up costs shouldered by PSU, OSU, and UO; $12.8 million in program operating expenses from the state; and a one-time $20 million capital contribution.

Therefore, the net benefit of ONAMI to Oregon is $39 million, in nominal terms (i.e., not adjusted for inflation). These benefits are cash inflows from non-Oregon sources, including the federal government, charitable foundations, private investors, and donors.

As stated in Section 4, Oregon businesses have invested a substantial amount of value in ONAMI, including donated services, analytical instruments, processing equipment, and office space. The significance of this investment articulates the imperative the business community places on growing and diversifying Oregon's technology sector and integrating Oregon's universities more closely with its industry. Table 6-2 illustrates how inclusion of companies' contributions boosts net benefits by 76% from $39 million to $69 million.[1]

[1] Although donations and gifts from Oregon businesses to its universities are transfers of value between two parties, this analysis is from the ONAMI prospective; therefore, contributions from Oregon businesses are a cash inflow into ONAMI.

Table 6-1. Time Series of Benefits, Costs, and Net Benefits, non-Oregon Sources

Fiscal Year	Incremental Awards (Inflows) ($thousands)	Industry Cash Inflows ($thousands)	Shared Facilities—Non-OUS Revenue ($thousands)	Total Benefits ($thousands)	ONAMI Program Costs ($thousands)	Net Benefits ($thousands)
2004	—	—	—	—	($3,003)	($3,003)
2005	$7,198	$475	$187	$7,861	(23,284)	(15,423)
2006	12,664	7,984	345	20,994	(2,873)	18,121
2007	12,216	1,345	253	13,814	(4,377)	9,437
2008	19,371	938	96	20,405	(4,500)	15,905
2009[a]	9,269	75	—	9,344	—	9,344
2010[a]	2,879	100	—	2,979	—	2,979
2011[a]	1,203	100	—	1,303	—	1,303
2012[a]	462	100	—	562	—	562
2013[a]		100	—	100	—	100
Total	**65,262**	**11,217**	**881**	**77,361**	**(38,036)**	**39,324**

[a] Values for 2009 and later reflect cash flows that were secured as of August 2008. Data in this table represent actual past or future cash flows and are not projections.

Table 6-2. Time Series of Benefits, Costs, and Net Benefits, Including Oregon and non-Oregon Sources

Fiscal Year	Economic Benefits from non-Oregon Sources ($thousands)	Investment in ONAMI by Oregon Business ($thousands)	Total Benefits ($thousands)	ONAMI Program Costs ($thousands)	Net Benefits ($thousands)
2004	—	$602	$602	($3,003)	($2,401)
2005	$7,861	1,393	9,254	(23,284)	(14,030)
2006	20,994	1,839	22,833	(2,873)	19,960
2007	13,814	567	14,380	(4,377)	10,003
2008	20,405	3,314	23,719	(4,500)	19,219
2009[a]	9,344	1,100	10,444	—	10,444
2010[a]	2,979	1,100	4,079	—	4,079
2011[a]	1,303	1,100	2,403	—	2,403
2012[a]	562	1,100	1,662	—	1,662
2013 and beyond[a]	100	17,600	17,700	—	17,700
Total	**77,361**	**29,715**	**107,076**	**(38,036)**	**69,040**

[a] Values for 2009 and later reflect cash flows that were secured as of August 2008. Data in this table represent actual past or future cash flows and are not projections.

6.2 ECONOMIC PERFORMANCE MEASURES

Economic performance measures are used to compare investments and monitor the effectiveness of policy initiatives. For each set of benefits (e.g., from non-Oregon sources and from all sources), we calculated three performance measures: net present value (NPV), benefit-to-cost ratio (BCR), and internal rate of return (IRR).[2]

6.2.1 Performance Measures: State Costs and Cash Inflows from Non-Oregon Sources

The NPV of the time series of net benefits is $25.1 million (see Table 6-3). The discount rate employed was the conservative 7% social discount rate recommended by the Office of Management and Budget (OMB) to evaluate publicly funded initiatives. [3]

Table 6-3. Performance Measures: State Costs and Cash Inflows from Non-Oregon Sources

Net present value (2008$)	$25.1 million
Internal rate of return	56%
Benefit-to-cost ratio	1.72

Any project that yields a positive NPV is considered economically successful. Projects that show a positive NPV when analyzed using OMB's 7% real discount rate are socially advantageous. A negative NPV would indicate that the costs to society outweigh the benefits, and an NPV equal to zero would indicate a breakeven point.

The BCR for ONAMI is 1.72, meaning that for every $1 dollar invested in ONAMI between FY 2004 and FY 2008, it received $1.72 in return, as measured in present value terms.

The BCR calculated in this analysis is the ratio of the NPV of benefits to the NPV of costs, which accounts for differences in the timing of cash flows (which in turn has implications for the real value of $1 in one time period versus another).[4] Essentially, a BCR greater than 1 indicates that quantified benefits outweigh the calculated costs. A BCR less than 1

[2] Calculating measures of economic return require all dollar values to be expressed in real terms (i.e., adjusted for inflation effects). To perform this adjustment, RTI employed the consumer price index (CPI) value for December of each calendar year—the midpoint of the fiscal year—and adjusted all values to FY 2008 values. Thus, calculation of measures using the unadjusted data in Tables 6-1 and 6-2 may yield different results.

[3] See OMB Circular A-94.

[4] Because benefits and costs occur at different time periods, both are expressed in present-value terms before the ratio is calculated.

indicates that costs exceeded benefits, and a BCR equal to 1 means that the project broke even.

The internal rate of return on ONAMI is 56%, inclusive of quantified costs and benefits accrued or secured by the close of FY 2008, but exclusive of future employment gains from gap-funded companies. IRR on an investment should be interpreted as the percentage yield on an R&D project over the life of the project, often multiple years.

The IRR on ONAMI is within a range observed for other successful technology policy initiatives (Tassey, 2003). Risk-free capital investments such as government bonds can be expected to yield rates of return under 5% in real terms, while equities seldom return more than 10% over an extended period of time. In academic studies of the diffusion of new technologies, however, real rates of return of 100% or more have been found for significant advances with broad social benefits.

6.2.2 Performance Measures: State Costs and Cash Inflows from Oregon and Non-Oregon Sources

Counting the value of Oregon business' contributions as a benefit impacts performance measures just as doing so affected the net benefits in Table 6-2. Table 6-4 illustrates the revised performance measures:

- NPV is $40 million
- BCR is 2.15
- IRR is 76%

Table 6-4. Performance Measures: State Costs and Cash Inflows from Oregon and Non-Oregon Sources

Net present value (2008$)	$40 million
Internal rate of return	76%
Benefit-to-cost ratio	2.15

6.3 FUTURE EMPLOYMENT AND ECONOMIC GAINS FROM GAP-FUNDED COMPANIES

Companies that receive ONAMI commercialization grant funding are expected to grow and generate jobs and income that contribute to the entire Oregon economy. In this section, we provide a summary discussion of how RTI forecasted these economic contributions for the years 2011 and 2013. A more detailed discussion is included as Appendix B.

Table 6-5. Forecasted Employment for Gap-Funded Companies in 2011 and 2013

Employment	2011	2013
Upper-bound forecast	282	630
Lower-bound forecast	183	410

Survey question: Assume the gap-funded company is successful, achieves its technical goals, and accomplishes all its planned and forecasted business ventures. Please provide the following measures: approximate sales in three years; approximate employment in three years; approximate sales in five years; and approximate employment in five years.

Gap-funded companies were asked to forecast their approximate employment and sales 3 and 5 years into the future under the assumption that that their company was successful, achieved its technical goals, and accomplished its planned business ventures. Since it is unlikely that all the goals set by these gap-funded companies will be accomplished, RTI used the respondent's answers to forecasting questions as an "upper-bound" employment estimate for the years 2011 and 2013. Table 6-5 provides the employment forecasts for 2011 and 2013 for all gap-funded companies.[5]

To create a "lower-bound" estimate for these companies, RTI reviewed the economics literature to determine what the survival rate was among university spin-off companies. During this review, RTI found that as part of the 2002 AUTM licensing survey, a survey was administered to university spin-offs that were formed between 1980 and 2001. Out of the 3,870 spin-offs surveyed, 2,514 (65%) were still in operation in 2001 (Ho and Smith, 2006).

RTI used this survival rate to create a lower bound for each respondent's employment forecast by assuming the lower bound to be 65% of their "upper-bound forecast."

In 2011, gap-funded companies are expected to contribute between $47 and $73 million to GSP—approximately $33 to $51 million of which is associated with salaries and benefits.[6] In addition, the economic impacts generated by these gap-funded companies in 2011 include creation of between 609 and 942 jobs. Furthermore, RTI estimates that the activity

[5] As part of the set up for the survey, respondents were allowed to provide ranges in their forecasts. In these instances, RTI took the average of their minimum and maximum forecasts to come up with a single forecast. For example, if a respondent forecasted that they would employ between 10 and 20 people 3 years in the future, RTI used a value of 15 for the economic impact analysis.

[6] In this report, salaries and benefits reflect total payroll costs (including benefits) and income received from self-employed work. IMPLAN refers to this measure as "labor income," which includes employee compensation and proprietary income.

stimulated by these companies will contribute between $4.7 and $7.2 million in state and local tax revenue (see Table 6-6).

Table 6-6. Future Economic Impact Estimates from ONAMI Gap-Funded Companies

Economic Performance Metric	2011 Estimates of Impacts		2013 Estimates of Impacts	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Gross state product per year (millions)	$47.0	$72.6	$107.5	$165.8
Salaries and benefits per year (millions)	$32.7	$50.5	$73.5	$113.4
Job generation (positions)	608	942	1,363	2,103
State and local taxes per year (millions)	$4.7	$7.2	$10.5	$16.2

In 2013, the impacts of gap-funded companies are expected to be much larger. This is a result of the fact that many gap-funded companies expect to grow rather rapidly over the next 5 years. Based on RTI's analysis, the gap-funded companies are forecasted to contribute between $107 and $166 million to GSP (between $73 and $133 million in the form of salaries and benefits). They are also expected to generate between 1,363 and 2,103 jobs, and $11 to $16 million in state and local taxes.

6.4 CONCLUDING REMARKS

The story of ONAMI is largely a story of infrastructure and human capital: ONAMI's mechanisms are designed to secure and procure the tools necessary for Oregon's university and private sector researchers to further Oregon's goals to rank among the preeminent micro/nano research centers in the world.

It is clear that ONAMI helps bridge several critical gaps in Oregon's economic structure. Higher education is underfunded by 43% compared with Oregon's competitors, and as such an overweighted proportion of Oregon's innovation is conducted by a relatively small number of large firms concentrated in a small number of industries.

Compounding this risk of economic dependence is that fact that there has been a disconnect between the quality and quantity of research in the private sector and that of the university sector. Given that successful states rely on integration and collaboration between their research universities and corporate R&D centers, the imbalance in Oregon means that adverse industry trends in semiconductors would be amplified in Oregon and the loss of employment and economic opportunities in one high-tech sector could not be absorbed by gains in another.

ONAMI spurs innovation in green chemistry, advanced materials, and micro/nanoelectronics that complement Oregon's industry strengths. Oregon business has rewarded ONAMI's efforts with significant donations of analytical equipment, office space, and services. Collaboration and commercialization is rewarded through progressive proposal matching schemes for interinstitutional proposals and commercialization support programs.

Only 10% of ONAMI's operating funds are consumed by administrative, outreach, and marketing expenses—an amount that would not be possible if the same funds were distributed to universities. Investing in resources at the ONAMI level reduces duplication across universities, which is a necessity given the dueling realities of limited state funds and the great expense of micro/nano research infrastructure.

Notably, ONAMI does not purely provide financial support—ONAMI, Inc.'s operations and leadership councils are composed of university and business leaders that volunteer their time to ensure that the program continues to align with the state's economic development priorities. Nor does ONAMI distribute funds based on predetermined levels: only the most competitive proposals to ONAMI are funded across the institute.

One researcher commented to us that he was working on a business plan with a company that received an ONAMI gap grant to commercialize technology funded in part with an ONAMI proposal match and that was conducted in an ONAMI shared facility. This comment illustrated ONAMI's comprehensive strategy of building the research infrastructure that will support the development of new business and industries in the future.

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Appendix A: Survey Instruments

ONAMI ECONOMIC IMPACT ANALYSIS: SURVEY FOR GAP-FUNDED COMPANIES

1. Gap-Funded Company Information

This survey is confidential; all companies' responses will be presented only in the aggregate. No individually identifiable responses will be shared publicly.

1a. Gap-funded company name: ______________________

1b. In what year was the gap-funded company founded? ______________________

1c. Was this the first business that the company's principal(s) founded? **[Select One]**

1d. Is the gap-funded company rooted in research either directly or indirectly support by ONAMI matching funds, shared facilities, or signature researchers? **[Select One]**

2. Institutional Affiliation.

With which Oregon institutions is the gap-funded company partnering? You may select multiple institutions, if applicable.

- ☐ Oregon State University
- ☐ Oregon Health & Science University
- ☐ Pacific Northwest National Laboratories
- ☐ Portland State University
- ☐ University of Oregon
- ☐ Other: ______________________

3. Role of ONAMI Commercialization Gap Grant.

The following questions explore the role the ONAMI commercialization gap grant plays(-ed) in the gap-funded company's corporate development..

3a Would the gap-funded company have been created in the absence of the commercialization gap grant? **[Select One]**

Would the gap-funded company have been able to sustain itself in the absence of the commercialization gap grant? **[Select One]**

If no, did the gap grant accelerate the company's development? **[Select One]**

If no, did the gap grant strengthen the company's IP position or technical foundations? **[Select One]**

3b. Did the gap-funded company receive any of the following types of funding <u>after</u> receiving the gap grant?

- ☐ Angel investment
- ☐ Federal grants
- ☐ Self funded
- ☐ Contract revenue
- ☐ Professional venture capital
- ☐ Other: ______________________

3c. What sources of funding the company receive, approximately how much, and when did the company receive any of the above (excluding principals' personal funds)?

Comments: ______________________

4. Company Size and Activity Measures.

The following questions ask you to speculate on future company employment levels, assuming that present technical goals are achieved and business ventures are successful. You may enter fractional numbers, if applicable.

4a. Distribute the number of persons <u>currently</u> employed by or contracted by the gap funded companies across the following labor categories.

Full-time, non-university staff: ____________ University post-docs: ____________

Part-time, non-university staff:	______	University graduate students:	______
University faculty/staff:	______	University undergraduate students:	______

4b. Assume the gap-funded company is successful, achieves its technical goals, and accomplishes all its planned and forecasted business ventures. Please provide the following measures; you may express your response as a range.

Approximate sales in three years: ______

Approximate employment in three years: ______

Approximate sales in five years: ______

Approximate employment in five years: ______

4c Consider the company's IP portfolio. How many patents have been licensed from a university, are jointly owned by the company and university, or are owned by the company? Include patent applications and invention disclosures, if applicable.

Licensed from university: ______

Jointly owned by university and company: ______

Owned by company: ______

5. Shared Facilities Usage.

Please indicate whether you or your research staff use one or more of the ONAMI shared facilities. Indicate whether you are:

- Current facility user (within the last 4 months)
- Past facility user
- Likely to use the facility in the future
- Have no current plans to use the facility
- Facility infrastructure is not applicable for my research.

You may select more than one response for each facility.

	Current user	Past User	Future User	No plans to use	Not applicable
CAMCOR: Center for Advanced Materials Characterization in Oregon	☐	☐	☐	☐	☐
CEMN: Center for Electron Microscopy and Nanofabrication	☐	☐	☐	☐	☐
MBI/NMF: Microproducts Breakthrough Institute Nano/Micro Fabrication Lab	☐	☐	☐	☐	☐

6. Perceptions of ONAMI's impacts and influence.

To what extent do you agree or disagree with the following statements, where 1 indicates strong disagreement and 7 indicates strong agreement.

6a.	ONAMI-sponsored events connected me with researchers at Oregon universities.	**[Select One]**
6b.	ONAMI-sponsored events connected me with researchers, executives, and entrepreneurs at other Oregon-based technology businesses.	**[Select One]**
6c.	ONAMI has catalyzed greater professional interaction between Oregon universities and businesses active in micro- and nanoscale research.	**[Select One]**
6d.	The gap-funded company is more likely to remain a viable, on-going concern because of the credibility lent to it by the receipt of an ONAMI gap grant.	**[Select One]**
6e.	ONAMI has brought national recognition to Oregon's micro- and nanotechnology sectors.	**[Select One]**

7. Comments?

In you view, what are the top 3 challenges facing small, Oregon technology-based businesses, and how can Oregon InC, OECDD, or public policy mechanisms mitigate those challenges?

ONAMI ECONOMIC IMPACT ANALYSIS: SURVEY FOR OREGON UNIVERSITY SHARED FACILITIES USERS

Oregon InC and the Oregon Economic and Community Development Department (OECDD) have contracted with RTI International to conduct an economic impact analysis of ONAMI. The purpose of the study is to quantify the economic value the program has generated for the State since its creation in 2002.

RTI is engaging organizations that have directly or indirectly benefited from ONAMI's programs, particularly those that exploited ONAMI's meetings, conferences, and networking opportunities; proposal matching funds program; shared facilities program; commercialization gap financing program; and signature researcher recruitment and support.

Your response will help the RTI team assess the impact ONAMI may have had on your research opportunities and to provide feedback to Oregon InC and the State. **Questions? Contact Alan O'Connor with RTI International at 415-848-1316 (oconnor@rti.org) or Marian Hammond with OECDD at 503-229-5226 (marian.j.hammond@state.or.us).**

1. Contact Information (Optional)

This survey is confidential, however we welcome the opportunity to engage shared facility users to hear their views on the labs they used and ONAMI's effectiveness at promoting Oregon as a place for micro- and nanoscale research.

Respondent name (optional): ____________________

Discipline or Department (optional): ____________________

Geographic Location: ____________________

Email (optional): ____________________

Are you familiar with ONAMI (Oregon Nanoscience and Microtechnologies Institute), the state-supported economic development initiative to boost micro- and nanoscale activity in Oregon? **[Select One]**

Are you willing to participate in a 10- minute telephone discussion about how the shared facilities may or may not have improved your research opportunities? **[Select One]**

Is your use of the Oregon university facility(-ies) confidential? Note: this survey is about facility access, *not* about your organization's research at the facility. **[Select One]**

3. Collaborations with Oregon Institutions.

Do you have any active or past research, teaching, grant, or consulting collaborations with any of the following Oregon institutions, or have you had collaborations with them within the past 2 years?

☐ Oregon State University
☐ Oregon Health Sciences University
☐ Pacific Northwest National Laboratories
☐ Portland State University
☐ University of Oregon
☐ Don't known or unsure

If applicable, how does your recent level of collaboration with Oregon universities compare with that from 2 or more years ago? **[Select One]**

4. Shared Facilities Usage.

Please indicate whether you or your research staff used one or more of the ONAMI and Oregon university facilities. Indicate whether you are:

- current facility user (within the last 4 months)
- past facility user
- likely to use the facility in the future
- have no current plans to use the facility
- don't know or unsure

You may select more than one response for each facility.

	Current user	Past User	Future User	No plans to use	Don't know or unsure
CAMCOR: *University of Oregon* Center for Advanced Materials Characterization in Oregon	☐	☐	☐	☐	☐
CEMN: *Portland State University* Center for Electron Microscopy and Nanofabrication	☐	☐	☐	☐	☐
MBI/NMF: *Oregon State University* Microproducts Breakthrough Institute Nano/Micro	☐	☐	☐	☐	☐

Fabrication Lab					

5. Decision to Use a Shared Facility.

Why did you or your organization choose to use the shared facility(-ies)? Please select from the following decision factors; you may select as many as are applicable.

- ☐ Availability of laboratory instruments
- ☐ Quality and power of laboratory instruments
- ☐ On-site technical staff and management
- ☐ Training provided by on-site staff
- ☐ Ease of access
- ☐ Acceptable cost
- ☐ Privacy and information security
- ☐ Proximity to primary place of work/research
- ☐ Self-directed research (i.e., "do it yourself")
- ☐ Collaboration with university researcher(s)
- ☐ Availability of real-time webstreaming via Nano Network
- ☐ Don't know or unsure

Comments:

6. Alternative to Past Use of the Shared Facility.

Consider a scenario in which the facility(-ies) you used in the past were not available. How would you have performed the research if the facilities had not been available to you?

- ☐ Would not have conducted the research
- ☐ Performed research at a non-Oregon facility owned by our company or university
- ☐ Contracted with a non-Oregon laboratory, university, or service provider
- ☐ Purchased needed instruments and infrastructure
- ☐ Waited until instruments at Oregon-based facility were available for use
- ☐ Contracted with private vendor in Oregon

Please offer comments on how you would have otherwise performed the research and whether your organization accrued any cost or information benefits from its use of the shared facility:

7. Perceptions of Facilities' and ONAMI's Impacts and Influence.

To what extent do you agree or disagree with the following statements, where 1 indicates strong disagreement and 7 indicates strong agreement.

7a.	The specific research performed at the shared facility (i.e., CAMCOR, CEMN, and MBI/NMF) could not have been performed as effectively elsewhere.	**[Select One]**
7b.	The specific research performed at the shared facility could not have been performed as timely elsewhere.	**[Select One]**
7c.	Our products, services, and research are of a higher quality and/or are more technologically sophisticated because of the research performed at the ONAMI shared facility.	**[Select One]**
7d.	The availability of and ease of access to the ONAMI shared facilities and their instruments and technical staff offers my organization a competitive advantage.	**[Select One]**
7e.	The ONAMI shared facilities make Oregon a more attractive place for micro- and nanoscale research and development.	**[Select One]**
7f.	Our organization views the ONAMI shared facilities (CAMCOR, CEMN, and MBI/NMF) as extensions of our corporate research and development infrastructure.	**[Select One]**
7g.	ONAMI has brought national and international attention and recognition to Oregon's micro- and nanotechnology sectors and advanced-technology industries.	**[Select One]**

8. Comments?

If you would like to share any comments about the facilities, ONAMI, or other topics, please do so below.

Comments:

ONAMI ECONOMIC IMPACT ANALYSIS: SURVEY FOR MEMBERS & UNIVERSITY RESEARCHERS

Oregon InC and the Oregon Economic and Community Development Department (OECDD) have contracted with RTI International to conduct an economic impact analysis of ONAMI. The purpose of the study is to quantify the economic value the program has generated for the State since its creation in 2002.

RTI is engaging organizations that have directly or indirectly benefited from ONAMI's programs, particularly those that exploited ONAMI's meetings, conferences, and networking opportunities; proposal matching funds program; shared facilities program; commercialization gap financing program; and signature researcher recruitment and support.

***Your response will help the RTI team assess the impact ONAMI may have had on your research opportunities and to provide feedback to Oregon InC and the State.* Questions? Contact Alan O'Connor with RTI International at 415-848-1316 (oconnor@rti.org) or Marian Hammond with OECDD at 503-229-5226 (marian.j.hammond@state.or.us).**

1. Contact Information (Optional)

This survey is confidential, however we welcome the opportunity to engage OUS faculty and ONAMI members to hear their views on ONAMI, its mechanisms, and their effectiveness, including suggestions for improvement.

Respondent name (optional): ____________________

Title (optional): ____________________

Department or Discipline: ____________________

Email (optional): ____________________

Are you willing to participate in a 10- minute telephone discussion about how ONAMI may or may not have improved your research, commercialization, or professional networking opportunities? **[Select One]**

2. Institutional affiliation.

What is your institutional affiliation?

- ☐ Oregon State University
- ☐ Oregon Health & Science University
- ☐ Pacific Northwest National Laboratories
- ☐ Portland State University
- ☐ University of Oregon
- ☐ Other:

3. Collaborations with other Oregon institutions.

Do you have active research, teaching, grant, or consulting collaborations with any of the following Oregon institutions, or have you had collaborations with them within the past 4 years?

- ☐ Oregon State University
- ☐ Oregon Health Sciences University
- ☐ Pacific Northwest National Laboratories
- ☐ Portland State University
- ☐ University of Oregon
- ☐ Industry (specify): ____________________

If you have been with OUS for more than 4 years, how does your recent level of inter-institution collaboration compare with that from 4 or more years ago? **[Select One]**

4. Shared Facilities Usage.

Please indicate whether you or your research staff used one or more of the ONAMI shared facilities. Indicate whether you are: • current facility user (within the last 4 months) • past facility user • likely to use the facility in the future • have no current plans to use the facility • facility infrastructure is not applicable for my research. You may select more than one response for each facility.	Current user	Past User	Future User	No plans to use	Not applicable
CAMCOR: Center for Advanced Materials Characterization in Oregon	☐	☐	☐	☐	☐
CEMN: Center for Electron Microscopy and Nanofabrication	☐	☐	☐	☐	☐

MBI/NMF: Microproducts Breakthrough Institute Nano/Micro Fabrication Lab	☐	☐	☐	☐	☐

5. ONAMI and its mechanisms' influence on your research proposals and awarded projects.

5a Consider your grant, project, and research **proposals** since 2004.

Are there proposals that you would not have submitted or would not have been possible if you did not have access to ONAMI's shared facilities, matching funds, or ONAMI co-funded equipment? **[Select One]**

If yes, which proposals would you not have submitted and why (incl. short title, value, and funding source)?

5b. Consider your **active, awarded research projects and grants** since 2004.

Are there projects that you believe you would not have been awarded if you did not have access to ONAMI's shared facilities, matching funds, or ONAMI co-funded equipment? **[Select One]**

If yes, which projects grants do you believe would not have been awarded and why (incl. short title, value, and funding source)?

5c. Consider **ONAMI's conferences, networking opportunities, and advocacy work**.

Have you attended any ONAMI-sponsored conferences, workshops, or events, such as the Micro/Nano Breakthrough Conference? **[Select One]**

Have you made professional connections through ONAMI-sponsored events that led to collaborative proposals and/or grants and projects? **[Select One]**

If yes, please offer a few short words on research opportunities that grew out of connections made at ONAMI-sponsored events (incl. short title, value, and funding source, if possible)?

6. Researcher perceptions of ONAMI's impacts and influence.

To what extent do you agree or disagree with the following statements, where 1 indicates strong disagreement and 7 indicates strong agreement.

6a.	ONAMI-sponsored events connected me with researchers at other OUS institutions.	**[Select One]**
6b.	ONAMI-sponsored events connected me with researchers in the private sector.	**[Select One]**
6c.	ONAMI and its initiatives have been a catalyst for collaboration across OUS institutions.	**[Select One]**
6d.	ONAMI's commercialization support programs have invigorated my interest in private sector collaboration.	**[Select One]**
6e.	ONAMI and its initiatives likely lend greater credibility to my grant, research, and consulting proposals, in the eyes of my non-OUS collaborators and grant application reviewers.	**[Select One]**
6f.	The novelty and quality of research conducted at my university is greater than it otherwise would have been because of ONAMI's shared facilities support and signature researcher programs.	**[Select One]**
6g.	My students have better educational opportunities because of ONAMI's shared facilities, matching funds for training initiatives, and other programs.	**[Select One]**
6h.	My students likely have better professional opportunities because of ONAMI's shared facilities, matching funds for training initiatives, and other programs.	**[Select One]**

7. Comments?

If you would like to share any comments about ONAMI, its programs, or its initiatives, please do so below.

Comments:

Appendix B: Overview of Input-Output Analysis Using IMPLAN

To measure the economic contributions of gap-funded companies to the Oregon economy, RTI used a 2006 input-output (I/O) model of the Oregon economy that was constructed using IMPLAN economic modeling software. This model simulated how sales and employment in one industry can affect other industries and the state economy as a whole. The process through which this takes place can be separated into three types of impact:

- **Direct Effects or Impacts:** the immediate consequences in industries that experience new sales.
- **Indirect Effects or Impacts:** responses in other industries to changes in the industries experiencing direct impacts.
- **Induced Effects or Impacts:** responses by households to the extra income received as the economy expands. Since additional wage payments will be received as the economy grows, households will purchase more goods and services, which will lead to greater expansion of the economy.

Since RTI measured the impact of gap-funded companies in the future (in the years 2011 and 2013), using a model from 2006 assumes that the structure of the Oregon economy will not change over the next 5 years. This is certainly a strong assumption, but I/O models for the Oregon economy in either 2011 or 2013 are unavailable. As a result, the most recent data available were chosen as a next best option.

IMPLAN was also an attractive choice because it is one of the most widely used I/O modeling software packages in economic development analysis. It has been used in a variety of studies, include those that sought to measure the economic impacts of state-level technology development programs (Markely and McNamara, 1995; RESI, 2001; and RTI, 2007).

B.1 IMPLAN MULTIPLIERS

IMPLAN, like all I/O models, quantifies the economic impact associated with a change in final demand using mathematical representations of the direct, indirect, and induced impacts discussed earlier. These mathematical representations are called "multipliers." IMPLAN offers three different types of multiplier that can be used in estimating economic impacts, each taking different effects and information into account.

- Type I multipliers only measure the direct and indirect impacts of a change in economic activity.
- Type II multipliers measure the direct and indirect impacts of changes in final demand as well as take into account induced effects on household spending. However, households are assumed to spend all their additional income on personal consumption.
- Type SAM multipliers measure direct, indirect, and induced impacts of changes in final demand using all information about the institutions selected to include in the model. For example, for households, Type SAM multipliers account for commuting, social security tax payments, and household income taxes and savings, among other things.

The analysis in this study used Type SAM multipliers, because they contain the most information available in IMPLAN for estimating economic impacts of final changes in demand.

IMPLAN can construct these Type SAM multipliers for several measures of regional economic activity (including GSP, income and salaries, and jobs) for 509 industries and institutions.

B.2 USING MULTIPLIERS GENERATED BY IMPLAN

The multipliers generated by IMPLAN can be used in two ways. First, they can be used to estimate changes in macroeconomic variables that result from a change in final demand for the products produced by one sector or industry.[1]

For example, suppose that an increase in demand for durable goods occurs and leads companies in the durable goods manufacturing sector to hire 100 new employees. Assuming the durable goods sector has an employment multiplier of 2.4, one can see this would result in a total employment effect (impact after direct, indirect, and induced impacts have been taken into account) of 240 employees (100 x 2.4). This means that the 100 jobs initially created in the durable goods sector resulted in 140 additional jobs throughout the economy (240 −100).

A second analytical approach is to use multipliers to compare the relative influence an industry or sector has on the state economy. For example, assuming the employment multiplier in the construction sector is 0.7, then a 100-employee increase in the construction sector leads to only 70 additional jobs—half the number of jobs that would be produced by a similar increase in the durable goods sector.

This implies that employment increases in the construction sector will have a smaller impact on the state economy than increases in the durable goods sector. Highlighting these differences can support and strengthen claims about the importance of a particular industry.

As part of this study, RTI used both analytical approaches. First, we used multipliers generated by IMPLAN to estimate the economy-wide impact of gap-funded companies in 2011 and 2013 as measured by increase in GSP, salaries and benefits, and number of jobs created. Then we compared the multipliers of industries occupied by these companies to demonstrate that they have above average “multiplier” impacts on the Oregon economy.

B.2.1 Constructing Prospective Employment Gain Scenarios

RTI used the 2006 IMPLAN model of the Oregon economy to simulate how jobs created by ONAMI gap-funded companies will contribute to the Oregon economy in 2011 and 2013. To estimate the number of jobs

[1] For the remainder of the economic impact analysis discussion, “industries” refers to groups of businesses producing similar types of goods and services. For example, firms producing semiconductors would be members of the semiconductor manufacturing industry. Sectors are more aggregated, grouping industries based on broad similarities in what they produce. For example, the firms in the semiconductor manufacturing industry and in the textile manufacturing industry both manufacture durable goods. Therefore, they are included in the durable goods manufacturing sector.

created by these gap-funded companies (their “direct impact or effect”) RTI used a variety of data sources.

Gap-funded companies were asked to forecast their approximate employment and sales for 3 and 5 years in the future, assuming that their company is successful, achieves its technical goal, and accomplishes all its planned and forecasted business ventures. Table B-1 provides the total sales and employment forecasts for 2011 and 2013 for all gap-funded companies.[2]

Table B-1. Forecasted Sales and Employment for Gap-Funded Companies in 2011 and 2013

	2011	2013
Sales	$56,900,000	$340,000,000
Employment	282	630

Survey question: Assume the gap-funded company is successful, achieves its technical goals, and accomplishes all its planned and forecasted business ventures. Please provide the following measures: approximate sales in three years; approximate employment in three years; approximate sales in five years; and approximate employment in five years.

Since it is unlikely that all the goals set by these gap-funded companies will be accomplished, RTI used the respondent’s answers to these forecasting questions as an “upper-bound” employment estimate for the years 2011 and 2013.

In order to create a “lower-bound” estimate for these companies, RTI surveyed the literature to determine what the survival rate was among university spin-off companies.

During this search, RTI found that as part of the 2002 AUTM licensing survey, Lori Pressman and AUTM administered a survey to university spin-offs that were formed between 1980 and 2001. Out of the 3,870 spin-offs surveyed, 2,514 (65%) were still in operation in 2001 (Smith and Ho, 2006). RTI used this survival rate to create a lower bound for each respondent’s employment forecast by assuming the lower bound to be 65% of their “upper-bound forecast.” Upper and lower bound forecasts for employment in gap-funded companies in 2011 and 2013 are provided in Table B-2.

[2] As part of the set-up for the survey, respondents were allowed to provide ranges in their forecasts. In these instances, RTI took the average of their minimum and maximum forecasts to come up with a single forecast. For example, if a respondent forecasted that they would employee between 10 and 20 people three years in the future, RTI used a value of 15 for the economic impact analysis.

Table B-2. IMPLAN Inputs

Employment	2011	2013
Upper-bound forecast	282	630
Lower-bound forecast	183	410

However, as discussed above, the impact that these companies have on other industries and the state economy as a whole depends on the size of the multipliers they are associated with. In IMPLAN, these multipliers differ based on industry. Therefore, to effectively model the economic impact of gap-funded companies, RTI had to assign each company to its appropriate industry. These assignments were made by researching each company's activities in through secondary sources and in-person interviews.

Based on this research, RTI was able to categorize each of the eight gap-funded companies into seven IMPLAN-defined industries. Direct impact employment information is not reported for these industries because of concerns related to revealing information for individual companies. However, a detailed description of whether these industries are associated with high labor and employment impacts is provided later in this section.

After the direct impacts were measured and associated with the correct industry, RTI fed the information into the IMPLAN model of the Oregon state economy. The model generated estimates of the indirect and induced impacts of incubator companies along several measures of economic health. The results of this analysis are summarized in the following sections.

B.2.2 Contribution of Gap Fundees to Oregon's Gross State Product, Salaries and Benefits, Jobs, and Taxes

The total forecasted impact of gap-funded companies on the Oregon economy in 2011 and 2013 is reported in Table B-3 for several measures of economic health.

Table B-3. Summary of IMPLAN Results

Economic Performance Metric	2011 Estimates of Impacts		2013 Estimates of Impacts	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Gross state product per year (millions)	$47.0	$72.6	$107.5	$165.8
Salaries and benefits per year (millions)	$32.7	$50.5	$73.5	$113.4
Job generation (jobs)	$608.7	$941.6	$1,362.9	$2,102.9
State and local taxes per year (millions)	$4.7	$7.2	$10.5	$16.2

In 2011, gap-funded companies are expected to contribute between $47 and $73 million to GSP—approximately $33 to $51 million of which is associated with salaries and benefits.[3] In addition, the economic impacts generated by these gap-funded companies in 2011 include creation of between 609 and 942 jobs. Furthermore, RTI estimates that the activity stimulated by these companies will contribute between $4.7 and $7.2 million in state and local tax revenue.

In 2013, the impacts of gap-funded companies are expected to be much larger. This is a result of the fact that many gap-funded companies expect to grow rather rapidly over the next 5 years. Based on RTI's analysis, the gap-funded companies are forecasted to contribute between $107 and $166 to GSP (between $73 and $133 million in the form of salaries and benefits). They are also expected to generate between 1,363 and 2,103 jobs, and $11 to $16 million in state and local taxes.

Job Contributions Total 609 to 942 Million in 2011 and 1,363 to 2,103 in 2013

Earlier in this section, we described forecasts that gap-funded companies will employ between 183 and 282 persons in 2011 and between 410 and 630 persons in 2013. These jobs created indirect and induced impacts that resulted in the creation of up to 660 additional jobs in other sectors of the economy in 2011 and up to 1,473 in 2013. As a result, the total annual employment impact of incubator clients and graduates is the creation of a maximum of 942 jobs throughout the state

[3]In this report, salaries and benefits reflect total payroll costs (including benefits) and income received from self-employed work. IMPLAN refers to this measure as "labor income," which includes employee compensation and proprietary income.

in 2011 and up to 2,103 jobs in 2013 (see Table B-4). As one can see, the sectors benefiting most from the incubated companies are the professional services and durable goods industries.

Table B-4. ONAMI Gap-Funded Company 2011 Job Contributions by Industry (Number of Jobs)

Sector	2011 Estimates of Impacts		2013 Estimates of Impacts	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Agriculture	4	6	9	14
Construction	5	7	10	15
Durable goods manufacturing	167	258	334	515
Education	8	12	18	27
Finance insurance & real estate	18	29	42	64
Government	5	8	11	17
Health	28	44	64	98
Information	2	4	5	8
Mining	2	3	4	6
Nondurable goods manufacturing	41	63	124	192
Other services	77	119	173	267
Professional services	135	208	305	471
Retail trade	41	62	91	140
Transportation	16	25	41	63
Utilities	2	3	4	6
Warehousing	7	10	15	24
Wholesale trade	52	81	113	175
Total	609	942	1,363	2,103

Gross State Product Contributions Total $47 to $73 Million in 2011 and $107 to $166 in 2013

GSP measures changes in earnings (employee compensation, proprietor income, and other property income) and indirect business taxes paid by individuals and businesses (primarily excise and sales taxes). The total impact of gap-funded companies is forecasted to be $47 to $73 million in 2011 and $107 to $166 in 2013.

A detailed breakdown of these impacts is presented in Table B-5. To avoid the possibility of revealing company-level information, only total impacts are only reported for broad "economic sectors" that are aggregated over many industries. As one can see, the sectors that were most affected by these companies are professional services and durable goods manufacturing.

Table B-5. ONAMI Gap-Funded Company Contributions to 2011 Gross Product by Industry (Millions of $2007)

	2011 Estimates of Impacts		2013 Estimates of Impacts	
Sectors	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Agriculture	$12.1	$18.7	$24.2	$37.3
Construction	$9.3	$14.3	$21.0	$32.4
Durable goods manufacturing	$6.6	$10.2	$14.3	$22.0
Education	$5.5	$8.5	$17.4	$26.8
Finance insurance & real estate	$4.3	$6.7	$9.7	$15.0
Government	$1.9	$2.9	$4.2	$6.5
Health	$1.8	$2.8	$4.1	$6.3
Information	$1.8	$2.8	$4.1	$6.3
Mining	$1.1	$1.7	$2.8	$4.4
Nondurable goods manufacturing	$0.8	$1.3	$1.8	$2.8
Other services	$0.6	$0.9	$1.3	$2.0
Professional services	$0.4	$0.6	$0.9	$1.3
Retail trade	$0.2	$0.4	$0.5	$0.8
Transportation	$0.2	$0.3	$0.4	$0.6
Utilities	$0.2	$0.3	$0.4	$0.6
Warehousing	$0.1	$0.2	$0.3	$0.5
Wholesale trade	$0.1	$0.2	$0.2	$0.4
Total	$47.0	$72.6	$107.5	$165.8

Salary and Benefit Contributions Total $33-$50 Million in 2011 and $73-$113 in 2013

The total impact of incubated companies on annual salary and benefit contributions is estimated to be between $33 and $50 million in 2011 and between $73 and $113 million in 2013 (see Table B-6). The vast majority of these salaries and benefits are paid to workers in the professional services and durable goods sectors.

Table B-6. ONAMI Gap-Funded Company Contributions to 20013 Salaries by Industry (Millions of $2007)

	2011 Estimates of Impacts		2013 Estimates of Impacts	
Sectors	**Lower Bound**	**Upper Bound**	**Lower Bound**	**Upper Bound**
Agriculture	$0.1	$0.1	$0.2	$0.2
Construction	$0.2	$0.3	$0.5	$0.7
Durable goods manufacturing	$11.6	$17.8	$23.0	$35.5
Education	$0.2	$0.3	$0.4	$0.6
Finance insurance & real estate	$1.1	$1.6	$2.4	$3.7
Government	$0.4	$0.6	$0.8	$1.3
Health	$1.6	$2.4	$3.5	$5.4
Information	$0.1	$0.2	$0.2	$0.4
Mining	$0.1	$0.1	$0.1	$0.2
Nondurable goods manufacturing	$3.5	$5.4	$10.6	$16.4
Other services	$1.6	$2.4	$3.5	$5.5
Professional services	$6.3	$9.7	$14.3	$22.1
Retail trade	$1.1	$1.7	$2.5	$3.9
Transportation	$0.8	$1.3	$2.1	$3.3
Utilities	$0.2	$0.4	$0.5	$0.8
Warehousing	$0.3	$0.5	$0.7	$1.1
Wholesale trade	$3.7	$5.7	$8.0	$12.3
Total	$32.7	$50.5	$73.5	$113.4