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Executive Summary

Oregon Nanoscience and Microtechnologies Institute (ONAMI) is a novel economic development initiative that integrates the nanoscience and microtechnology programs at Oregon's major research institutions. Established in 2003, ONAMI was created pursuant to the philosophy that the coordinated efforts of Oregon's universities would be able to acquire more funding, deliver greater economic potential, and offer better educational and economic opportunities for Oregonians than if each university launched individual initiatives. ONAMI collects researchers into an institute that has the collaborative and scale-in-research elements of a science park, leverages research facilities across campuses, and avoids the fixed investment of dedicated facilities and real estate. Our assessment estimated the economic benefits accruing to Oregon that are attributable to ONAMI and its programs that would not have accrued had ONAMI not been created. The net benefit was $39 million. The annualized rate of return on the state government's investment from cash inflows from non-Oregon sources was 56%. A benefit-to-cost ratio of 1.72 means that for every $1 the state government invested, Oregon received $1.72 in return.

1. Introduction to the Oregon Nanoscience and Microtechnologies Institute (ONAMI)

The Oregon Nanoscience and Microtechnologies Institute (ONAMI) is a novel economic development initiative that integrates the nanoscience and microtechnology programs of the U.S. state of 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 public resources makes Oregon universities and their private-sector partners more competitive for public–private R&D centers, federal funding opportunities, and private-sector funding for product development and commercialization.

The ONAMI model represents a revision to the model of shared facilities typical in the research park model. The ONAMI model incorporates a distributed model in which university researchers in different institutions are part of a network that allows them access to a variety of specialized facilities. The faculty network and the shared facilities are distributed among the research universities rather than being concentrated in a single space. Nevertheless, the model offers the important economies of scale necessary to increase the competitivness of Oregon's researchers in a crowded field of larger, better-funded and better-known universities.

This distributed network model was necessary to overcome some of Oregon's competitive disadvantages. 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 private-sector semiconductor R&D

to drive innovation means that adverse industry trends are amplified in Oregon. These changes, in turn, impact 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 create new opportunities through the creation of new companies and catalysis of new economic sectors. The goal of this paper is to measure progress.

2. A Small State: Oregon's Rationale for Investment in ONAMI

Oregon's rationale for creating ONAMI is perhaps best conveyed through a review of key R&D activity measures and comparing them with those of Oregon's peer states. Relevant competitiveness measures were: employment in technology sectors, R&D expenditures, and state appropriations for universities. We selected seven states for comparison that have significant micro- and nanoscale R&D clusters similar to those in Oregon: Arizona, California, Massachusetts, New York, North Carolina, Texas, and Washington (see Table 1).

Whereas most states rely on their universities to diversify and support innovation, Oregon has historically relied on a small number of large employers concentrated in comparatively few industries. Over 83% of Oregon's R&D was performed by industry. Academic and other institutions accounted for only 12% and 5% of total R&D expenditures, respectively. 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 the 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'. Adverse industry trends would be amplified in Oregon.

State spending on higher education largely corresponds to the quality and level of preparedness of the local workforce. 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. By comparison, the governments of the seven comparison states appropriated an average of approximately $5 million per 1,000 students, or 43% more than Oregon.

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 US 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.

RTI selected 12 science and technology universities against which to compare Oregon's research universities to illustrate their competitive position in the competition for research funding. [1] The selected universities are also active in nanoscience and microtechnology research and have researchers

[1] 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.

that compete with Oregon 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.

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

Table 1. Comparison of State Technology Competitiveness Metrics

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 per capita ($/person)	**37,073**	33,676	42,535	47,691	46,547	37,991	40,155	40,913
Total state employment (thousands)	**1,356**	2,044	13,265	2,980	7,434	3,366	8,118	2,269
Employment in high technology establishments	**147**	228	1,765	447	795	324	1,100	279
% of total employment in high technology establishments	**10.8%**	11.1%	13.3%	15.0%	10.7%	9.6%	13.5%	12.3%
% of total employment in semiconductors	**0.8%**	0.9%	0.6%	0.6%	0.4%	0.3%	0.5%	0.3%
Total state R&D performance ($millions)	**3,664**	3,544	59,607	15,987	13,113	6,491	14,266	10,936
Industry	**83%**	73%	78%	74%	67%	70%	77%	81%
Academic	**12%**	17%	9%	11%	24%	21%	19%	8%
Unclassified	**5%**	10%	13%	15%	9%	8%	4%	11%
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: 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). Source: National Science Foundation (NSF) (2006, 2007). Sources: National Center for Education Statistics (NCES) (2008) and Fischer (2006).

3. ONAMI's Structure, Programs, and Mechanisms

ONAMI is a multi-institutional, multidisciplinary program that spans many stages of the research and development process—from research through application and commercialization. ONAMI contributes to Oregon's research in nanotechnology by providing incentives and mechanisms for cooperation among institutions and disciplines and between universities and the private sector. These incentives and mechanisms include the following:

- A network of shared user facilities that enable nanotechnology research,
- A pool of funding used for match on competitive extramural proposals,
- Funds that contribute to packages for recruiting signature researchers,
- Grants to researchers working with a company to advance the status of a university-developed technology to commercialization, and
- Distribution of federal funding.

Table 2. 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.

3.1 ONAMI's 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 is administered by ONAMI, Inc., a non-profit corporation 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. 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, serving on ONAMI's Board of Directors and Commercialization Councils. Together, these groups set strategic priorities, oversee funding, and monitor progress.

A light administrative structure is intentional. Rather than burden limited state financial resources with overhead and other expenses, ONAMI's leadership awards state appropriations competitively among researchers through a proposal process. ONAMI, Inc. operates on less than 10% of the total amount of funding provided it by the state.

ONAMI members—almost entirely researchers at university campuses—submit proposals to ONAMI for matching funds to complement external research and infrastructure grants and meet any co-funding requirements (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 universities. 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.

Oregon's investment in ONAMI can be divided into two periods: early start-up expenses and ongoing program support. 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.

3.2 Proposal Matching Fund Program

One of ONAMI primary objectives is to accelerate the growth of federal and private awards to nanoscience and microtechnology researchers. Attracting extramural funding often requires an investment by the proposing institution to share in the costs. Even when match is not required by a

funding agency, a proposal that includes matching funds, particularly cash match, can be more attractive to a potential funder because the resulting leverage increases the potential impact of the investment.

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.

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.

ONAMI offers matching funds for research, workforce development, and equipment purchases that support research and education in nanoscience and microtechnology. ONAMI provides a ten percent match for proposals that include faculty from one ONAMI-affiliated institution. For proposals submitted by a team that includes two or more ONAMI-affiliated institutions, the match rises to 15 percent. A proposal for equipment that will be available for use in one of ONAMI's shared facilities is matched up to 33 percent. ONAMI will also match 33 percent of the value of a donated piece of equipment to facilitate installation and set-up if the equipment will be available to the ONAMI network.

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.

3.3 Shared Facility Support Program

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. 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.

The Center for Advanced Materials Characterization in Oregon (CAMCOR), is located at the University of Oregon in Eugene. The facility contains over 20 instruments with capabilities that include microanalysis, surface analysis, electron microscopy, nanofabrication, and traditional chemical characterization. The facility is located in a building that, through a combination of unique geological structure and advanced building engineering, is much quieter than a typical structure. As one of the quietest measurement structures in the world, the CAMCOR facility itself improves the precision of the measurements performed by the array of tools it houses.

The Center for Electron Microscopy and Nanofabrication (CEMN) is located at Portland State University. CEMN offers imaging using a comprehensive set of electron microscopy tools. These tools can be used

to image and analyze a variety of nano and micro structures. Researchers can access the CEMN by visiting the facility at PSU, or through remote-access high-speed Internet connections.

The Microproducts Breakthrough Institute (MBI), in Corvallis on the Hewlett-Packard campus is a nano-micro fabrication facility that is jointly operated by the OSU College of Engineering and the Pacific Northwest National Laboratory. The MBI has a comprehensive suite of tools for building prototypes of, fabricating and measuring micro devices. These tools are being used to develop, test, and create prototypes of microchannel devices that can be used in a variety of applications in distributed energy production, drug delivery, and other medical applications.

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. The second mode of support was initially through 1:1 matching grants for "external" billings and usage. In order to provide an incentive for the facilities to make their equipment and services available to ONAMI researchers and the private sector, ONAMI matches the fees the facilities collect from users in order to subsidize these maintenance costs. Private sector users pay commercial rates to use the facilities.

3.4 Signature Researcher Recruitment Program

Although equipment and matching funds are important in competing for research funding, talent is the key ingredient for building Oregon's competitiveness in nanoscience and microtechnology. 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. Attracting top talent requires a substantial investment, not only in salary and benefits, but also in the laboratories and equipment that will enable the scientist to conduct research that will advance their career as well as Oregon's position in nanotechnology.

ONAMI co-invests up to $500,000 with its member institutions to recruit researchers that are most likely to contribute to Oregon's ability to compete now and in the future. ONAMI has committed about $3 million to the recruitment of 5 signature researchers and has 4 active searches.

3.5 Commercialization Gap Financing Program

ONAMI's second key objective is to increase the commercialization of nano- and microtechnologies. As Oregon companies adopt these technologies to develop products and improve processes, they will create new opportunities on the cutting edge of nanotechnology.

To facilitate the transfer of ONAMI technologies into the marketplace, ONAMI awards commercialization gap grants to university researchers who are working directly with a private for-profit company. These grants fill the funding gap between university research and the availability of private funding for technology commercialization.

The goal of these projects is to develop the technology to the point at which the technology is attractive to private investors. ONAMI looks for projects with the potential to attract private capital at least three times the gap fund award within 12 to 18 months. 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.

ONAMI has awarded gap funds to ten projects totaling about $2 million (see Table 3). Most of the companies working with these researchers have also received funding from other sources, such as the Small Business Innovation Research (SBIR) program. 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. 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.

Table 3. Commercialization Gap Fund Recipients and Projects through FY 2008

Gap-Funded Company	University Partner	Gap Fund Amount	Gap-Funded Company	University Partner	Gap Fund Amount
Home Dialysis Plus	OSU	$250,000	Dune Sciences	UO	237,131
CCT	UO	219,440	CNXLs	OSU	50,074
Nanobits	OSU	162,221	Trillium Fiber Fuels	UO	248,000
Mtek	OSU	191,809	Peregine Power	OSU	201,000
Inpria	OSU	249,725	ABP Biodiesel	OSU	174,994

3.6 Federal Funding Agenda

ONAMI has received about $44.5 million in direct federal appropriations for research in areas of specific interest to the federal government. This funding has allowed ONAMI to build research capabilities in its four research thrust areas:

- Microtechnology-Based Energy and Chemical Systems
- Safer Nanomaterials and Nanomanufacturing
- Nanoscale Metrology and Nanoelectronics
- Nanolaminates and Transparent Electronics

The funding provided by these programs is generally awarded through a competitive process within the ONAMI network. Thus, rather than being distributed according to some formula that allows for a certain level of funding for each institution, teams of faculty submit white papers and compete for the funds.

ONAMI has received a total of $10.9 million from FY 2005 to FY 2009 for the Miniature Tactical Energy Systems (TES) program through the Department of Defense. This funding has provided core support for the MECS thrust, which is led jointly by OSU and PNNL. The Department of Defense has also provided funding totaling $13.7 million over five years to support the Safer Nanomaterials and Nanomaufacturing research program, which is led by the University of Oregon. The Nanoscale Metrology and Nanoelectronics program, led by PSU, has received $11 million over four years, beginning in 2006, from the Office of Naval Research. The Army Research Lab also has provided over $8 million to support ONAMI's thrust in Nanolaminates and Transparent Electronics.

4. Analytical Approach to Measuring ONAMI's Impacts

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.

4.1 Primary and Secondary Data Collection

We 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. We 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.

We complemented 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.

We 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.

We 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 4).

Table 4. 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%**

4.2 Cost-Benefit Analysis

Economic benefits were defined as cash inflows into Oregon from federal agencies, foundations, and private-sector companies. These inflows were 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 Defense Advanced Research Projects Agency (DARPA), National Institutes of Health (NIH), and the National Science Foundation (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.

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. Thus, 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.

4.3 Time Period of Analysis

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 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.

5. Quantitative Results

5.1 Proposal Matching Funds

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

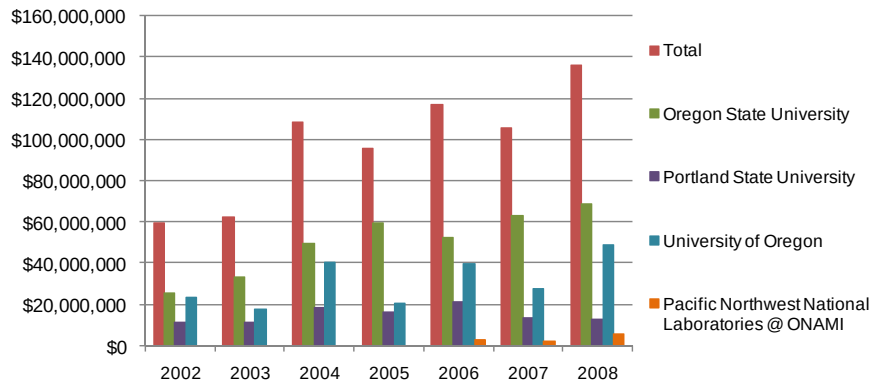
- submitted proposals worth more than $562 million, which corresponds to a compound annual growth rate of 57%;
- received project and grant awards worth $110 million, which corresponds to a annual growth rate of 65%; and

- accounted for $91 million in research activity, which corresponds to an annual growth rate of 78% between 2002 and 2008.[2]

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."

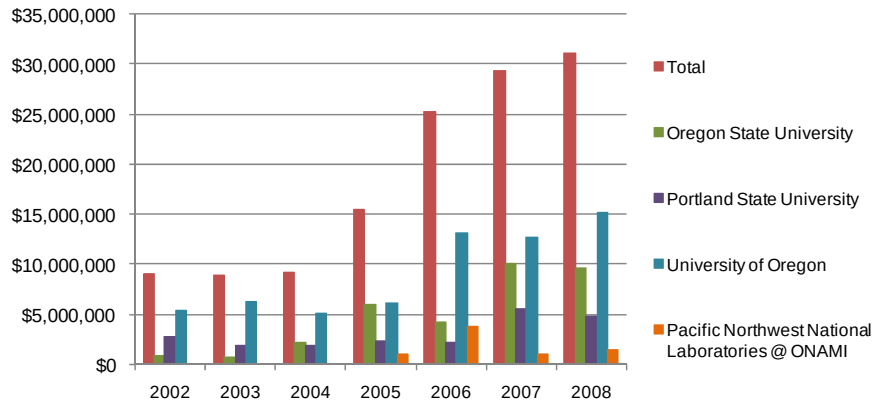
Fifty-five percent of the researchers that responded to the survey indicated that they were involved in proposals that would not have been possible in the absence of ONAMI. Of the $684 million proposals in nanoscience and microtechnology submitted between FY 2002 and FY 2008, survey respondents indicated 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).

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

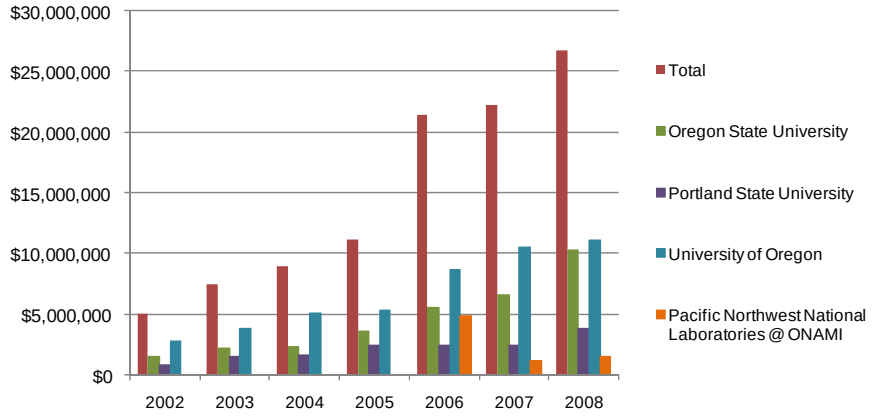


a. Growth in proposal value

[2] 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.



b. Growth in research awards



c. Growth in research expenditures

Researchers provided project information that we were 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 6).

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.

Table 5. ONAMI Members' 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 6. 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.

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 7 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 7. 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.

5.2 Shared Facilities Use

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 8).

Table 8. 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%
Waited until instruments at Oregon-based facility were available for use	4%
Contracted with private vendor in Oregon	—

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.

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 9). 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 9. Private-Sector Users' Perceptions of Facilities' and ONAMI's Impacts and Influence

	Range of Responses (1 = strongly disagree, 7 = strongly agree)	
	Average	**Median**
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
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
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

5.3 Commercialization Gap Financing

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. They indicated that ONAMI assisted them in their ventures, lent a "halo effect" to their research projects and business plans, made their technologies more commercially viable, and improved their probability of success.

ONAMI's impacts on these small businesses expand beyond financing; benefits included introductions to Oregon's financiers and business leaders (see Table 10). 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 10. Gap-Funded Companies' Perception of ONAMI's Impacts and Influence

	Range of Responses (1 = strongly disagree, 7 = strongly agree)	
	Average	**Median**
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

5.4 Private Industry

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. 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. 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 11 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 and revenue that accrued because of a connection ONAMI forged between an Oregon business and a non-Oregon entity.

The table also includes the value of equipment and facility donations provided by Oregon businesses. 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."

Table 11. Time Series of Industry Cash Inflows and Shared Facilities' Non-OUS Revenue

Fiscal Year	Cash Inflows to Oregon to/from Companies ($thousands)	Contributions to ONAMI from Oregon Businesses ($thousands)	Shared Facilities Revenue ($thousands)
2004	$524	$602	—
2005	8,521	1,393	$207
2006	1,340	1,839	369
2007	938	567	252
2008	75	3,314	96[a]
2009[b]	100	1,100	—
2010[b]	100	1,100	—
2011[b]	100	1,100	—
2012[b]	100	1,100	—
2013 and later[b]	524	17,600	—

[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.

- 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.

5.5 Summary Results

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 12 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 12), 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.

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 13 illustrates how inclusion of companies' contributions boosts net benefits by 76% from $39 million to $69 million.[3]

Table 12. Time Series of Benefits, Costs, and Net Benefits, non-Oregon Sources

Fiscal Year	Incremental Awards (Inflows) ($thousands)	Industry Cash Inflows ($thousands)	Shared Facilities—Non-Oregon 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

[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.

The NPV of the time series of net benefits is $26.9 million. The discount rate employed was the conservative 7% social discount rate recommended by the U.S. Office of Management and Budget (OMB) to evaluate publicly funded initiatives. [4] 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.

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).[5]

[3] 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.
[4] See OMB Circular A-94.
[5] Because benefits and costs occur at different time periods, both are expressed in present-value terms before the ratio is calculated.

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. The IRR on ONAMI is within a range observed for other successful technology policy initiatives (Tassey, 2003).[6]

Table 13. 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.

Counting the value of Oregon business' contributions as a benefit impacts performance measures:

- NPV is $42.9 million
- BCR is 2.15
- IRR is 76%

6. Discussion: Learning from the ONAMI Experience

The story of ONAMI is primarily a story of gaining scale economies, enabling the emergence of new research areas, and capturing network spillovers. Just as research parks attempt to take advantage of these factors by collocating researchers, ONAMI has harnessed these forces by sharing infrastructure, leveling disciplinary silos, reducing barriers between universities, and facilitating connections between universities and business. Some of the lessons learned from the ONAMI experience are transferable to

[6] Tassey, Gregory. 2003. Methods for Assessing the Economic Impact of Government R&D. NIST Planning Report 03-01. Gaithersburg, MD: National Institute for Standards and Technology.

other settings; others resulted from circumstances unique to Oregon at the time of ONAMI's development.

ONAMI's pursuit of scale economies in R&D is not new. Consortia of research universities and companies have often developed shared infrastructure to reduce costs. But ONAMI's approach to gathering the required resources was forced, in part, by the political and financial realities facing ONAMI's architects. Oregon is simply too small a state to invest vast sums in research infrastructure. Joint requests from the entire university system, the use of donated equipment and space, and the preference for shared equipment built into the funding model have produced the leverage necessary to build a research infrastructure that allows Oregon to compete with much richer states

ONAMI's combination of competition and collaboration has encouraged the breakdown between disciplinary silos. By favoring collaborative proposals, ONAMI has taken advantage of a collaborative culture that already existed but needed incentives. Because ONAMI does not itself conduct research, it is not seen as a threat or competitor, but rather a facilitator and connector. ONAMI's leadership is able to see potential technical complementarities among the talent within the university system and encourage the interdisciplinary collaboration that has expanded Oregon's research capabilities in new and growing fields such as green chemistry, advanced materials, and micro/nanoelectronics. These research areas build on Oregon's industry strengths while diversifying the economy and keeping its research on the leading edge of the product cycle.

By identifying niche areas in which Oregon can lead and building collaboration in these areas among the universities, ONAMI has enabled Oregon to take a leadership position in several small but important areas of nanotechnology. While higher education is underfunded by 43% compared with Oregon's competitors, the focus these niche areas has provided a competitive advantage and enabled key faculty to gain strong reputations and win important grants.

These niche areas were not chosen randomly; rather, they resulted from a search for the intersection between the problems and solutions of interest to Oregon industry and the strong and unique capabilities of university researchers. This orientation has provided compelling incentives for the participation of Oregon industry leaders who have donated their market knowledge, expertise, space, and equipment to the effort. This industry influence has encouraged a shift in perspective at the research universities, which has been aided by the pursuit of university faculty with extensive industry experience. The longer-term perspective of the university research culture, combined with the market orientation of the industry participants, will lead to the development and commercialization of research that has immediate impact on Oregon's economy while building a pipeline of research results that can be commercialized in the longer term.

ONAMI's long-term strategy requires continued public investment. ONAMI's board of advisors must continuously examine the long-term usefulness of ONAMI's research results to industry and insist on transparency and accountability. But the early estimates of the economic performance of investments in ONAMI indicate that these investments are paying off. With a 56 percent internal rate of return and a benefit-cost ratio of 1.72, the state's investment is ONAMI is reaping strong returns for Oregon's taxpayers.