

**Analysis of reports on impacts and outcomes of
infrastructure projects funded by the Canada
Foundation for Innovation and other funding partners**

Volume 1–Overview

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1 Introduction

This overview summarizes the outcomes and impacts of research infrastructure provided by the Canada Foundation for Innovation to universities, hospitals, colleges and research institutes. The overview is based on the analysis of information found in institutional reports submitted by 67 universities and other institutions and in 796 project reports submitted by project leaders in early 2002. Reports cover outcomes that occurred in 2001.

A second volume presents a more complete analysis of the information. Volume 2 includes an analysis of the outcomes and impacts of each CFI Fund, namely the New Opportunities Fund, the Canada Research Chair Fund, the Innovation Fund, the University Research Development Fund and the College Development Fund. Volume 2 also includes specific examples of outcomes and more quantitative data. Institutional reports are posted on the CFI website, www.innovation.ca.

Institutions were asked to report on the impact of CFI investments in achieving the objectives and priorities of institutional research plans in the past year as well as on the implementation and utilization of the infrastructure.

Project leaders were asked to report on the outcomes of their projects. For example, they had to answer quantitative questions on the impact of the infrastructure in attracting researchers and students and on any benefits to Canada that were realized in the past year. They also submitted a narrative description of the results attributable to the CFI infrastructure.

Some projects were approved in the second half of 2001. Also, many of the infrastructure projects involve the acquisition, construction, development and testing of complex facilities. Therefore, a significant number (357 or 45%) of reports relate to infrastructure that was not fully operational at the end of 2001.

2 The institutional perspective

There is no question that investment in infrastructure by CFI, provincial governments and other partners of the institutions has a major impact on research at Canadian institutions, particularly on:

- > increasing the quality of research and research productivity
- > attracting and retaining excellent faculty members
- > transforming research
- > fostering the development of partnerships with the provinces and others
- > encouraging research planning

- > generating enthusiasm in the research community
- > attracting students and providing them with better training
- > encouraging collaboration and multidisciplinary approaches
- > generating concrete social, economic, health and environmental benefits
- > increasing research funding.

The impacts are growing given the growing investment, of course, but also given that more and more projects are generating interesting results and that students who used the CFI infrastructure are now graduating and finding rewarding jobs.

The synergy between CFI infrastructure and other new programs that fund human resources such as Canada Research Chairs, the Canadian Institutes of Health Research and a plethora of provincial initiatives in some provinces, particularly Ontario, Québec and Alberta, is truly remarkable. This has completely transformed Canadian research, boosted morale, attracted individuals and increasingly made Canadians real partners in international collaborations.

The matching requirements of the CFI have forced universities to seek partners in the funding of infrastructure. A number of universities mention that this has helped them forge new partnerships with their provincial government. Partnerships with industry and with various donors have also been strengthened. However, in some cases, finding matching funding remains very difficult. This is discussed in Chapter 4.

At its inception, CFI made institutional planning a pre-condition to applying for funds. Many institutions commend CFI for this requirement and state that this has helped them focus on their strengths. Not only did CFI encourage institutions to identify their priority areas, it encouraged them to pool resources and join in the development and sharing of infrastructure. This joint planning and sharing is evident across the country but above all in Canada's largest cities that have a number of universities, hospital research institutes and colleges. For example: the British Columbia Institute of Technology, Simon Fraser and the University of British Columbia in Vancouver; and numerous universities and hospital institutes in Montreal. These are only examples; there are many more. In all regions, there is evidence of increased collaboration among institutions of all sizes and types.

CFI has an impact on attracting and retaining faculty members, graduate students and other trainees. The combination of Canada Research Chairs and CFI infrastructure is particularly powerful. It provides institutions with major development tools at the time when they are renewing their faculty complement.

New collaborations are developing around shared infrastructure. This is particularly noticeable in institutions that have moved to a system of major shared facilities. Such facilities also promote the effective management and use of the infrastructure.

Most institutions note the impact of CFI infrastructure on research productivity, mentioning that researchers are now able to add new dimensions to their programs of research and to conduct studies that were previously not possible. CFI enables greater depth and breadth of investigation, in addition to accelerating the research.

All institutions, but especially smaller ones, are convinced that the new infrastructure has already had a major impact on the ability of researchers to obtain research funding from a variety of sources.

3 The researchers' perspective

3.1 Innovative research capability

CFI has provided new researchers with research infrastructure via the New Opportunities Fund. The Canada Research Chair Fund is giving a boost to newly appointed Canada Research Chairs by providing them with the infrastructure they need to initiate or accelerate their research program. Through the Innovation Fund, the University Research Development Fund (for smaller universities) and the College Research Development Fund, CFI has provided institutions with the opportunity to enhance, develop and improve their research capability in their priority areas.

The CFI infrastructure has facilitated the creation or expansion of major centres in genomics, proteomics, bioinformatics, neurosciences, rehabilitation, tissue engineering, medical devices, drugs, information technologies, advanced materials, transportation, earthquakes, geomatics, manufacturing, food, agriculture, aquaculture, water, oceans and environmental sciences to give only a few examples.

The CFI infrastructure has enabled the creation of centralized instrumentation centres in numerous departments and faculties across Canada, particularly in the area of imaging technologies and analytical facilities. It has also facilitated the renewal of campus networks and the creation of high performance computing facilities accessible to researchers across the country.

CFI has contributed to the modernization of animal care facilities. It has contributed to the creation and development of databases on the health and social conditions of Canadians. It has provided clinical researchers in the

biomedical sciences with equipment and infrastructure to study major diseases and conditions. CFI is providing researchers in all disciplines with access to shared library facilities. The list could go on.

3.1.1 Recruitment and retention of faculty

Researchers were asked whether the availability of the infrastructure had been an important factor over the past year in the decision of researchers (faculty members, PDFs and other researchers) to join the institution. The results, given in Table 1, show that CFI had a major impact on attracting researchers in the last year. The impact was most pronounced in the Innovation Fund where 169 of 211 respondents said that the infrastructure had an influence in attracting researchers in the last year.

Table 1–Influence of infrastructure in attracting researchers in 2001*				
	Yes	No	n/a	Total
New Opportunities	286 (66%)	169 (34%)	13	468
Innovation	169 (82%)	37 (18%)	5	211
University Research Development	51 (66%)	26 (34%)	4	81

*In this table and in all the subsequent ones, the percentage applies to the number of projects that answered the question and not to the total number of projects.

Project leaders stressed the importance of the infrastructure in attracting and retaining faculty members, researchers and PDFs. Again and again, project leaders from large and small institutions mention that candidates for positions are excited by the availability of the infrastructure. Many state categorically that this is one of the most important reasons for their success in attracting first class people (faculty members, postdocs and students). Holders of Canada Research Chairs note that the Chair Program and the associated infrastructure played a role in attracting new faculty members in the last year (in addition to attracting/retaining the incumbent). Many New Opportunities researchers state that the infrastructure played a major role in their decision to stay in Canada or to come here (note that, in most instances, this occurred prior to 2001).

3.1.2 Recruitment of students

Project leaders were asked whether, in the past year, the infrastructure contributed to the recruitment of students from outside their institution. For a vast majority of projects, the infrastructure played a role in recruiting students in the last year. About 3% came from the US and 29% from other countries.

Responses show that, for about half of the projects, more than three students were recruited last year.

In general, project leaders are satisfied with the quality of the students they recruited. They give numerous examples of scholarships and awards won by students. On the other hand, some project leaders are disappointed that they were not successful in recruiting students. They note that a number of research projects were delayed because no students were available.

3.1.3 Recruitment of professional and technical staff

Sixty-six percent of respondents mentioned the infrastructure had some influence on the creation of jobs in their groups or laboratories (Table 2). They generally referred to the research assistants, research associates, technicians, postdocs and students who joined in the past year. Most project leaders mention that their group is still growing.

Table 2—Number of projects reporting influence of infrastructure on job creation

No influence	Some	Considerable	Total
229 (36%)	396 (48%)	139 (18%)	764

Of course, the recruitment of professional and technical staff is limited by research funding available and by the availability of funding to operate, maintain and repair the infrastructure, and some project leaders so note in their report.

3.1.4 Access to world competitive infrastructure

In 58% of the projects, more than 3 researchers (faculty, PDFs and other researchers) substantially advanced their research in the past year because of the availability of the infrastructure (see Table 3).

Table 3—Researchers who advanced their research thanks to infrastructure

Number of projects reporting such researchers

1 researcher	2 researchers	3 researchers	>3 researchers	None	Total
65 (9%)	93 (12%)	99 (12%)	463 (58%)	76 (10%)	796

Researchers think highly of the quality of their infrastructure as shown in Table 4:

Table 4—Quality of infrastructure compared to other laboratories

Number of projects stating that the infrastructure is:					
Below average	Average	Above average	Comparable to best in Canada	Comparable to best in the world	No answer
10 (1%)	79 (10%)	135 (17%)	275 (35%)	282 (36%)	15

Researchers stress that their infrastructure allows them to compete with other groups worldwide. Others state that the presence of the infrastructure allowed them to generate results much faster than previously, thus making their group more competitive.

3.1.5 Collaboration

A vast majority of respondents say that the presence of the CFI-supported infrastructure helped them to create, maintain or strengthen collaborations, particularly international collaborations, in the last year (Table 5).

Table 5—Influence of infrastructure on creating/maintaining/strengthening:

	Number of projects reporting			
	No influence	Some influence	Considerable influence	No answer
Informal linkages with colleagues at the institution	19 (4%)	160 (30%)	358 (67%)	259
Research collaborations	17 (3%)	182 (34%)	335 (63%)	262
Formal signed partnerships	219 (43%)	151 (29%)	143 (28%)	283
International collaborations	143 (18%)	376 (48%)	262 (34%)	15

Project leaders describe many of these linkages. They talk about linkages among researchers in the same unit who share infrastructure. They comment that centralization of infrastructure fosters meetings and discussion that often evolve into collaborations. They talk about collaborations between institutions in a region, including universities and colleges. They note that, thanks to the infrastructure, they are better placed to initiate international collaborations and no longer play second fiddle to their international colleagues. They note new collaborations with government labs. They talk about new partnerships with industry and industrial use of the infrastructure. Often, facilities are not purchased off-the-shelf and their development and implementation are a collaborative project with scientific equipment and instrumentation manufacturers.

3.1.6 Creation of, or support for, centres of excellence

Especially through the Innovation Fund, CFI infrastructure contributed to the creation and expansion of numerous centres of excellence. Centres and networks are being created around the infrastructure, a significant number with provincial research funding, for example, in Ontario (Ontario Research and Development Challenge Fund) and Québec (Valorisation-Recherche Québec). Centres funded by Genome Canada and its regional partners are also mentioned.

The infrastructure also helped individual researchers gain access to centres or networks. For example, numerous New Opportunities researchers have been invited to participate in Networks of Centres of Excellence and some of them have played a leading role in the development of winning proposals in the most recent competition. They state that this would not have been possible without the infrastructure. Similarly, researchers in smaller universities note that they have definitely increased their participation in various networks of centres of excellence and Ontario Centres of Excellence. They are also included in multi-institutional projects funded by Valorisation-Recherche Québec.

3.2 Innovative research productivity

New Opportunities researchers who received funding in the first competition held in 1998 are starting to build impressive research records and a significant fraction of them state that the CFI-supported infrastructure helped them generate world-class results as shown in Table 6. In fact, two thirds of respondents from this Fund estimate that their research is at or exceeds international standards (if it is not too early for results):

Table 6—Self-assessment of the quality of research in the last year (New Opportunities Fund)					
Too early	Modest advance	National standards	International Standards	Breakthrough	No answer
32	32	61 (14%)	74 (19%)	223 (52%)	4

In the case of the Innovation Fund, 71% of the projects for which it is not too early to tell report research that is at or exceeds international standards.

One recurring comment in the case of New Opportunities is that the new infrastructure enables researchers to start their research program more quickly and to generate high quality results faster and more effectively than they would have otherwise.

In the narrative part of the report, some researchers chose to list the numerous publications and presentations they generated with the help of CFI-funded infrastructure. Others have stressed the high quality and impact of their discoveries, mentioning invitations to international conferences, noting that results had received international press coverage and referring to increasing grant support.

Researchers were invited to talk about the level of risk in the research undertaken. There is a difference in approach among respondents. Indeed, some researchers believe that taking risks early in their career could jeopardize future chances of research funding. Others are taking the gamble and saying that the infrastructure helped them in this regard as they could get better results faster. Some project leaders take a middle-of-the-road-approach, conducting both longer-term high risk projects that “push the envelope” and projects that generate results in a shorter time frame. Many state that, without the infrastructure, they would not be able to enter relatively unexplored areas.

3.3 Multidisciplinary nature of research activities

Without any doubt, the most striking outcome of CFI is its major influence on fostering multidisciplinary research.

No less than 96% of respondents from all Funds replied that the availability of the infrastructure had enhanced their opportunities for interdisciplinary research in the last year:

Table 7—Number of projects reporting that interdisciplinary research has been enhanced		
No	Somewhat	Considerably
30 (4%)	295 (38%)	456 (58%)

There are synergies between medicine and science, engineering and social sciences, between basic researchers and clinicians, computer scientists and researchers from numerous other disciplines. Furthermore, techniques honed in one discipline are used to solve problems in another.

3.4 Training for research and other careers

Very large numbers of students at all levels utilize the infrastructure. A majority of projects in the Innovation Fund involve three or more graduate students.

Students are trained in a multidisciplinary environment and researchers are convinced that their trainees are gaining skills that will help them find employment.

Again and again, researchers stress that the multidisciplinary environment prepares students very well for careers in industry. Students who have used CFI infrastructure are starting to graduate and they indeed find jobs. In fact, researchers are quite proud of the employment record of their graduating students. Only a handful mention that their students had spent some time looking for work. A number of researchers note that graduating students choose to continue their studies abroad or find employment abroad. The lure of lucrative jobs in the United States and elsewhere is still there.

3.5 Benefits to Canada

Table 8 indicates the number of projects reporting various types of benefits enabled by the infrastructure in the last year. Only about 120 projects did not report any benefits in the last year. The majority are projects that are not fully operational or projects that became operational in 2001.

Table 8—Benefits enabled by the availability of the infrastructure				
	# of projects reporting no benefits	# of projects reporting some benefits	# of projects reporting considerable benefits	No answer
Intellectual property	451 (59%)	208 (27%)	103 (14%)	34
Products and services	344 (45%)	279 (36%)	143 (19%)	30
Spin-off companies	632 (84%)	90 (12%)	33 (4%)	41
Cost savings	315 (42%)	311 (41%)	130 (17%)	40
Public policy improvements	599 (80%)	127 (17%)	25 (3%)	45
Health benefits	460 (61%)	249 (33%)	48 (6%)	39
Social benefits	574 (77%)	152 (20%)	22 (3%)	48
Environmental benefits	500 (67%)	175 (23%)	71 (10%)	50

Among the projects that mention intellectual property, most report patents (applied for and granted), some mention software, others licences. A number of patents resulted from collaborative work with companies. The infrastructure helped 422 projects with the development of new or improved products, processes or services. The examples below show that these projects represent an interesting range of devices, stemming from research in many disciplines.

Examples of products and processes improved or developed using CFI infrastructure in 2001

Chemical manufacturing processes that will lead to cleaner and more efficient manufacturing technologies

Improvements to electric motors and magnetic materials; processes for dehydrating food; design of automotive components; manufacturing and assembly operations in the electronics industry; products being used in fracture fixation for medical applications

Design and construction of a robot for neurosurgery

Enhancements to the efficiency of seismic imaging and the resulting resource exploration

Development of protective eyewear for electrical utility workers

Powder coating and pulmonary drug delivery technologies

New protocols for the analysis of inorganic compounds

Table 8 shows that the infrastructure contributed to the creation of spin-off companies in 123 projects. Examples include companies in medical applications, biotechnology, genomics, proteomics, veterinary immunotherapies, bioinformatics, software, information technologies, optoelectronics and nanotechnology. It is unlikely that 123 infrastructure projects led to the creation of spin-off companies in the last year alone. In reading the reports, it is obvious that respondents mentioned companies created since the infrastructure first became operational as well as companies that are at an early stage of planning. One must also remember that this does not mean 123 companies, but 123 projects. Some researchers who created companies are involved in more than one project.

With a few exceptions, the question on cost savings was interpreted not as long-term cost savings to the Canadian economy thanks to project outcomes (e.g., saving in health, education or correctional costs), but cost savings in the labs, due to the fact that the research is more effective and efficient.

Table 8 shows that a substantial number of researchers state that the infrastructure contributed to the generation of health improvements, policy improvements and social benefits. However, in the narrative part of the reports, it is evident that the real impact and benefits for Canadians lie mainly in the future. Indeed, in these areas, the time lag between the actual research and the

outcomes is longer than in the “high tech” area (including information technology, advanced materials and biotechnology) where patents, spin-offs and process improvements can occur in a relatively short time frame.

Interesting outcomes were obtained in the environmental area, for example, with respect to monitoring environmental changes, bioremediation, air pollution, mercury and other metal pollution, potable water treatment, forest management, nuclear waste disposal, etc.

3.6 Awards, recognition (international, domestic)

The leverage effect of CFI infrastructure is impressive. Respondents are convinced that the infrastructure has helped them increase their funding in the last year. In the opinion of project leaders, most impressive is the influence of the infrastructure on federal granting agency, provincial and industrial research funding.

Table 9—Impact of the infrastructure on the ability of its users to attract funds (leverage)				
Funding source	# of projects with no CFI influence	# of projects with some CFI influence	# of projects with considerable CFI influence	No answer
Institution	215 (28%)	333 (44%)	212 (28%)	36
Federal granting agencies	110 (14%)	227 (29%)	434 (56%)	25
Other federal	327 (46%)	179 (25%)	198 (28%)	92
Provincial government	191 (25%)	214 (28%)	346 (46%)	45
Canadian industry	298 (40%)	239 (32%)	208 (28%)	51
International	356 (50%)	208 (29%)	153 (21%)	79

An impressive number of New Opportunities researchers have subsequently been awarded Canada Research Chairs. In part, they attribute their success in the Chair Program to the availability of the infrastructure, which helped them increase their research productivity early in their careers.

As well, project leaders and other principal investigators in the Innovation and University Research Development Funds have received Chairs.

Respondents also mention numerous prizes and awards as well as invitations to prestigious international conferences.

Finally, a number of researchers mention that their research has been featured in various media in the past year.

4 Implementation and utilization issues

Institutions were asked to discuss delays in implementation or utilization issues in their reports. In the narrative part of their reports, researchers were invited to describe measures taken to ensure the efficient management, use and sharing of the infrastructure. They were asked to describe any delays in implementing their projects and to comment on whether or not the infrastructure was adequately utilized.

4.1 Implementation

Institutions report that implementation took longer than anticipated, and listed numerous reasons for delays: long delay before award finalization by CFI, delays in securing matching funds or in receiving such funds (from province or industry), delays in obtaining approval from the province, backlog with construction projects on campus, construction and renovation delays, lack of administrative resources, long regulatory approval process, lack of space, complex planning of complex projects, delays in delivery of equipment, defective equipment, changes in technology, lack of personnel. In total, perhaps 60% of the projects experienced delays.

This long list looks like a disaster story, but as shown from the impressive list of outcomes, most of these delays were overcome and the infrastructure is now up and running except for more recent projects and “older” very large and complex projects.

In general, smaller projects face shorter delays whereas delays of one year or more are not unusual for larger projects involving construction. Major construction projects take time even when there are no major delays. Therefore, a number of very large infrastructure projects funded in the first CFI competition are not fully operational yet. In such instances, equipment has been purchased and is used for research but benefits of the infrastructure will increase when all the user groups occupy the new space.

Provincial matching funding remains a potential challenge for institutions implementing their CFI-funded projects. In British Columbia, the change in government, which entailed a complete program review, delayed the approval of matching funding by several months. In Atlantic Canada, finding matching funding has been difficult and some institutions are unable to begin implementation of approved projects because they are still awaiting word on matching funding from various levels of government. These institutions are

working hard with their provincial government and federal organizations to find the necessary resources to initiate these projects¹.

4.2 Utilization

In general, institutions report that infrastructure is used adequately, with a small number of projects where infrastructure is under-utilized and some where the infrastructure is so heavily used that they cannot meet demand. One university is organizing workshops to “advertise” under-utilized infrastructure to a broader community of potential users.

Quantitative data from project reports confirm the institutional assessment: 89% of projects are used appropriately or are even oversubscribed (Table 10).

Table 10—Utilization of infrastructure			
Under-utilized	Adequate	Over-subscribed	No answer
85 (11%)	578 (75%)	112 (14%)	85 (11%)

Fifty-five of the 85 projects where infrastructure is under-utilized give completion dates in the future. The others give a variety of explanations, although essentially the reason is a lack of personnel to operate and use the infrastructure:

- > faculty turnover;
- > maternity leave;
- > lack of students;
- > high teaching loads mean that equipment is fully used in the summer only (this is mentioned by respondents from smaller institutions);
- > insufficient technical staff;
- > use depends on the stage of the research;
- > reluctance of colleagues to pay user fees.

Some of the 578 respondents who state that their infrastructure is used adequately hint at under-utilization in the narrative part of the report. They generally say that they expect that use will increase in the next year because they will find the necessary human or financial resources to enlarge their group. Some new researchers would like to have more graduate students. In such cases, the barrier is not always the lack of funds, but the lack of student applications given that their laboratory is relatively new.

¹ At the time of writing this analysis (April 2002) there is renewed hope that a solution will be found shortly, with some provincial governments and the federal government developing mechanisms to overcome the issue.

Nevertheless, it is obvious that lack of staff and lack of funds cause problems in a number of cases and this may eventually lead to under-utilization, especially if equipment cannot be maintained in a timely fashion. The CFI Operating Fund will help future projects, but not most of those who reported this year because this new Fund applies only to infrastructure projects approved after mid-2001. Indeed, in institutional reports, several universities mention that it has been a struggle to find operating funds and they are happy that CFI will now contribute to funding these costs.

4.3 Management of the infrastructure

A number of institutions, large and small, are strong proponents of shared, centralized facilities. They consider this the best means to ensure an efficient and economical use of complex infrastructure. It also facilitates the sharing of infrastructure.

For the most part, larger projects have formal management structures with a manager in charge and, often, with management committees. Smaller infrastructure is managed by the principal investigator(s) and shared on an informal basis.

If there are problems, they are due to lack of personnel to operate, maintain and repair the infrastructure.

5 Conclusion

This overview of the 2002 institutional and project reports submitted to CFI has shown that CFI-funded infrastructure is having a major impact on research and that research results are starting to generate benefits to Canada. This confirms the conclusions of the recent independent evaluation of the New Opportunities Fund.

Institutional reports mention the impact of CFI not only in leveraging matching funding for the infrastructure, but its effects on increasing provincial government investments in research as well. The fact that research planning is now commonplace in Canadian research institutions can also be linked directly to CFI requirement for research plans.

CFI investments have enhanced considerably the ability of institutions to attract and retain faculty members and researchers. The coupling of Canada Research Chairs and CFI infrastructure is increasing this impact by providing universities with better tools to renew their research workforce.

Not only is CFI influencing research capacity, it is also helping to transform the way research is done. Perhaps most remarkable is the impact on interdisciplinary research, where 96% of respondents state that the availability of the infrastructure had some or considerable influence on the interdisciplinary character of the research.

The nature and quality of training given to students and other trainees is also enhanced by their exposure to state-of-the-art infrastructure. Again and again, researchers comment that graduating students are better prepared for employment.

The availability of state-of-the-art infrastructure also helps increase the quality of research, as results are more reliable and can be generated faster. As a result, research productivity is enhanced.

The research conducted with CFI infrastructure is starting to generate benefits to Canada in terms of the development of products and services, creation of intellectual property, health, social and environmental benefits. Reports promise more in the future.

Clearly, the CFI is achieving its intended objectives. However, there are some implementation problems. A significant proportion of projects experience delays. In some cases, these are due to difficulties in finding matching funding. In others, these are due to unforeseen complexity and increased costs.

Overall, infrastructure is used adequately but there is a danger of underutilization for lack of human and financial resources. The new CFI Infrastructure Operating Fund will help solve the situation for new projects but projects approved prior to mid-2001 (those that reported this year) will not benefit from this fund.