Research Manitoba

# Taking stock: research and knowledge translation in Manitoba

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# TABLE OF CONTENTS

## Appendices



## List of Tables



## List of Figures

## List of Acronyms

| | |
|---|---|
| CAHS | Canadian Academy of Health Sciences |
| CANARIE | Canadian Advanced Networks for the Advancement of Research in Industry and Education |
| CARIC | Consortium for Aerospace Research and Innovation in Canada |
| CARSI | Centre for Applied Research in Sustainable Development |
| CASRAI | Consortia Advancing Standards in Research Administration Information |
| CAUBO | Canadian Association of University Business Officers |
| CHRR | Centre for Human Rights Research Initiative |
| CFI | Canada Foundation for Innovation |
| CHI | Centre for Healthcare Innovation |
| CIC | Composites Innovation Centre |
| CIHR | Canadian Institutes of Health Research |
| CISTI | Canada Institute for Scientific and Technical Information |
| CRA | Canada Revenue Agency |
| CSB | Commercialization Support for Business |
| EM | Entrepreneurship Manitoba (formerly Entrepreneurship, Training and Trade) |
| GARDN | Green Aviation Research & Development Network |
| GCCRD | Genomic Center for Cancer Research and Diagnosis |
| HSC | Health Sciences Centre |
| ICID | International Centre for Infectious Diseases |
| ICTAM | Information and Communications Technology Association of Manitoba |
| IIC | Internet Innovation Centre |
| IP | Intellectual property |
| ITC | Industrial Technology Centre |
| KT | Knowledge translation |
| LSAM | Life Sciences Association of Manitoba |
| MAFRD | Manitoba Agriculture, Food and Rural Development |
| MAHRN | Manitoba Agri-Health Research Network |
| MCHP | Manitoba Centre for Health Policy |
| MEMS | Microelectromechanical Systems |
| MIT | Manitoba infrastructure and Transportation |
| MITC | Manitoba Industrial Technology Centre |
| MAA | Manitoba Aerospace Association |
| NAPHRO | National Alliance of Provincial Health Research Organizations |
| NML | National Microbiology Lab |
| NMM | New Media Manitoba |
| NRC | National Research Council |
| NSERC | Natural Sciences & Engineering Research Council |
| OECD | Organization for Economic Co-operation and Development |
| OIC | Orthopaedic Innovation Centre |
| PAMI | Prairie Agricultural Machinery Institute |
| PHSI | Partnerships for Health System Improvement (PHSI) Program |

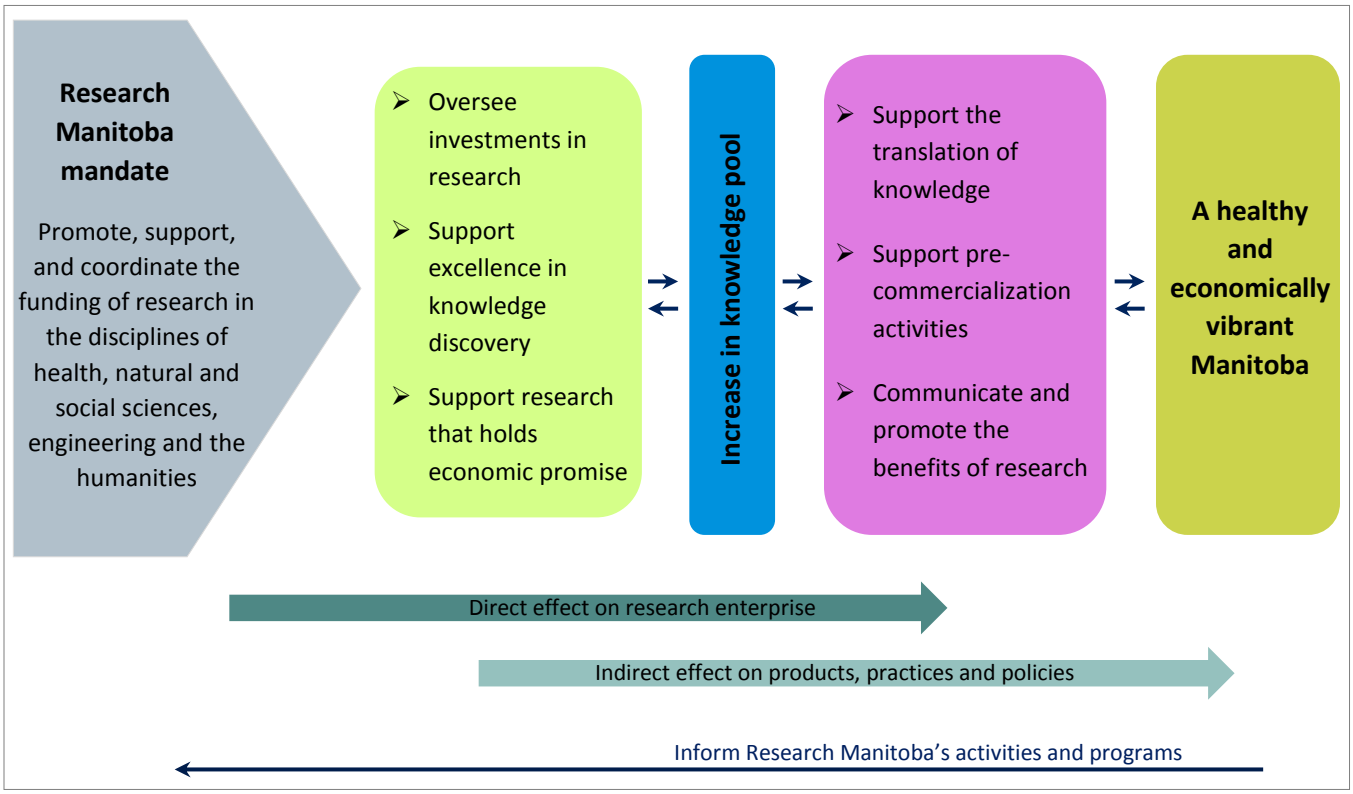
| | |
|---|---|
| RAC | Research Advisory Council |
| SIM | Structural illumination microscopy |
| SIRI | Strategic Investments in Research and Innovation |
| SPM | Scanning probe microscopy |
| SPOR | Strategy for Patient Oriented Research |
| SR&ED | Scientific Research and Experimental Development |
| SSHRC | Social Sciences & Humanities Research Council |
| SWOT | Strengths, weaknesses, opportunities, threats |
| TTO | Technology Transfer Office |
| U of M | University of Manitoba |
| U of W | University of Winnipeg |
| USPTO | US Patent and Trademark Office |
| VC | Venture capital |

# PART 1 – BACKGROUND

## 1. Research Manitoba's support to the research enterprise

The mandate of Research Manitoba is to promote and support, and coordinate the funding of research in the health, natural and social sciences, engineering and the humanities in Manitoba, towards a healthy and economically vibrant Manitoba.[1] It does this by directly supporting the creation of knowledge and the contribution to the knowledge pool through its investments in research, emphasizing excellence in research (Figure 1). In addition, Research Manitoba encourages and facilitates knowledge translation (KT). KT, as defined by CIHR, is a dynamic and iterative process that includes synthesis, dissemination, exchange, and ethically-sound application of knowledge to improve the quality of life of Canadians, and provide more effective services and products and strengthen existing systems.[2] For the purposes of this document, KT is the umbrella term for all of the activities involved in moving research from the laboratory or research institution into the hands of people and organizations who can put it to practical use[3].

Figure 1. Research Manitoba's support to the research enterprise[4]




[1] This was the vision identified by the provincial health research strategy in 2006.

[2] Adapted from CIHR definition of knowledge translation.

[3] Definition broadened and adapted from CIHR definition of Knowledge Translation

[4] The colored boxes (except the mandate) correspond to the five categories of the Canadian Academy of Health Sciences (CAHS) impact framework: the first is building capacity, the second advancing knowledge, the third informing decision making, and the last health benefits and broad socio-economic impacts (see Appendix 1). In light of Research Manitoba's broader mandate, the health impacts have been subsumed under the category "benefits and improvements".

In the context of Research Manitoba's mandate, there are two major pathways in KT. One is the path to commercialization. Commercialization is everything a firm does that transforms knowledge and technology into new goods, processes or services to satisfy market demands.[5] In other words, it is a process by which a new product or service is developed for, and ultimately enters the market. It takes time and money to develop research that happens in a lab, into a product ready for commercial use. Commercialization is crucial to supporting the innovation necessary for economic growth. The other path of knowledge translation involves translating research into benefits and improvements for society, which includes changes in policies, programming, practice, interventions, and changes in awareness.

Through the support of knowledge translation activities, Research Manitoba aims to increase the uptake of knowledge in decision and policy making, and the improvement and/or development of products and services.

As outlined in a mandate letter from the Minister of Jobs and the Economy dated 30 September 2014, Research Manitoba will:

- Develop, coordinate, and implement a provincial research strategy and major funding programs;
- Focus on research being conducted in Manitoba's post-secondary institutions, including affiliated research centres, hospitals, and not-for profit organizations;
- Encourage the creation of partnership that will better leverage funding from national and international programs and industry;
- Focus on existing strengths and emerging opportunities towards advancing Manitoba's position as a national and international leader;
- Ensure research funding is awarded in strategic areas that align with provincial priorities;
- Invest in activities that will generate knowledge with the potential translated to improve the health of Manitobans or to be commercialized into value added products and services of benefit to Manitoba's economy; and
- Support pre-commercialization activities designed to improve the competitive position of Manitoba's applied research organizations such that Manitoba industries may be indirectly assisting in accelerating the pace of innovation;
- Take an advisory and coordination role for programming activities across research disciplines; and
- Communicate and promote the benefits of research.

## a. Governance structure

Research Manitoba is a provincial agency, created by the Research Manitoba Act in 2014.

Research Manitoba reports to the Minister of Jobs and the Economy. The Chair of the Board is Dr. Brian Postl, Dean, Faculty of Health Sciences, University of Manitoba.

The business and affairs of Research Manitoba are managed by a board of directors consisting of at least 9 but not more than 17 directors. The directors are to be appointed by the Lieutenant Governor in Council on the recommendation of the minister.

[5] This is the definition used by the Centres of Excellence for the Commercialization of Research (CECR) 2014.

## b. Programs, initiatives and activities, budget

### Programs, initiatives

Research Manitoba has the following funding programs, the awardees of which are determined through a rigorous peer review process:

| Programs | Description |
|---|---|
| Operating Grant for new investigators (health) | Helps establish independent health research programs within the province and achieve the research productivity necessary for obtaining longer term and more substantial funding from national and other external agencies |
| Operating Grant for mid-career investigators (health) | Helps established health research programs within the province develop and/or re-establish key components of research programs that will increase success in obtaining funding from national and other external agencies |
| Applied Health Services Research Grants | Supports applied health services research, which is relevant to the health system in Manitoba and to support collaborations between policy, makers, service providers and researchers interested in working together to address health system challenges |
| Collaborative Research Team/Cluster Program (health) | Supports multidisciplinary health research programs, which have a specific major objective/basic theme and are innovative and cutting-edge research that advances Manitoba as a national/international leader in the field |
| Manitoba Partnership Program (health) | Supports grant applications that are judged to be of high scientific merit through peer review but are below the funding capacity of CIHR's base budget, and to increase the chances of success in the next submission |
| Bridge Funding Program (health) | Allows investigators who have recently lost funding, after a sustained period of support from a national funding agency, to maintain their research program for up to one year while attempting to regain their funding by re-application |
| Trainee programs (graduate studentships, postdoctoral awards, clinical fellowships, PhD dissertation award) in health | Support for post-graduate students and postdoctoral fellows to prepare for careers as independent health researchers, in industry or within the health system |
| Partnerships for Health System Improvement (PHSI) Program | In partnership with CIHR, this supports teams of researchers and decision makers interested in conducting applied health research useful to health system managers and or policy makers |
| Manitoba Dementia Research Chair | In partnership with the Alzheimer Society of Manitoba, the Chair will increase the profile and productivity of dementia research in Manitoba |
| Canada Foundation for Innovation (CFI) matching program | Provides matching funds (40% of project total) for proposals that have been awarded grants through one of CFI's competitions |
| Strategic Investments in Research and | Supports proposals that fill a strategic, system-wide gap |

| | |
|---|---|
| Innovation (SIRI) | or promise a significant system-wide impact by looking beyond one particular research or innovation question |
| Manitoba Centres of Excellence Fund | Supports research activities that are associated with large networks funded by the federal Networks of Centres of Excellence Program |
| Health Research Initiative | Supports the indirect costs of research |
| Research Connections Program | Supports research conferences, workshops, research days, and like events to promote advancement of research, and exchange linkages between and among researchers and others |

Research Manitoba also supports the following initiatives:

| Initiative | Description |
|---|---|
| Strategy for Patient Oriented Research (SPOR) | Ensure the translation of innovative, diagnostic, and therapeutic approaches to the point-of-care, as well as to help the health system in Manitoba meet the challenge of delivering high quality, cost-effective health care |
| Consortia Advancing Standards in Research Administration Information (CASRAI) | Research Manitoba supports CASRAI in standardizing the data that researchers, their institutions and their funders must produce, store, exchange, and process throughout the life-cycle of research activity |
| National Alliance of Provincial Health Research Organizations (NAPHRO) | The alliance aims to promote increased dialogue, linkages, and partnership activities. Sharing of information and identifying potential opportunities for working collaboratively on common issues is carried out on a regular basis |

## Activities

Research Manitoba's coordinating role has revolved around the following recent activities:

| Activities | Description |
|---|---|
| Indirect costs of research | Working with the Centre for Healthcare Innovation (CHI), the aim is to clearly define the issues and begin to develop potential solutions that will be recommended to the Province of Manitoba |
| Rx&D | Research Manitoba and Manitoba Health are working to follow up on issues and concerns identified by the by the research intensive pharmaceutical industry in Canada (Rx&D) to develop a plan to improve access to data and to enhance the relationship and communication between Rx&D and health professionals and health researchers |
| Enhancing clinical trials and access to data in Manitoba | At the request of the Ministers of Health, Healthy Living and Seniors, and the Jobs and the Economy, Research Manitoba will convene a steering committee to review the current barriers to accessing data in Manitoba and to barriers hampering clinical trial activity in the province |

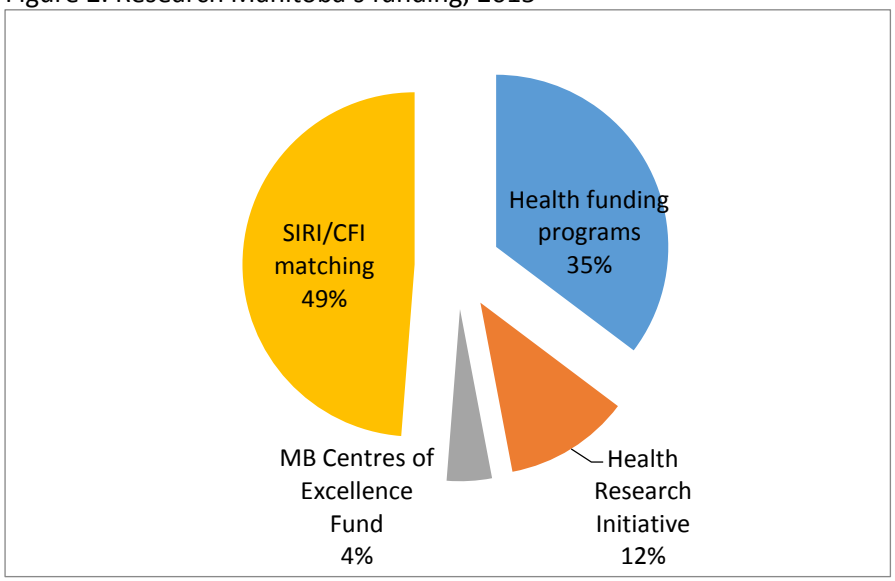
Communicating the benefits of research as well as measuring impact are regular activities that Research Manitoba undertakes. Communicating the value and benefits of research is carried out with stakeholders and the public through publications (Wave, press releases), an online newsletter, social media (Twitter, Facebook, and a blog), and sponsorships.

Research Manitoba has adapted the Canadian Academy of Health Sciences (CAHS) impact framework to monitor and evaluate the impacts of supported research at the individual, group/institutional and provincial levels. Additionally, Research Manitoba undertakes evaluation of its programs. In 2014, it carried out a funding objectives review for all its health funding programs with the goal of determining a better way to support the health research enterprise. A working group with members drawn from Research Manitoba's Research Advisory Council (RAC) led the review. The perspective of the wider health research community was solicited through a survey and examined further in focus group discussions. Important changes that came out of the review were a) the integration of two programs that supports new and mid-career researchers; b) realignment of the objectives of the programs; and, c) revisions in the eligibility criteria in both programs.

## Budget

The annual budget of Research Manitoba is $17M. Nearly half of Research Manitoba's funding is allocated to the CFI matching program and SIRI, a third goes to health funding programs and the rest to Health Research Initiative and the Manitoba Centres of Excellence Fund (Figure 2).

Figure 2. Research Manitoba's funding, 2015




Demand for Research Manitoba funding has grown over the years as indicated by a) the rise in requests for matching funds in recent years, b) request for funding for research projects in a wide variety of applications and disciplines, and c) the declining success rates in the annual competition of Research Manitoba's health funding programs. Success rates in these programs went down from 48% in 2007 to 23% in 2014.

## 2. About the report

The objectives of the environmental scan are as follows:

- Determine the current status of the province's research enterprise,
- Determine how discoveries and research findings are being translated/used,
- Identify the external events/changes that affect Manitoba's research enterprise,
- Identify its strengths and weaknesses, and
- Identify the opportunities and threats facing Manitoba's research enterprise.

In doing the environmental scan, Research Manitoba's internal team adapted the CAHS impact framework to reflect the spectrum of its mandate – supporting knowledge generation to supporting the translation of knowledge into action, from its uptake in professional/clinical practice, program development, and decision/policy making to commercialization activities. In knowledge generation, the team determined the current status of the research enterprise by looking at the inputs (funding, research platforms, researchers, and post-secondary graduates), outputs (publications and patents), and the stakeholders involved; the same was done for knowledge translation.

Data came from the following sources:

- Research Manitoba's reports and databases
- Office of Research Services, University of Manitoba
- Office of Research Services, Brandon University
- Research Implementation, University of Winnipeg
- Canadian Institutes of Health Research funding database
- Natural Sciences and Engineering Research Council funding database
- Social Sciences and Humanities Research Council funding database
- Canada Foundation for Innovation
- Statistics Canada
- Canadian Association of University Business Officers (CAUBO)
- National Alliance of Provincial Health Research Organizations (NAPHRO)
- SciVal, a tool that assesses an entity's performance from bibliometric data
- Published reports, strategic plans, provincial priorities

Because of the multiple sources of data, the period being reported for a set of data may vary. For instance, funding data covers the period between 2000 and 2013 for NSERC and SSHRC, while patent data is available for 2001 to 2011.

Questions that the team wanted to answer in the environmental scan are:

- How does Manitoba compare with the rest of the Canadian provinces in terms of inputs into and the outputs of the research enterprise?
- What are Manitoba's areas of research strengths?
- What policies, events and changes in the environment influence Manitoba's research enterprise?

This document is the first iteration in establishing the current status of the Manitoba research enterprise, and a very preliminary strengths, weaknesses, opportunities, and threats (SWOT) analysis. The scan is divided in two: the first part presents the state of the research enterprise, knowledge translation and pre-commercialization activities organized around inputs, outputs the stakeholders; and

the second part is about the factors and events that affect the provincial research enterprise. The last section of the report presents the preliminary SWOT analysis.

Additional data is being requested (e.g. number of researchers, types of programs etc.) from Manitoba institutions and national agencies like NSERC. Nevertheless, this report **still has many data gaps**, which can/will be rectified with the contributions of the Board members and other readers/stakeholders.

# PART 2 – THE STATE OF MANITOBA'S RESEARCH ENTERPRISE

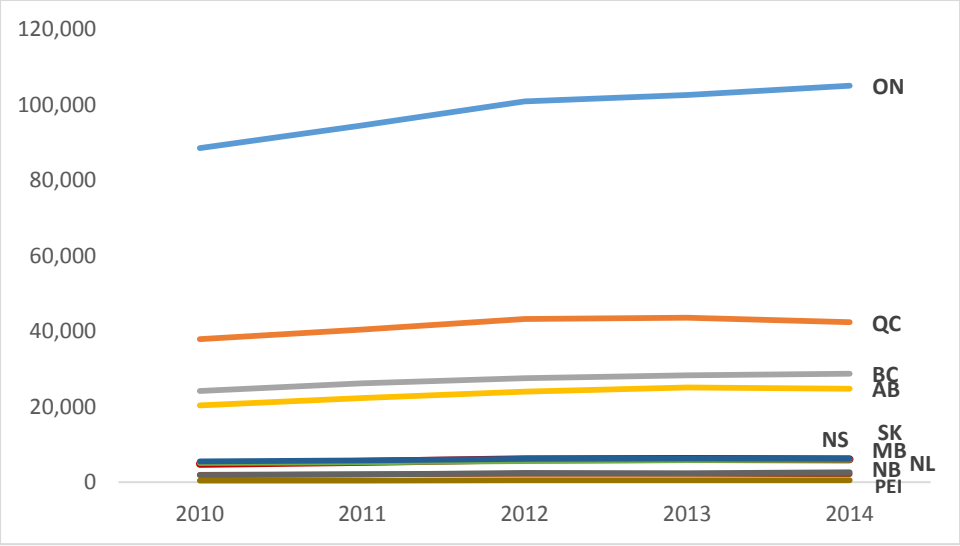
## 1. Knowledge generation

### a. Inputs into the research enterprise

#### Researchers[6]

Researchers are the drivers of the research enterprise. They conceive of different kinds of research in myriad subject areas, find funding to operationalize their research, collaborate with colleagues within and outside Canada, mentor students and fellows, and produce discoveries that lead to health and socio-economic impacts, and contribute to the national and global knowledge pool. Between 2010 and 2014, the highest concentration of published researchers is in Ontario (Figure 3), having two and a half as many as Quebec and four times as many as British Columbia and Alberta.

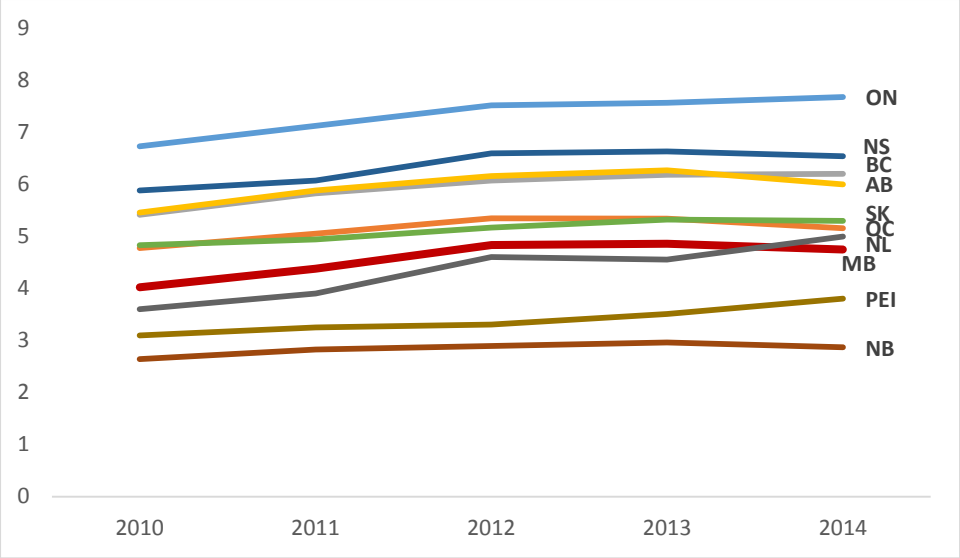
Figure 3. Number of researchers by province




[6] The number of authors in SciVal is used as a proxy for number of researchers. This limits the estimate to published researchers. Double counting happens since a researcher can publish in multiple years and papers can be published in more than one journal; also a subfield can be in more than one field e.g. Statistics and Probability is in the fields of Decision Sciences and Mathematics. These estimates are being presented to provide one of the indicators of the size of the research enterprise. This data has been requested from the University of Manitoba, University of Winnipeg, and Brandon University.

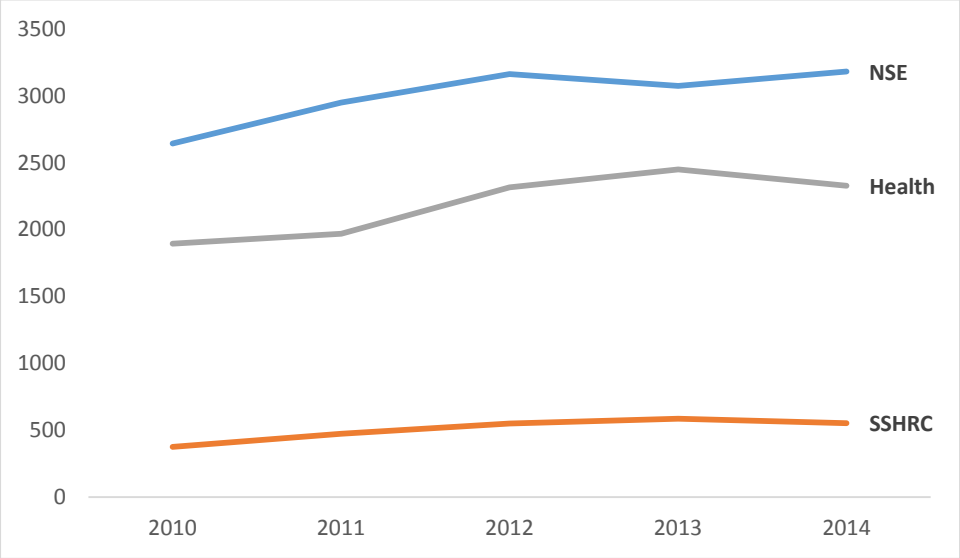
Adjusting for variations, Ontario still has the highest number of researchers per thousand population at seven, followed by British Columbia, Alberta, and Nova Scotia with six each (Figure 4). Manitoba has five researchers per thousand population, the same as Quebec and Saskatchewan.

Figure 4. Number of researchers by province per 1,000 population



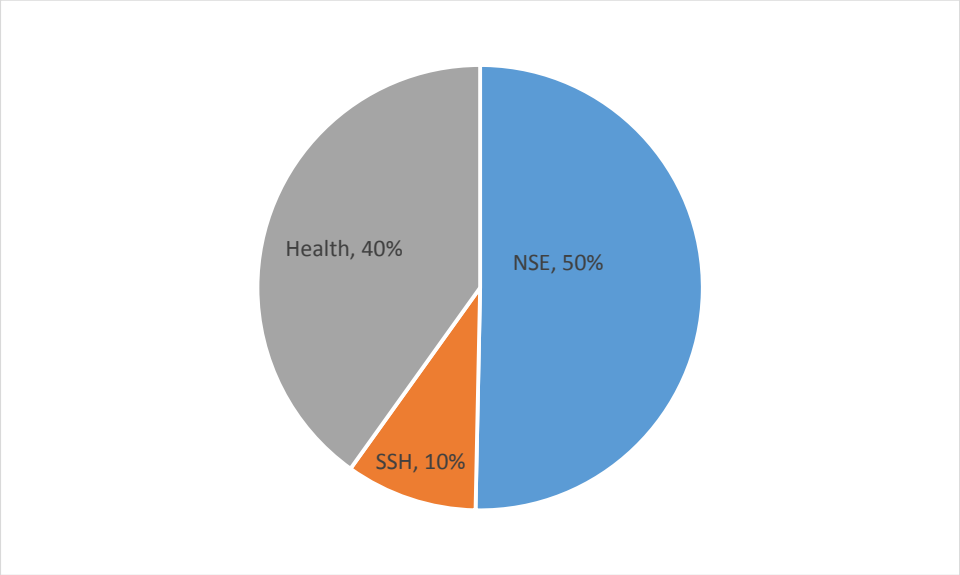

The number of researchers in Manitoba has gradually increased between 2010 and 2014 (Figure 5). The social sciences and humanities sector (SSH) has shown the highest increase at 11% during the same period while in health and the natural sciences and engineering (NSE), the increase has been about the same at 5% and 6%, respectively.

Figure 5. Number of Manitoba researchers by sector



50% of Manitoba researchers who are published are in the natural sciences and engineering, 40% in health, and the rest in the social sciences and humanities (Figure 6).

Figure 6. Distribution of Manitoba researchers by sector, 2013




## Funding

Funding from sources such as federal agencies, provincial funding organizations, and not-for-profit organizations and many others support the performance of research. It can also be used as a measure of research excellence.[7]

As can be seen in the discussion below, Canada's provinces can be divided into the big four (Ontario, Quebec, British Columbia, and Alberta), the middle three (Manitoba, Nova Scotia, and Saskatchewan), and the smaller provinces (Newfoundland & Labrador, New Brunswick, and Prince Edward Island). From 2000 to 2013, the big four took the lion's share of total funding (Figure 7) at 91% or a combined total of $17.8 billion ($1.3 billion/year), with the rest ($1.8 billion or $126 million/year) going to the other provinces.

Distinct groupings that displays when looking at the total value of funding dollars in each province is not as evident when per capita funding is considered (Figure 8). The big four still have the highest per capita funding (Quebec with $49, Ontario $45, British Columbia $43, and Alberta with $39), but Nova Scotia also has a high per capita funding of $40. Manitoba averaged $27 per capita funding, ranking seventh after Saskatchewan, which had a per capita funding of $30. Spikes in funding such as for most provinces in 2002 and for Saskatchewan was due to funding from CFI that are higher in some years coinciding with CFI's competition every two years.

[7] Paul Jarvey and Alex Usher (2012), Measuring Academic Research in Canada: Field-Normalized Academic Rankings 2012. Toronto: Higher Education Strategy Associates. from http://higheredstrategy.com/wp-content/uploads/2012/08/rankings2012.pdf accessed 4 May 2015

Figure 7. Total (CIHR, NSERC, SSHRC, CFI) funding by province ('000 $)

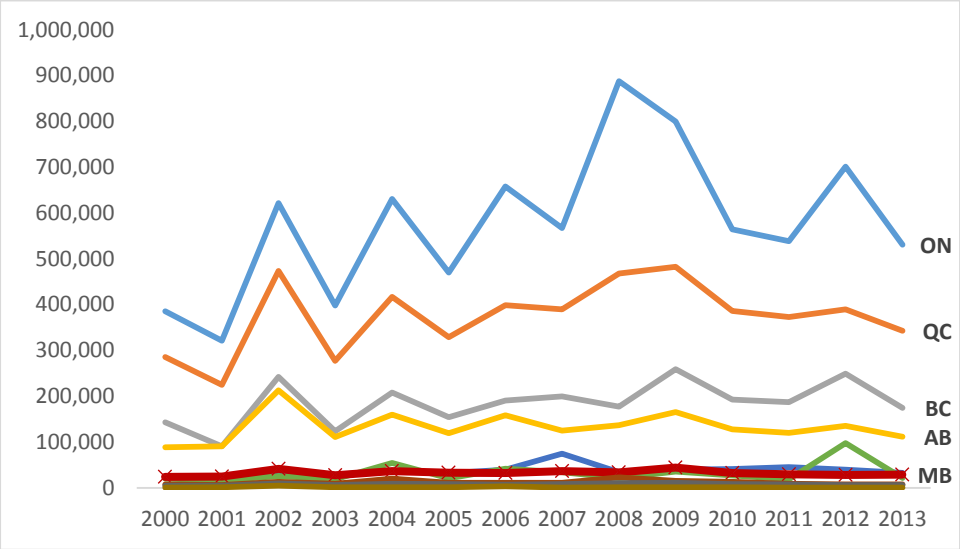
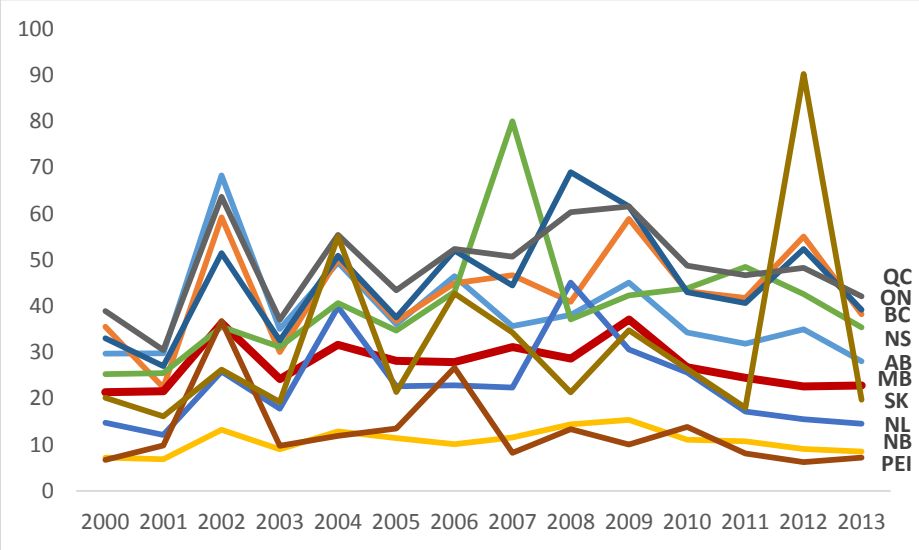



Figure 8. Per capita funding by province (CIHR, NSERC, SSHRC, CFI)




Excluding CFI funding would show that Quebec ($38), Ontario ($35), and British Columbia ($34) have the highest per capita funding, followed by Nova Scotia ($32), and Alberta ($30). Manitoba had an average of $23 per capita funding, higher than Saskatchewan's $19.

Per capita funding for all provinces showed a downward trend generally, starting in 2008 (Figure 9). This coincides with the financial crisis of 2008/09 when CIHR funding reached a plateau and slowly decreased (Econometrics Project, NAPHRO 2013). In Manitoba, CIHR accounts for 61% of the total funding, which is higher when compared to other provinces (Figure 10).

Figure 9. Per capita funding by province (CIHR, NSERC, SSHRC)

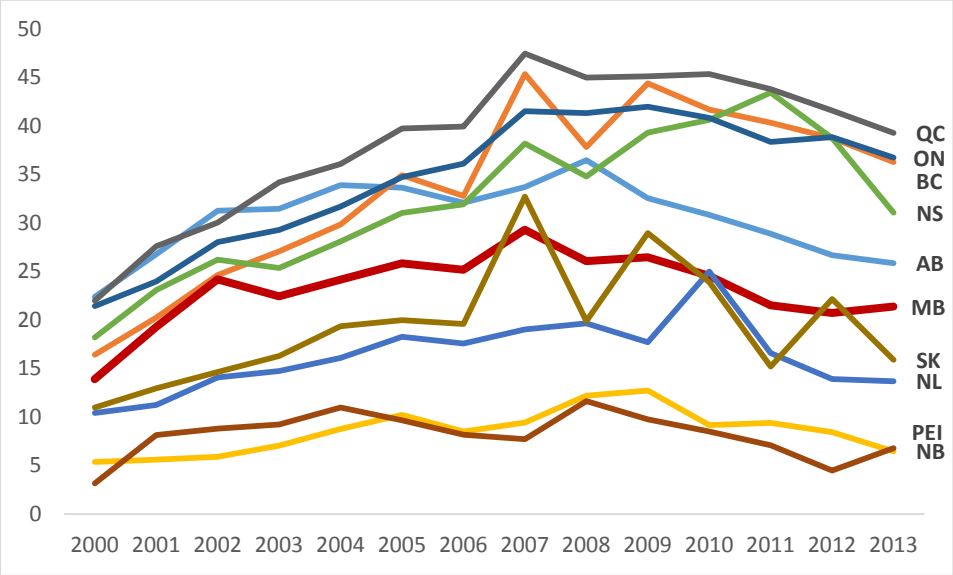
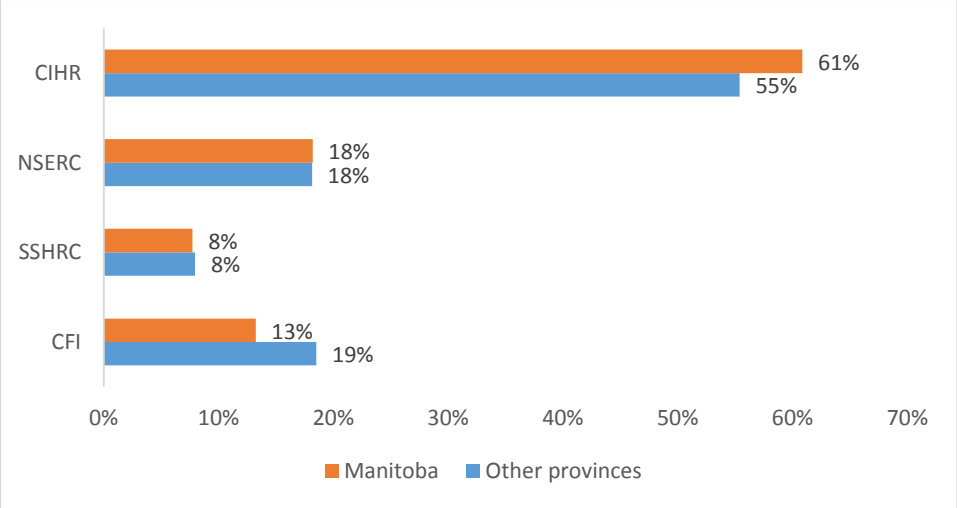



Figure 10. Distribution of Manitoba's total funding from national agencies, 2008-2013

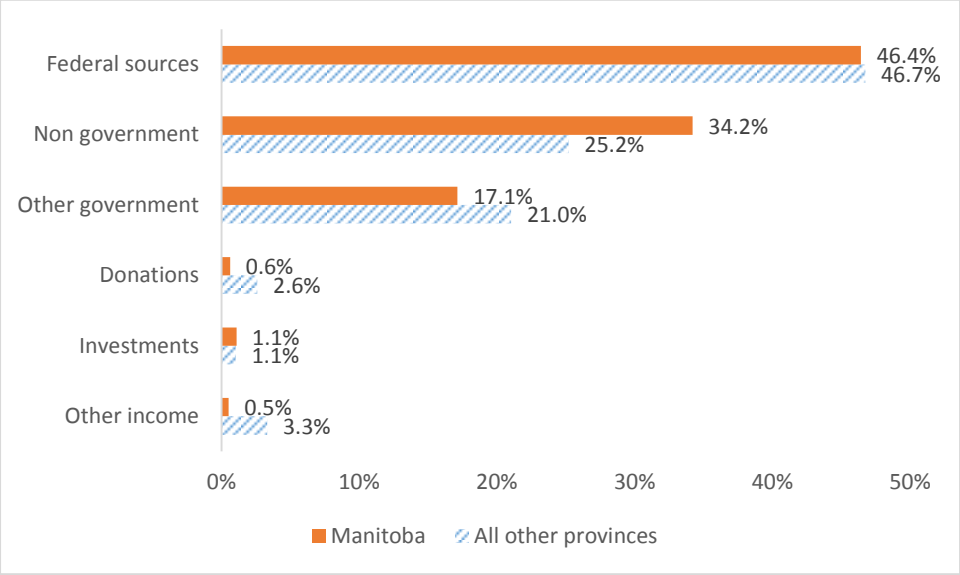



A more comprehensive look at Manitoba's research funding can be seen from the financial information obtained from universities and colleges by Statistics Canada for the Canadian Association of University Business Officers (CAUBO).[8] A limitation is that the most recent publication available is for 2012.

Manitoba's funding from federal sources (CIHR, NSERC, SSHRC, CFI, CRC, Health Canada, and other federal sources) compares well with the rest of Canada (Figure 11). From non-government sources, consisting of individuals, business enterprises, and not for profit organizations, funding is higher; but lower for funding from other government (provincial, municipal, foreign) sources.

[8] http://www.caubo.ca/resources/publications/financial_information_universities

Figure 11. Sources of research income by source, 2012




*When national funding is considered, Manitoba ranks 6th or 7th in terms of per capita funding.*
*Manitoba's provincial, municipal, and foreign sources of funding for research lags behind relative to the rest of Canada.*
*Manitoba partners well with the non-government sector.*
*Competition for CIHR funding has intensified since 2008/2009.*
*Health research takes the bulk of funding that comes into the province.*

*Are we supporting the research enterprise in the best way?*
*Should the support to natural science, engineering, social sciences and humanities be strengthened? If so, how?*
*How do we increase Manitoba's share of national funding?*

## Postsecondary students

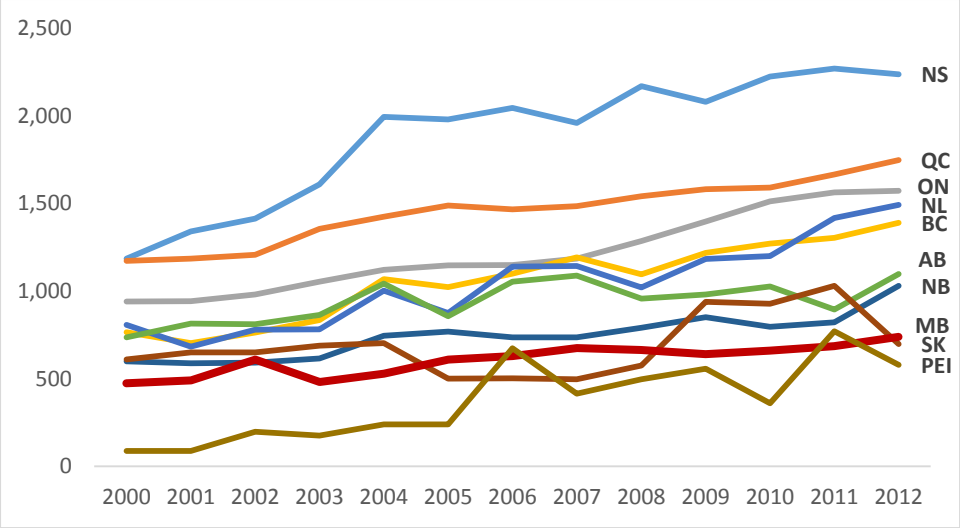
Graduate students and fellows, as they complete their academic and post-academic training, provide invaluable contributions to the research enterprise by way of their direct engagement in the implementation of research projects and programs. According to the 2012 State of the Industrial R&D of Canada, "universities…role in local development is… their ability to attract talent and, through that talent, disseminate leading-edge knowledge in the local economy. But to attract the best and brightest and properly train them, they need to conduct leading-edge research."[9]

From 2000 to 2012, Ontario and Quebec produced the biggest number of graduate students, representing 70% of the total or 347,061 students. Manitoba had 9,405 graduates over the same period,

[9] Miller, R. & Côté, M (2012). *Innovation Reinvented: Six Games That Drive Growth*. Toronto (ON): University of Toronto Press as cited in the 2013 State of Industrial R&D in Canada

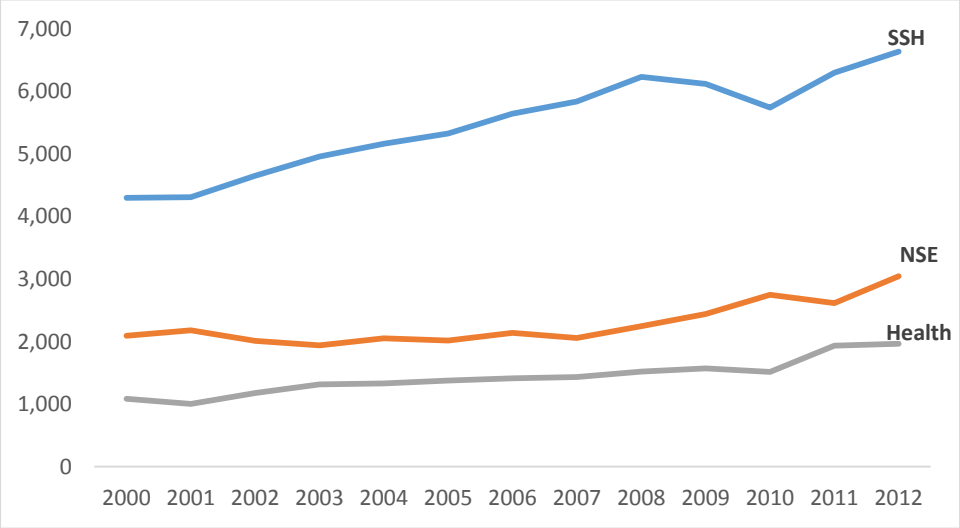
averaging 723 graduates per year. Adjusting for variations, Nova Scotia produced highest number of graduates per million population, followed by Quebec and Ontario (Figure 12). Manitoba ranks sixth in terms of the average number of total graduates per year and ninth in the average number of graduates per million inhabitants.

Figure 12. Number of postsecondary graduates per million population by province




In Manitoba, the number of postsecondary graduates has been increasing (Figure 13), averaging an overall annual 4% growth from 2000 to 2012. The rate of growth for each of the sector has been 3-4% for the same period.

Figure 13. Number of postsecondary graduates in Manitoba




A recent article in Nature[10] points to a "postdoc pile-up" where the number of postdoctoral fellows in science in the US and Europe has been increasing since the late 1970s, but receive poor compensation.

[10] http://www.nature.com/news/the-future-of-the-postdoc-1.17253

As the number has grown, “tenured and other full-time faculty positions has plateaued and, in some places, is even shrinking”.

## Research infrastructure

The province of Manitoba is home to some world class R&D expertise and infrastructure. Research infrastructure, which includes facilities, equipment, and other key resources, plays an increasingly important role in the advancement of knowledge and technology. It helps attract the best and the brightest researchers, brings stakeholders together to facilitate collaborations, and enables the research community to conduct top-level research in their respective fields. Manitoba’s growing base of research-related activity has given the province an increasing international profile in agriculture and health biotechnology, pharmaceuticals, medical and diagnostic devices, and industrial research. The following chart outlines some key research infrastructure in Manitoba.

Table 1. List of research infrastructure in Manitoba

| Infrastructure/Institution | Description |
|---|---|
| **Agriculture** | |
| Canada - Manitoba Crop Diversification Centre | The Centre develops agronomic solutions for crop diversification and to support sustainable water management. It undertakes evaluation of irrigation technologies, field testing of crop performance, and evaluation of speciality and niche crops. |
| Canadian International Grains Institute | Winnipeg offers technical expertise and strong commercial experience with on-site processing and testing facilities. |
| Canadian Grain Commission, Grain Research Laboratory | An internationally known centre for research on the quality of grain |
| Agriculture and Agri-Food Canada’s Cereal Research Centre | This Winnipeg based Centre and the research station in Morden bring together expertise in the development of, and uses for crops such as wheat, oats, barley, flax, pulse crops and landscape plants |
| **Life Sciences** | |
| Next Generation Sequencing Core Platform (U of M) | Next Generation DNA Sequencing is the sequencing of genomes, which in humans are the three billion base pairs of DNA found in every cell of the body. The Next Generation Sequencing platform consists of three different sequencers which use different technologies and have different capacities that enable genetic and epigenetic research. |
| Lentiviral Vector Viral Particles Production Core Platform (U of M) | The platform will a) support consistent production of high quality lentiviral particles at a very low cost for Manitoban researchers; b) expand the users’ base of the existing Faculty of Medicine-funded Biomedical Functionality Resource (that has housed 4 lentiviral vector shRNA libraries and two human ORFeome collections) on campus; and, c) facilitate discovery and validation of gene/protein functions in basic and translational research in Manitoba. |
| Core Platform for Molecular Imaging (U of M) | This core platform, which is part of the Genomic Center for Cancer Research and Diagnosis (GCCRD) is a regional/national facility for all cutting edge imaging applications. The goals of the GCCRD are basic and translational research using molecular imaging approaches, as well as the education of students and highly qualified personnel in genomic instability, cancer genetics and all aspects of imaging. |
| Core Platform for Histology, Histomorphology, and Ultrastructural Imaging (SIM, EM) | The Histomorphology and Ultrastructural Imaging service platform offers histomorphology services, ultrastructural imaging services, structural illumination microscopy (SIM) for high-resolution fluorescent imaging of |

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| (U of M) | subcellular structures, and educational modules. |
| Flow Cytometry Core Platform (U of M) | The platform will create an integrated structure for management and promotion of flow cytometry technology and will support, among others: immunophenotyping and biomarker analyses of human samples and animal models; and, cell function studies such as cell division, cell death, DNA content, enzyme activity, membrane permeability, ion and redox states. |
| Core Platform in Mass Spectroscopy Analysis of Proteins and Metabolites (U of M) | The Mass Spectrometry core platform provides advice in experimental design, perform mass spectrometry and data interpretation. Workshops for students and researchers in the instrumentation and methodologies will be on-going. |
| Large scale RNA and Protein Analysis for immunological biomarkers in health and disease (U of M) | The platform consists of a high throughput Real-time PCR automation system, a high throughput system for simultaneous measurement and analysis of multiple secreted proteins of interest, and an ELISpot system for qualitative and quantitative analyses of activated immune cells. Collectively, the platform allows for a large scale and robotic detection of a wide range of immunological biomarkers at both mRNA and protein levels. |
| Small Animal and Materials Imaging Core Platform (U of M) | Provides capabilities for both structural and functional imaging to Manitoba scientists |
| Richardson Centre for Functional Foods and Nutraceuticals (U of M) | Brings together researchers from the agriculture, foods sciences, human nutrition, medicine and pharmacology disciplines, along with their industry partners, to study and develop functional foods and nutraceuticals. |
| Canadian Centre for Agri-Food Research in Medicine (CCARM) | Located at the St. Boniface General Hospital Research Centre, CCARM is dedicated to investigating and understanding the potential health-related benefits found in nutraceuticals, functional foods, and natural health products (health food). |
| The Canadian Science Centre for Human and Animal Health | The Centre is Canada's only research facility with Level 4 biocontainment capability for the study of both human and animal diseases. Its research focuses on the areas of sexually transmitted diseases, enteric pathogens, bacteriology, special pathogens, and viral oncology. It is the home of Canada's Public Health Agency. |
| The National Research Council (NRC) | ▪ *NRC Industrial Research Assistance Program (NRC-IRAP)* brings together a diverse network of organizations, services and programs to help Canadian small and medium-sized enterprises (SME's) develop and exploit new technologies.<br>▪ *NRC Canada Institute for Scientific and Technical Information (NRC-CISTI)* is the country's largest scientific and technical information service, and the Institute provides instant online access to North America's most extensive collection of scientific and technical literature. Its services include customized literature searches, the development of highly specialized data banks and expertise in finding answers to complex questions |
| The St. Boniface General Hospital Research Centre | A first-tier research facility that has gained a world-wide reputation for excellence in medical research, the Centre encompasses 3 free-standing medical research facilities:<br>▪ The G. Campbell MacLean Building – the Centre's main facility, with a mandate in three primary areas: basic and applied cardiovascular sciences, magnetic resonance imaging and spectroscopy, and degenerative disorders associated with aging.<br>▪ The Dr. Andrei Sakharov MRI Centre -- a recognized leader in the MRI field, where radiologists can diagnose abnormalities of the brain, spine, internal organs and joints.<br>▪ The I.H. Asper Clinical Research Institute - a state-of-the-art facility that enables researchers to conduct clinical trials of discoveries made at the |

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| | Centre.<br>The Centre is also home to the University of Manitoba's Institute of Cardiovascular Sciences, the Division of Neuro-degenerative Disorders, and the Canadian Centre for Agrifood Research in Medicine, and houses a number of other research programs. |
| Health Sciences Centre | HSC serves as one of the province's two teaching hospitals and actively participates in the health industry's research environment. Research is conducted through the following facilities:<br>▪ Health Sciences Centre Foundation<br>▪ Children's Hospital Foundation<br>▪ CancerCare Manitoba<br>▪ HealthTrials |
| CancerCare Manitoba | As the coordinating centre for oncology research in Manitoba, it is responsible for cancer prevention, detection, care, research, and education for Manitobans. The affiliate Manitoba Institute of Cell Biology performs basic research in areas that include the molecular origins of cancer, the regulation of gene activity, AIDS, control of cell movement, inflammation, and wound healing, programmed cell death and the biochemical action of cancer chemotherapeutics. |
| International Centre for Infectious Diseases (ICID) | ICID is a Canadian organization providing innovative leadership and collaborative solutions for the global fight against infectious diseases. |
| Orthopaedic Innovation Centre (OIC) | The team of surgeons, scientists, engineers, and technologists, offer a unique combination of testing capabilities and expertise, supporting the medical device industry. Services range from testing and validation to clinical research services and implant retrieval analysis using a diverse Implant Retrieval Database. |
| National Microbiology Lab (NML) | The NML is Canada's main infectious disease public health laboratory with responsibility for reference microbiology and quality assurance, laboratory surveillance for infectious diseases, emergency outbreak preparedness and response, training, and research and development.<br>The NML is located at the Canadian Science Centre for Human and Animal Health in Winnipeg, the first facility in the world to have high containment laboratories for human and animal health in one building. It is recognized as a leader in an elite group of centres around the world, equipped with laboratories ranging from biosafety level 2 to level 4 designed to accommodate the most basic to the most deadly infectious organisms. |
| **Clinical Trials** | |
| HealthTrials Inc. | An office within the Department of Research at the Health Sciences Centre in Winnipeg, HealthTrials offers project administration services to researchers and pharmaceutical companies to enhance clinical research conducted at the Health Sciences Centre. |
| Manitoba Clinic | One of Canada's largest private multi-specialty medical clinics, with over 75 physicians on staff in a diverse range of medical programs and health care services. The Manitoba Clinic Research and Clinical Study unit acts as the coordinating centre for numerous advanced (beyond Phase II) pharmaceutical clinical trial programs. |
| Hill Top Research Inc. | A contract research organization offering a wide range of studies including clinical research, microbiology, and CRO services for the health care, personal care and oral care industries, with specialized capabilities in dry skin dermatology and SPF testing. |
| The Office of Clinical Research at St. Boniface General Hospital | In conjunction with the University of Manitoba, it provides clinical research support services to investigators, local companies, and other agencies. Services |

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| | that are offered include protocol/proposal development, project management, pre-clinical consultation, regulatory affairs support, research submissions, auditing, and other administrative support services. |
| GVI Clinical Development Solutions Inc. | An innovative clinical research organization providing strategic consulting and hands-on clinical and regulatory support to biotechnology, pharmaceutical, diagnostic, medical device, and nutraceutical companies. |
| **Information and Communications Technology** | |
| TRLabs | Conducts research and technology development focused on future network needs in areas such as: data networking, digital media, health, home technologies, network systems, photonics, and wireless communications. The Winnipeg lab has a particular focus on data networking (improving the speed, reliability and efficiency of the communications network), and eHealth (ICT application to the health sector). |
| Internet Innovation Centre (IIC) | IIC a focus for the array of interdisciplinary Internet-related research projects at the University of Manitoba. The IIC encourages collaborative interdisciplinary activities among researchers and offers opportunities to work with external communities. |
| University of Manitoba Nano Systems Research Group | Performs research in the fields of scanning probe microscopy (SPM), Nanoelectronics, and Microelectromechanical Systems (MEMS). |
| Canadian Advanced Networks for the Advancement of Research in Industry and Education (CANARIE) | Through its Manitoba affiliate MRNet, offers members access to a Canada-wide high-speed optical network delivering unrivaled network capability for broadband research. |
| NRC Institute for Biodiagnostics' Biomedical Informatics Group | Focuses on the development of state-of-the-art methods for managing complex biomedical data and commercializing the software that is developed. |
| CISCO Innovation Centre for Collaborative Technologies (UoW) | Explores the collaborative potential of high-speed fibre optic networks |
| **Industrial R&D** | |
| Composites Innovation Centre (CIC) | The CIC conducts research and development in the application of composite materials in manufacturing industries, focusing on aerospace, bio-materials, ground transportation, and civil infrastructure. Projects are performed in partnership with industry, government agencies, and educational establishments. |
| Food Development Centre | Located in Portage la Prairie, it provides state-of-the-art facilities for applied research and development for the food, beverage and feed industries. Clients can develop and produce new food products and processing technologies in its federally-licensed pilot plant. Resources and services include: pilot plant, product development, process development, nutritional labelling, regulatory affairs/HACCP, library and information services, and educational services. |
| Manitoba Industrial Technology Centre (ITC) | The ITC provides engineering, technical, advisory, and information services to companies in many sectors, including: aerospace, transportation, health, energy, environment, general manufacturing, building, architecture, and construction. |
| Virtual Reality Research and Innovation Centre | The Centre is a state-of-the-art facility housing some of the most advanced visualization hardware and software available in the world today. It allows manufacturing and other industry sectors such as civil, architectural, urban planning, design, and medical, to visualize complex datasets within a virtual model or immersive environment. |
| Vehicle Technology Centre | The Centre is an industry-led non-profit corporation that serves Manitoba's heavy vehicle manufacturing industry. It provides a forum for promoting industry co-operation and for identifying ways to improve technological capacity within the industry. |
| Prairie Agricultural Machinery | PAMI is an applied research, development, and testing organization with |

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| Institute (PAMI) | clients in agriculture, forestry, mining, transportation, and the military. Services include design, development, fabrication and evaluation of vehicles, machinery, and components. |
| WESTEST | An industrial testing and engineering facility, WESTEST provides advanced product engineering and development services and a wide array of physical testing capabilities to equipment and vehicle manufacturers across North America. WESTEST evaluates components, full vehicles and machines for a broad range of equipment and manufacturing industries. |
| Emergent Biosolutions | As a global specialty pharmaceutical company, Emergent offers specialized products to healthcare providers and governments to address medical needs and emerging health threats. |
| Smartpark – U of M | Smartpark's vision is to "Build a Community of Innovators" on the doorstep of the University of Manitoba. It does this by developing land and space for lease to research and technology companies and organizations involved in the following broad research areas that coincide with research expertise at the University: information and communications technology, engineering and advanced materials, health and biotechnology, and agricultural and nutritional sciences. |

## Collaborations

Collaborations – institutional, national or interprovincial, and international – bring in skills that complement existing expertise or provides the necessary expertise leading to a transfer in skills and knowledge. They also bring in additional resources required by the research, and contribute to the faster movement of research findings to knowledge translation.

For all provinces, international collaborations have shown positive growth from 2000 to 2014. The national collaborations on the other hand have remained fairly stable at around 20% beginning in 2003. Institutional collaboration, starting from 44% in 2000 has dropped to 28% by 2014. The average of the institutional collaboration rate in the same period was 34%, comparable to the 36% average for international collaboration.

Manitoba's collaboration rates present the same pattern: a positive trend in international collaboration, a relatively constant national collaboration, and a declining institutional collaboration. Manitoba averaged 36% for international collaboration between 2000 and 2014, which compares well with most of the provinces whose rates range from 37% to 39%. Its national collaboration averaged 18% over the same period. Manitoba's institutional collaboration rate of 34%, the average from 2000 to 2014, is the same as Ontario's and ranks behind Alberta (35%), Quebec (35%).

*Even as institutional and national collaborations remain strong in Manitoba, international collaboration appears to be intensifying.*
*The number of graduate students in the province is gradually increasing in health, the natural sciences and engineering, and social sciences and humanities.*
*There are multiple platforms in basic research.*

*Should the Manitoba post-secondary educational system produce more graduate students and postdoctoral fellows?*
*Do we have enough research capacity in Manitoba? Do we need to build capacity in certain areas?*
*Should we expand the number and type of research platforms?*

## b. Outputs of the research enterprise

### Number of publications[11]

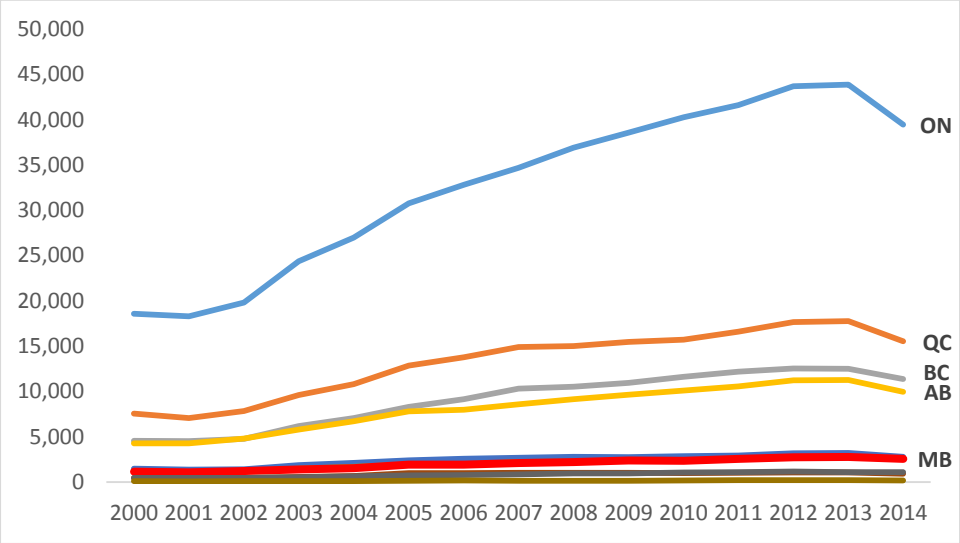
Publications, especially peer-reviewed ones, are a well-known output of research and an indicator of productivity. They also serve as an important mechanism for disseminating research results and discoveries.

Similar to the funding situation, Ontario, Quebec, British Columbia, and Alberta accounts for the majority of publications in Canada (Figure 14). Between 2000 and 2014, these provinces produced 947,800 or 88% of all publications in all disciplines. Ontario produced 2.5 times as much as Quebec, the second most productive province. The remaining 124,513 publications or 12% were produced by the rest of the provinces with Manitoba accounting for 24%, Saskatchewan 25%, and Nova Scotia 29%.

Manitoba's total publications in 2000 was 1,152 reaching around 2,800 in 2013.

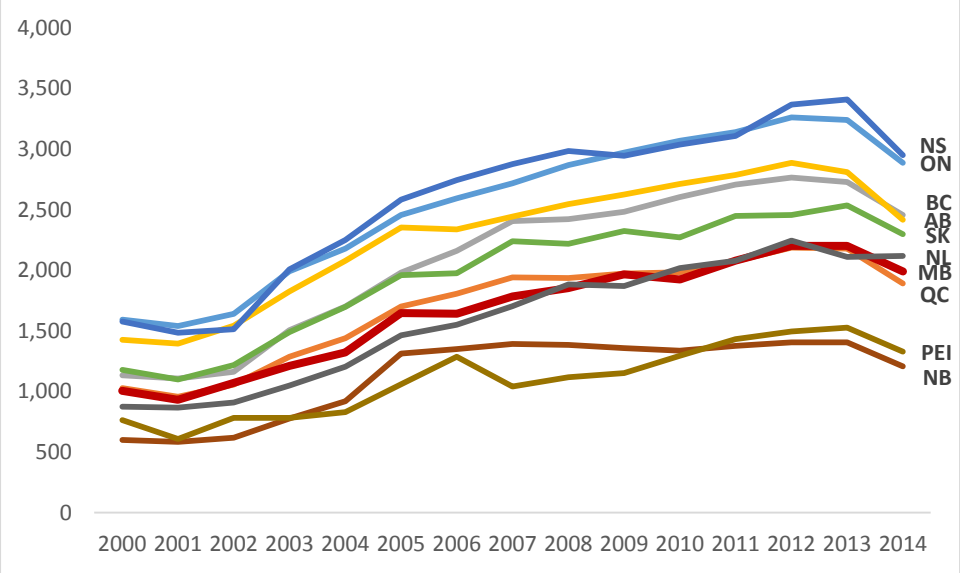
[11] Publication data was obtained from Scival.

Figure 14. Total number of publications by province




Adjusting for variations, publications for all provinces exhibit an increasing trend until 2013, when publications declined (Figure 15). Provinces with the highest publication (at least 2,300) per million population in 2014 were Nova Scotia, Ontario, British Columbia, Alberta, and Saskatchewan. Manitoba's publication per million inhabitants has risen from 1,000 in 2000 to 2,200 in 2012 and 2013 before dropping in 2014. Taking the average number of publications per million inhabitants between 2000 and 2014, Manitoba ranks seventh among the provinces. Nova Scotia and Ontario are at the top, averaging 2,587 and 2,541 publications respectively then followed by Alberta, British Columbia, Saskatchewan, and Quebec.

Figure 15. Publications per million population by province

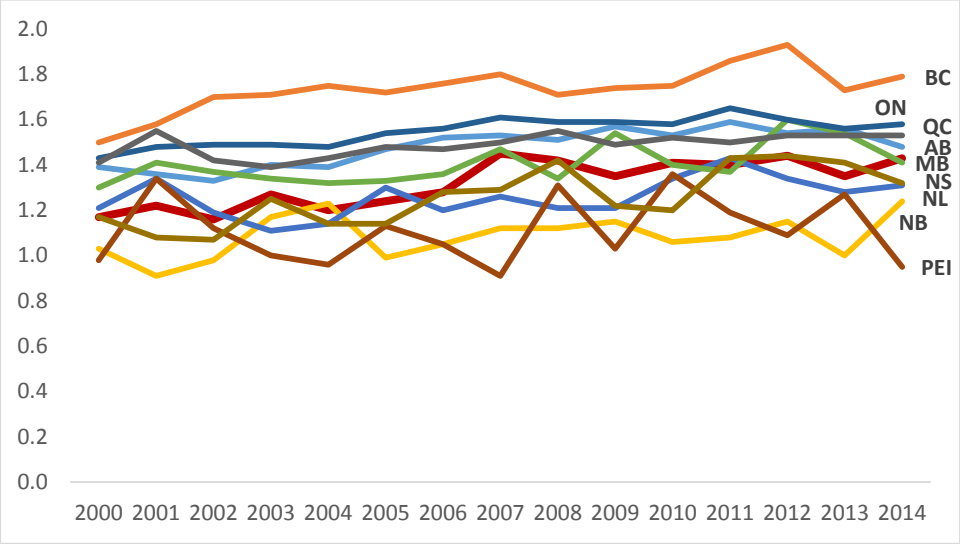


## Quality of publications

Citations indicate the usefulness or value of a publication. The field weighted citation impact of publications[12] is an indicator of the quality of publications and results are compared to the global average of 1. This metric takes into account the differences in research behavior across disciplines i.e. certain disciplines have more output than others.

Between 2000 and 2014, the average of field weighted citation impact of publications for each province indicates that publications have been cited more than the global average. Relative to other provinces, publications from British Columbia have been consistently cited higher since 2000 (Figure 16). Manitoba's publications have been cited around 40% more than expected or the global average since 2007.

Figure 16. Field weighted citation impact by province




## Patents[13]

Patents, although not produced in a similar volume as publications, is also a measure of productivity. It is important to remember that many research do not produce patents but have an impact, whether in health or socio-economic in nature.

In general, counts of patent applications and issued patents based on inventor[14] and assignee addresses measure the intellectual property (IP) and inventiveness of regions. Since important time lags exist

[12] It is the ratio of citations actually received and the average number of citations received by all other similar publications. Snowball Metrics Recipe Book June 2014

[13] Patent data used in this report is from NAPHRO's Econometrics Project, which came from the US Patent and Trademark Office (USPTO). Canadian firms tend to patent more at the USPTO according to the 2013 State of Industrial R&D in Canada.

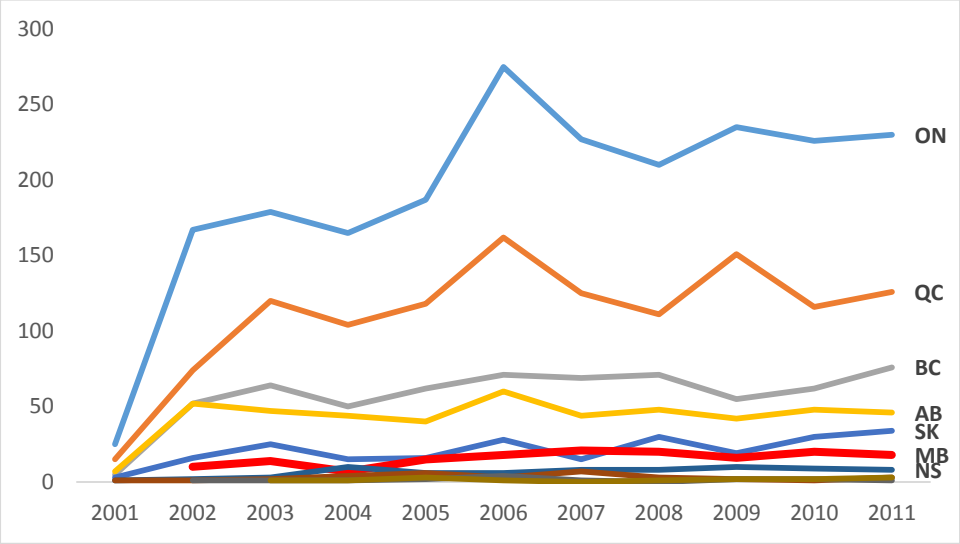
[14] The inventor is the person(s) who conceived the invention while the assignee is the entity with the property right to the patent. US law requires that the patent application be in the name of the inventor. The inventor and the assignee may be one and the same.

between the filing date of applications and the issuance of the corresponding patents, data on applications provide more up-to-date information on the current (i.e. in recent years) inventiveness of regions (when based on the location of inventors).

## Biotechnology patents

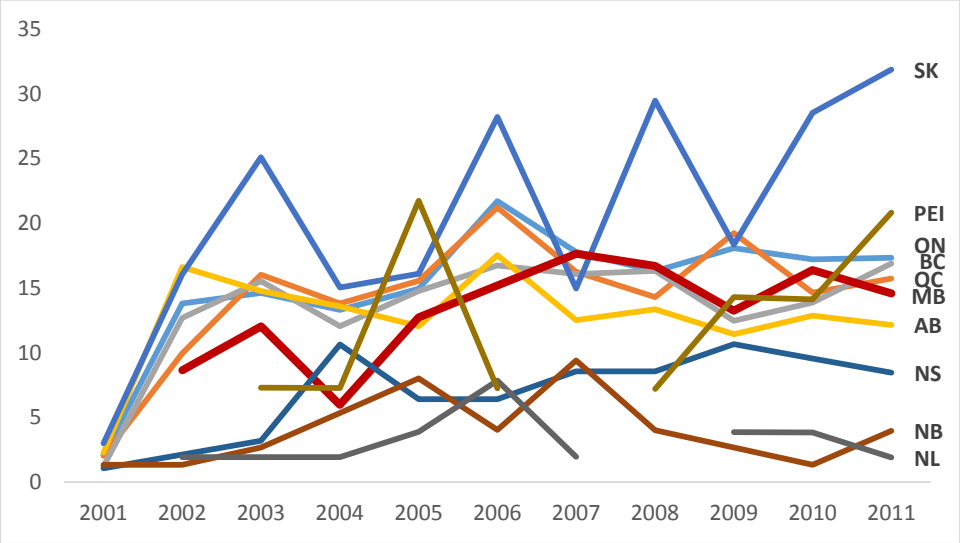
Eighty nine percent (89%) of biotechnology patents (4,463 patents) applied for between 2001 and 2011 were made by Ontario, Quebec, British Columbia, and Alberta; Ontario produced almost twice as much as Quebec (Figure 17). The rest of the provinces had a combined patent application of 524 over the same period and combined issued patents of 186. Manitoba had an average of 16 patent applications and 6 issued patents from 2001 to 2011. In general, patent applications were twice as many as issued patents.

Figure 17. US Patent applications in biotech based on the location of inventors




Adjusting for variations in patent production, biotechnology patent applications were highest for Saskatchewan and Prince Edward Island in 2011 per million population (Figure 18). Saskatchewan averaged 21 patent applications between 2001 and 2011 while Prince Edward Island had 11. Manitoba produced 13 patents on average over the same period, the same as Alberta and comparable to Ontario (15), Quebec (14), and British Columbia (14).

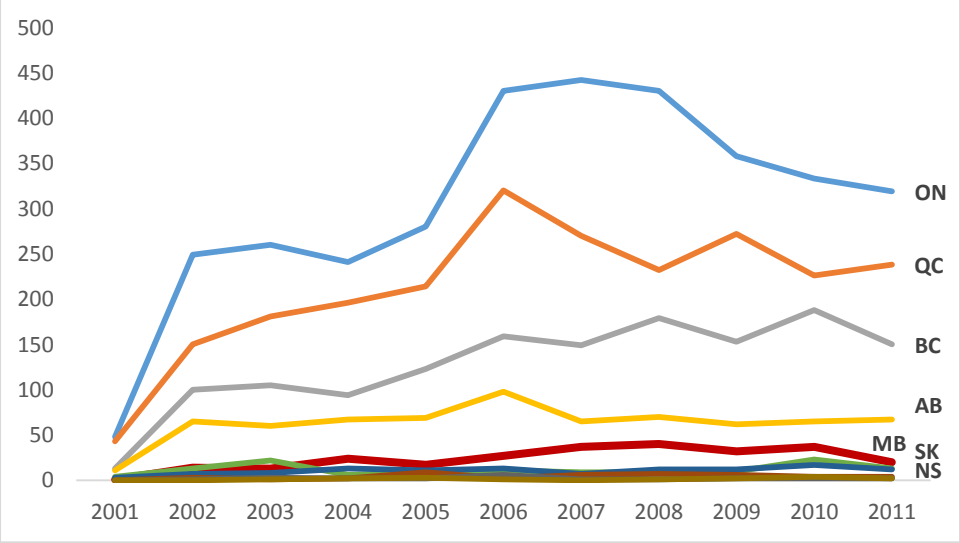
Figure 18. US patent applications in biotech based on the location of inventors per million population




## Health patents

Ontario, Quebec, British Columbia, and Alberta dominated health patent applications from 2001 to 2011 (Figure 19). These provinces held 93% of health patents applied for (7,844) between 2001 and 2011 while the rest (587 patents) were accounted for by the other provinces. Overall, health patent applications and issued patents were one and a half times as many as biotechnology patents. All provinces had more applications and issued health patents except Saskatchewan, which had almost twice as many biotechnology patent applications as in health.

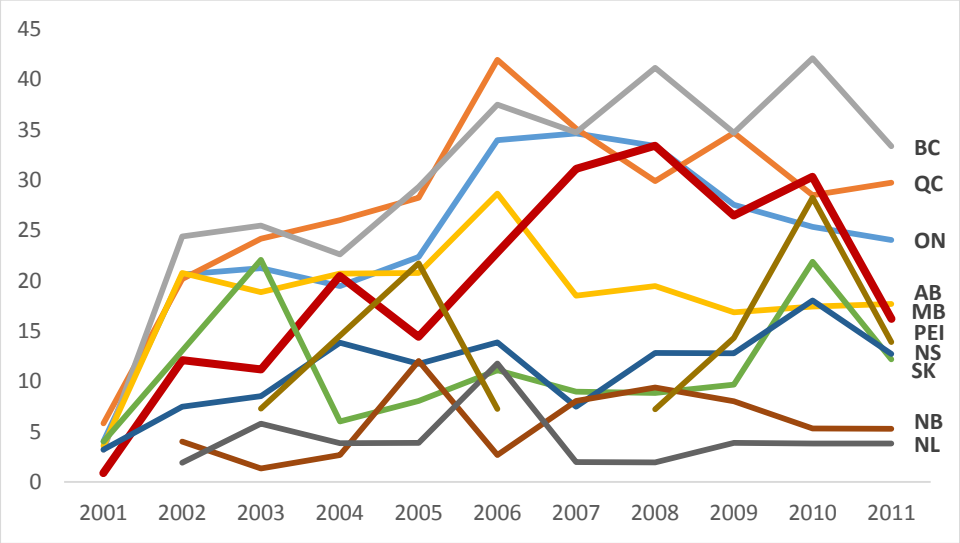
Figure 19. US Patent applications in health based on the location of inventors




When controlled for population, British Columbia and Quebec had the highest number of health patent applications per million inhabitants from 2001 to 2011 (Figure 20). In that same period, British Columbia had an average of 30 applications per year followed by Quebec's 28. Manitoba averaged 20 applications

per year per million inhabitants, and showed an overall increasing trend despite the drop between 2010 and 2011. The rest of the provinces also had a positive trend in the growth of patent applications.

Figure 20. US patent applications in health based on the location of inventors per million population




In addition to biotechnology and health patents, Manitoba produced one fifth of patents in agriculture, forestry, fishing, and hunting. This is on par with Quebec and second to Ontario's 55%.[15]

*Manitoba ranks seventh in terms of publications, but is productive in terms of patents relative to Ontario, British Columbia, and Quebec, when patent data is adjusted for variations. Manitoba is not far behind the same provinces in inventiveness as well.*
*Manitoba ranks seventh among the provinces in terms of total publications or when adjusted for variations.*

*How do we foster greater inventiveness and innovation?*

## c. Research strengths

Table 2 lists the areas of excellence from the University of Manitoba's 2015-2020 Strategic Research Plan, Brandon University's 2014-2017 Strategic Research Plan, and the University of Winnipeg's Research 2011-13,[16] and the "distinctive competencies" or research strengths derived from SciVal, a tool based on publications and citations.

15
http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/research%20and%20develop/ird_fullreporten.pdf p98

16 Obtained through internet search; a request was sent out to these institutions about their respective research strengths

Table 2. Manitoba's research strengths

| | |
|---|---|
| University of Manitoba | Home to internationally renowned programs of research in Arctic science, climate change and its effects on Arctic sea ice |
| | Internationally recognized leadership in immunity, inflammation, and infectious disease research |
| | World leading team of researchers in population and global health |
| Red River College | Sustainable infrastructure and transportation<br>Home to Centre for Applied Research in Sustainable Development (CARSI) |
| Brandon University | Community connective research that crosses traditional faculty boundaries and facilitate inter-disciplinary approaches |
| University of Winnipeg | Urban studies |
| | Indigenous studies |
| | Medical istopes |
| Based on publications (Scival)[17] | Inflammatory Bowel Diseases; Crohn Disease; Colitis, Ulcerative |
| | Osteoporosis; Bone Density; Hip Fractures |
| | Diet; Anesthesia; Intraoperative Awareness |
| | Anti-Bacterial Agents; Vancomycin; Methicillin-Resistant Staphylococcus aureus |
| | Sea ice; ice; ocean |
| | Linoleic Acids, Conjugated; Flax; Diet |
| | Influenza, Human; Influenza A Virus, H1N1 Subtype; Pandemics |
| | Alcohols; Anxiety Disorders; Diagnostic and Statistical Manual of Mental Disorders |
| | Microwaves; Imaging techniques; Imaging systems |
| | Transformational leadership; Workplace; Leadership |
| | Knowledge; management; adaptive management |
| | Papillomavirus Infections; Papillomavirus Vaccines; Condylomata Acuminata |
| | Muscle, Smooth; Asthma; Cells |
| | Anthracyclines; Antineoplastic Agents; Heart Failure |
| | Anaphylaxis; Epinephrine; Hypersensitivity |
| | Pegmatite; mineral; tourmaline |
| | Acute Kidney Injury; Kidney Transplantation; Graft Rejection |
| | Phytosterols; Cholesterol; Cholesterol, LDL |
| | Obesity; Diabetes Mellitus, Type 2; Insulin Resistance |
| | HIV; HIV Infections; Sex Workers |
| | Asthma; Obesity; Child |
| | Small area estimation; Area; Model |
| | Reynolds number; Velocity; Turbulence |
| | Algorithms; Cameras; Target tracking |

Other known research strengths of Manitoba are in functional foods, agriculture, and aerospace. Low levels, relative to other provinces, of industrial R&D were noted for Manitoba in aerospace and computer system design.[18]

[17] Listed as ranked in Scival, from #1 to #24; All are from the University of Manitoba except "algorithms, cameras and target racking" for which is from the University of Winnipeg. See Appendix 2 for more details.

[18] 2013 The State of Industrial R&D in Canada p124

### d. Stakeholders

Table 3 lists the stakeholders that are engaged directly or indirectly in the creation of knowledge and their primary roles.

Table 3. Stakeholders in knowledge creation/generation

| Stakeholders | Role |
|---|---|
| Researchers | Conducts and research |
| Universities/Institutions | Provides support (e.g. administration, infrastructure) for research |
| Research Manitoba | Promotes and supports research in health, natural sciences and engineering, and social sciences and the humanities |
| Manitoba Health | Funds research, user/beneficiary of research |
| Ministry of Agriculture, Food and Rural Development | Funds research |
| Provincial government | Funds research |
| Non-profit organizations | Funds research |
| Industry | Funds research, conducts research, pre/commercialization |
| Public | Users/beneficiaries of research |

## 2. Knowledge translation

Knowledge translation (KT) as defined by CIHR as a dynamic and iterative process that includes synthesis, dissemination, exchange, and ethically-sound application of knowledge to improve the quality of life of Canadians, and provide more effective services and products and strengthen existing systems.[19] For the purposes of this document, KT is the umbrella term for all of the activities involved in moving research from the laboratory into the hands of people and organizations who can put it to practical use. KT is not an action, but a spectrum of activities which change according to the type of research, the timeframe, and the audience being targeted. Understanding and optimizing how research is translated is critical to identifying and improving research outputs – including commercialization activities and broad social, environmental, and economic benefits to Manitoba ( i.e. non-commercial in nature, which in this discussion is referred to as benefits and improvements).

The path from knowledge creation to commercialization is varied and potentially lengthy depending on many things including the regulatory environment, capital available, etc. For example, the development of a new drug or vaccine can take 20 years from basic research, to target validation, to phase 1-3 of clinical trials, regulatory approvals, and finally to production and into the market.

Research Manitoba's mandate includes support for pre-commercialization, which is not yet clearly defined. It is clear however that Research Manitoba supports post-secondary institutions, their researchers and affiliates and not for profit organizations, but it does not provide direct funding to industry.

[19] Adapted from CIHR definition of knowledge translation.

Below is a list of inputs and stakeholders working in commercialization in Manitoba. As Research Manitoba's role in supporting pre-commercialization is defined, it is important to understand the environment and work with existing groups to coordinate activities which add value and fill gaps rather than duplicate or compete.

Table 4. Inputs and stakeholders in KT in Manitoba

| Stakeholder | Input | Description/Output |
|---|---|---|
| Research Manitoba | Funding, publications/ communications, research connections | Requires a knowledge translation plan to be included as part of most applications for funding. The strength of this plan is an important factor in determining successful applications. Funds research, invests in innovative KT like CHI, plays important "connector" role |
| Technology Transfer Office (U of M) – | Patents, IP, industry connections, Tech development | Plays an important role in knowledge translation and mobilization. They meet with researchers to discuss their work and work with researchers to develop their IP by creating commercial objectives, coordinating patents, developing commercialization strategies, and regularly reviewing the plan to monitor its progress. TTO provides a range of intellectual property services to the University community, including; Intellectual Property (IP) and market assessments, and patent/trademark/copyright registration and maintenance. |
| Knowledge translation programs related to health research | CIHR funding, infrastructure and activities | ▪ Knowledge translation is recognized as an important aspect of the mandate and activities of several health research organizations including:<br>- University of Manitoba's Manitoba First Nations Centre for Aboriginal Health Research<br>- The Centre for Global Public Health<br>- The Centre for Healthcare Innovation<br>- TREKK<br>- Manitoba Centre for Health Policy (MCHP)<br>▪ These groups, networks and organizations incorporate KT in the health field as a critical part of their mandate. Conduct workshops, create publications, and find innovative ways to translate discoveries into practice.<br>▪ Other federal organizations focus on this issue: Canadian Knowledge Transfer and Exchange Community of Practice, Knowledge Translation Canada, Canadian Dementia Knowledge Translation Network, etc. |
| Provincial government | Funding, policy, programming, service delivery | Funds research, commercialization, and supports industry through various programs. Seeks research to inform decision making (not one clear |

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| | | mechanism for this), can play a "connector" role between institutions and other stakeholders – largely dependent on the individuals and department involved. Key departments include Manitoba Health, MAFRD, Jobs and the Economy, Entrepreneurship Manitoba (EM), and Manitoba Infrastructure and Transportation (MIT) |
| Manitoba Health | Funding, policy, programming, service delivery | Funds research, user/beneficiary of research, participation/representation in KT organizations like MCHP, CHI |
| Manitoba Agriculture, Food and Rural Development (MAFRD) | Funding, policy, programs, connectors/people | Funds research, innovation funding, agriculture-related business supports, CIC support, Manitoba Agri-Health Research Network (MAHRN), CCARM etc. |
| KT in Natural Sciences and Engineering | Funding, programs, people | It is less obvious how knowledge translation happens in relation to research in Natural Sciences and Engineering, in that there seem to be fewer funded programs dedicated to knowledge translation activities. There are pockets of programs/ or events run through industry associations or federal programs like Consortium for Aerospace Research and Innovation in Canada (CARIC)/Green Aviation Research & Development Network (GARDN). NSERC, the main federal source of funding for this kind of research, has the Innovation: Research Partnerships program, which supports the transfer of knowledge and skills to the user sector through awards that support research projects and network activities intended for socioeconomic impact. KT is likely happening through other channels such as collaborations or agreements that exist between research institutions and industry or government. Examples are the relationships between government departments and research groups like Intelligence Sensing and Innovation Structures Canada (ISIS) or the Water Systems Research Chair. |
| KT in social sciences and humanities | Funding, programs, people | In the social sciences and humanities, knowledge translation is happening through several means, including publications. SSHRC, through its knowledge mobilization strategy, supports knowledge translation by:<br>- funding activities that allow researchers to communicate their results to the world;<br>- supporting research partnerships that facilitate the co-creation and use of knowledge beyond the academic world; and<br>- developing networks, tools, and best practices in the areas of knowledge-sharing and knowledge mobilization. |
| Rural Development | Research, information, | Promotes, facilitates, coordinates, initiates and |

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|---|---|---|
| Institute, Brandon University | programs, publications, people | conducts multi-disciplinary academic and applied research on rural issues. Acts as an interface between academic research efforts and the community by acting as a conduit of rural research information and by facilitating community involvement in rural development. |
| Vital Outcome Indicators for Community Engagement (VOICE) Research Project, Brandon University | Research, programs, publications, people | Communities and researchers work together to help First Nations, Métis and Inuit (FNMI) children and youth achieve educational and career success. Success includes, but is not limited to, improved educational outcomes, improved workplace skills, increased engagement in community leadership and activities, retention of language and culture, more effective youth success programs, and increased career opportunities for youth in these communities. |
| Canadian Centre for Policy Alternatives | Programs, research, publications, conferences | The Canadian Centre for Policy Alternatives has a Manitoba office that works in collaboration with the community to conduct quality research that advances social justice and environmental sustainability in the province. |
| Manitoba Research Alliance | Programs, research, publications, conferences | The Manitoba Research Alliance is a closely-knit group of academic researchers and community and government partners that focus on policy-relevant research. Their work is widely accessible and facilitates the multi-directional flow of knowledge. |
| Researchers/investigators | Research, connections, patents | Conduct and submit research for publication, file for Patents and IP, work with potential end-users to develop research vision and KT plans, make connections with industry, government, and other potential partners, engage in networks |
| Universities/Institutions | Programs, funding, people | Conduct research, communicate research, transformational partnerships programs, TTO |
| Non-profit organizations – Applied Research | Hub of collaboration, conduct applied research, create new products and services | CIC, OIC, etc. Applied research, work closely with industry, researchers and government to translate research into useful technology, services, and products. CIC great example of unique funding model that produces results and bridges gaps |
| Industry | Funding, partnerships, R&D activities | Funds research, seeks to create partnerships to find solutions for their business problems. |
| Innovation support organizations and Industry associations | Programs, funding, events connector role | Run partnership or connection programs between industry and research such as Life Sciences Association of Manitoba (LSAM), Information and Communications Technology Association of Manitoba (ICTAM), New Media Manitoba (NMM), Manitoba Aerospace Association (MAA), Innovate Manitoba, and IP Manitoba. |
| Public | Consumers of knowledge and products and services | Users/beneficiaries of research |
| OTHER | Funding, programs, publications, conferences, people | Other research groups, clusters and programs like The Centre for Human Rights Research Initiative (CHRR) , which partners with the Canadian |

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| | | Museum for Human Rights, the Assembly of Manitoba Chiefs, the Truth and Reconciliation Commission of Canada and others to ensure that the U of M is at the forefront in developing research-based knowledge. |

## a. Benefits and improvements

An important result of knowledge translation is the engagement of end-users and the uptake and adaptation of discoveries. When policy makers, program and service deliverers make changes based on research discoveries, it can result in economic, social and environmental benefit and improvements for broader society.

Table 5. Stakeholders, inputs and outputs

| Stakeholders | Inputs | Outputs |
|---|---|---|
| Researchers, research institutions, TTOs, facilitator organizations, Industry | Publications/patents | Present the research results and discoveries to the public, uptake by policy makers and decision makers, or develops IP for industry |
| Actors, connectors or facilitators | Connections | It is often the actors, connectors or facilitators within the KT sector that actually highlight the potential uses and impact of new discoveries. These actors can exist at research institutions, industry, government or facilitator organizations, and often their role is not formalized |
| Government, society | Evidence based decision making | Difficult to measure, but when policy makers integrate new discoveries into decision making process and develop responsive and strategic public policy |

## b. Commercialization

Commercialization is one of the important outputs/end-goals of research and knowledge translation. When knowledge that has been generated by researchers is transformed into a commercializable product with value to society and/or the economy, it is viewed as a "win". Unfortunately, commercialization is still a grey area in Manitoba. There are several sources of funds, organizations, and programs that play in the commercialization space in the province, often with overlapping mandates. There is no clear or widely accepted definition of **pre-commercialization**. Many organizations or programs that focus on commercialization, accommodate EARLY commercialization activities, but where that line is drawn is unclear. Below is a list of identified stakeholders, inputs and outputs on the commercialization space in Manitoba.

Table 6. Stakeholders, inputs and outputs of commercialization

| Stakeholder | Input Description | Output |
|---|---|---|
| Research Manitoba | Provides funding for some applied research that fits into the pre-commercialization sphere – mainly through the Strategic Investments in Research and Innovation (SIRI) program. This funding is not available to companies, and must meet "system-wide" requirements, significantly limiting those eligible to apply. Funding is also very small amount to meet large demand. | ▪ The expected outputs of pre commercialization activities are to move ideas and prototypes further along the commercialization chain.<br><br>▪ Ultimately, commercialization will lead to economic growth though new products and services. |
| Applied research organizations | Pre commercialization activities take place at applied research organizations in the province including the Industrial Technology Centre, the Composites Innovation Centre, Red River College, the Orthopaedic Innovation Centre, Assentworks, etc. | |
| Manitoba Agriculture, Food and Rural Development (MAFRD) | (MAFRD) supports some pre-commercialization activities through its research and innovation funding (ARDI) , sometime partnering with federal agriculture programs like Growing Forward 2 (GF2) AgriInnovation Program | |
| Manitoba Agri-Health Research Network (MAHRN) | MAHRN supports the commercialization of research supported functional foods, food ingredients and natural health products in Manitoba through project coordination, communications, global outreach, and test market services | |
| Researchers/investigators | Publications/patents are produced and serve as important inputs into pre commercialization activities that enables the development of new technologies for industry | |
| Industry Associations | There are several programs that run through industry associations like LSAM, NMM, MAA, ICTAM - that are designed to increase collaboration and partnership between industry and research – these often take the form of workshops or events. Some of the activities fall into the realm of pre-commercialization | |
| Innovate Manitoba | IndustryConnects program is a one day workshop designed to bring researchers and industry together to form collaborative partnerships, or identify potential projects. | |
| University of Manitoba | ▪ The University of Manitoba's new Transformational Partnerships approach actively supports industry in making those innovation leaps through collaborative research and development partnerships. Interested companies can contact a partnership expert at the university to explore opportunities.<br>▪ Technology Transfer Office oversees an Intellectual Property estate of over 400 patents covering 300 university developed technologies. They manage over one-hundred technology-based alliances with local and global partners. Over the past two decades, TTO has launched forty new start-up ventures, creating over 1200 jobs in the local economy.<br>▪ IP Policy - recently changed to be more open and foster collaboration. | |
| Incubators and Accelerators | ▪ This entity exists to help technology companies accelerate their growth by increasing sales. It provides management expertise to innovators and small- and | |

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| | medium-sized companies with a desire to succeed on a global scale. The Eureka Project is home to more than 15 developing tech companies.<br>▪ The Manitoba Technology Accelerator (The Accelerator) business incubation program is committed to the long-term success of science or technology start-up companies. Their program helps start-ups to operate professionally but on a start-up budget, enabling them to reach a higher degree of business success.<br>▪ Assentworks is a non-profit workshop dedicated to providing hands-on access to fabrication and prototyping equipment, knowledge and a community of support for entrepreneurs, inventors, tinkerers, artists, and innovators. The organization is fully staffed by volunteers, and their passion is to help entrepreneurs, inventors, and makers get ideas off the ground, grow business, and support our community.<br>▪ TRTech is an industry-driven, not-for-profit technology commercialization company that fast tracks innovation to market by working with its 80 industry, government, and academic partners and clients to discover, develop, and commercialize technology.<br>▪ The Industrial Technology Centre (ITC) provides a wide range of advanced technical services enabling participating companies to improve their products and processes. Its clients include firms from various industrial sectors, along with federal, provincial and municipal government departments and agencies. | |
| Government: Commercialization Support for Business (CSB) | A provincial funding program developed to support Manitoba businesses with commercialization activities. It is not focused on pre-commercialization, however, Stream 1 focuses on product development, which may be considered pre-commercialization depending on the definition used.<br>- Stream 1 – Product Development (Max up to $50,000) – Funding targets market validation studies that include third party verification of the core results, registration of intellectual property, construction of a working prototype or finished good and obtaining product certification.<br>- Stream 2 – Commercialization (Max up to $250,000) – Funding targets ventures moving from prototype to a market-ready product.<br>- Stream 3 – Market Development (Max up to $30,000) – Funding targets ventures who engage in activities that will enable them to enter new markets outside of Manitoba. | |
| Government: Tax Credits | ▪ R&D Tax Credit: to encourage research and | |

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| | development in Manitoba, the Research and Development Tax Credit provides a 20% non-refundable tax credit applied against Manitoba corporate income tax payable. Eligible corporations must incur qualifying scientific research and development expenditures (as defined for federal income tax purposes) in Manitoba.<br>▪ The federal government's Scientific Research and Experimental Development (SR&ED) Program is designed to encourage Canadian businesses of all sizes and in all sectors to conduct research and development (R&D) in Canada. The program is administered by the Canada Revenue Agency (CRA). | |

Consistent with findings of studies conducted on the commercialization environment in Manitoba (Braid Report),[20] there are numerous organizations working with overlapping services and programs. It is not always clear where to apply for support and those seeking support for their activities are sometimes sent from one organization to another. There seems to be no overall provincial strategy to improve research/ industry connection, or bridge the gap between basic research and the commercialization process – the activities seem to be happening on their own, in various facilitator organizations. There is significant activity in the commercialization pipeline in Manitoba, but programs and funding are not coordinated, and organizations often do not work together to leverage their resources.

*We need to better understand how knowledge is translated and findings are shared in Manitoba, especially in non-health fields.*
*There are no programs dedicated solely to pre-commercialization activities*
*Numerous facilitator organizations work in the pre-/early commercialization space as part of broader overlapping mandates and service offerings.*
*There is no clear and commonly accepted definition of "pre-commercialization" in the research and innovation environment in Manitoba.*

*Should we establish a set of provincial priority areas to guide research funding?*
*How did we support research strength and emerging opportunities?*
*How do we encourage the translation of research findings more quickly?*
*How are discoveries being shared? Are there more effective ways to share discoveries?*
*Should we require publications from funded research to be published in Open Access?*
*Are there gaps in the supports for activities related to the early stage commercialization of research?*
*Is there a consistent alignment between provincial and federal programs that fund research and pre-commercialization activities?*

[20] A report that looks at the commercialization environment in the province.

# PART 3 – ENVIRONMENTAL EVENTS/FACTORS THAT AFFECT THE RESEARCH ENTERPRISE

## 1. Provincial priorities

Manitoba has an Innovation Strategy with six priorities:

- Build on Manitoba's research excellence
- Support collaborative models for the commercialization of research
- Create a clear path for innovators and entrepreneurs in Manitoba
- Help our graduates and young entrepreneurs find the 'jobs of tomorrow' right here at home
- Enable our existing businesses to grow and prosper through innovation
- Create an environment that fosters private sector investment for entrepreneurs and innovators in Manitoba

## 2. Institutional priorities and goals

- University of Manitoba's measures of success of its 2015-2020 Strategic Research Plan includes
  - Research capacity building through recruitment and retention of outstanding faculty, and
  - Recruiting top students and providing outstanding training opportunities.
- Brandon University's 2014-2017 Strategic Research Plan aims to, among others:
  - Continue to produce high quality research and creative activity building on existing strengths and partnerships,
  - Increase research capacity and to expand research partnerships and collaboration, and
  - Establish mechanisms to increase knowledge mobilization.
- One of the University of Winnipeg's strategic priorities is a continuing focus on teaching excellence and the expansion of research.
- Red River College's first strategic initiative includes a goal of increasing of applied research and innovation

## 3. Funding landscape

- Research Manitoba's funding for 2015-2016 is expected to remain at the same level
- Demand for funding for research projects and commercialization activities in Manitoba is strong as can be seen in the variety of projects and amount of funding being requested either as matching funds or direct support to research in the natural and social sciences, engineering, and humanities. In the health funding programs, the overall success rate of funding applications has gone down since 2007.
- The federal budget for 2015 does not include increases to the three federal granting agencies. However, new funds were announced starting in 2016-17:
  - $15 million per year ongoing to CIHR ($13 million for the expansion of SPOR and $2 million for research on anti-microbial resistance).

- $15 million per year ongoing to NSERC ($10 million for business innovation programs in areas such as natural resources and energy, advanced manufacturing, and environment and agriculture; and $5 million to the College and Community Innovation Program).
- $7 million ongoing to SSHRC for Partnership Grants
- This year's investments in research focuses on infrastructure, with support to the Canada Foundation for Innovation, TRIUMF and the international Thirty Meter Telescope project.

- In health, CIHR, the major source of funding, has overhauled its funding delivery system
- Pushback to CIHR's direction towards "health knowledge along the innovation pipeline and into health and economic benefits." Scientists fear that there will be less money for discovery science as a result. CIHR for its part has stated that 50% of CIHR funding has, and still goes to idea that's of top quality and in the area of health.[21]
- Greater requirements for matching funds
- Non-expanding funding universe

## 4. Barriers to translation of science and technology knowledge[22]

Although the following were identified for Canada as a whole, the validity of these factors in the Manitoba setting should be considered.

- Technology transfer. Investments in university research and technology transfer personnel have seen a marked increase since 2000 but the number of patents and licensing agreements has not shown a corresponding rise. The Organization for Economic Co-operation and Development (OECD) and other reports have suggested that this may suggest low and declining productivity of technology transfer or a weak commercialization culture at universities, driven in part by an overly bureaucratic mindset across TTOs.
- Dearth of management expertise and business acumen. This conclusion is derived from lower levels of educational attainment of Canadian managers as opposed to US counterparts, and the likelihood of managers to leave post-secondary education without obtaining a degree. Canada's low managerial skill set does not enable competing in fast-paced knowledge economies and in adequately meeting the needs of dynamic markets.
- Business support. The total venture capital (VC) investment and the number of firms receiving VC investment has shown a decline since the early 2000s.
- Public procurement. The 2011 Jenkins report suggest using public procurement as a lever to create demand, especially in public-good properties and high innovation propensity (e.g. health, education environment) since there are very few demand-side policies that encourage innovation.
- Business culture. Canadian business culture is highly risk averse. Ideas produced by universities are frequently further away from the market and inherently more risky, making Canadian businesses less willing to develop these ideas for markets.

Particular to Manitoba, there is no lead organization that provides early stage commercialization services, and current programming and services of organizations and agencies overlap.

[21] http://ottawacitizen.com/news/local-news/medical-researchers-fear-new-funding-protocol-would-hurt-discovery-science
[22] 2013 The State of Industrial R&D in Canada p144-149

# PART 4 – SWOT ANALYSIS (preliminary)

## 1. Strengths

- New mandate; fresh starting point
- As a smaller province, the province's research enterprise has a better sense of its abilities and expertise, and investigators can connect with each other easily (Manitoba's advantage).
- Able to leverage more research income from non-government sources compared to other provinces
- There are many organizations to draw from
- Research strengths in: arctic research; functional foods; agriculture; aerospace; immunity, inflammation and infectious disease research; and, population and global health
- Patents applications and issued patents compare well with bigger provinces

## 2. Weaknesses

- Outside of research not enough collaboration between stakeholders (or maybe no data about it?)
- Weak link between research and post research innovation programs
- No adequate pre-commercialization programs
- Research budget too small for system wide requirements
- Below average provincial research $
- Coordination and advising role not clearly defined functions
- Fixed funding for Research Manitoba in context of broad mandate

## 3. Opportunities

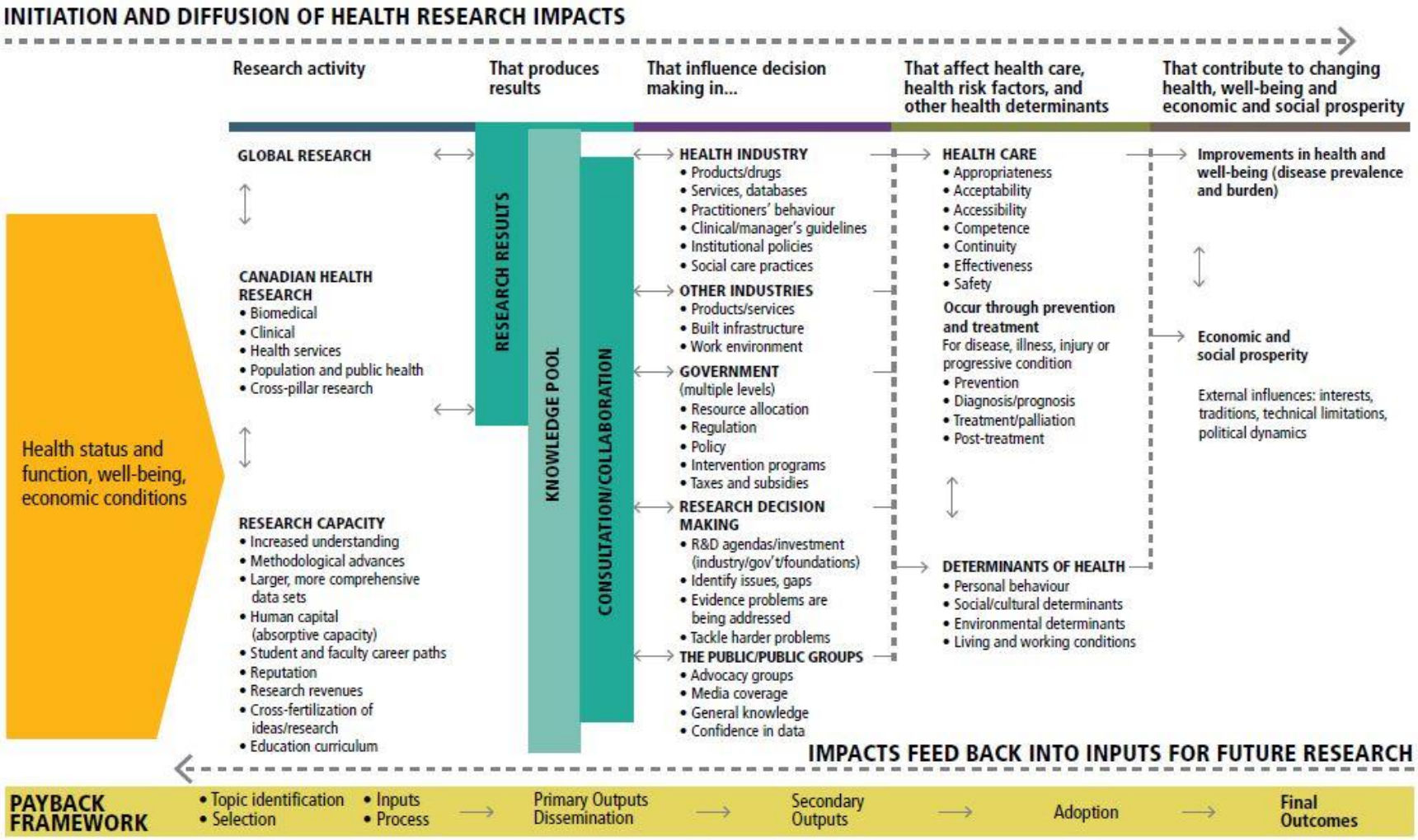
- Create or develop a role for CHI-KT planning for other areas of research
- Support to e-health industry(?) which is a huge trend going forward
- Develop additional clusters in agriculture, health, proteomics, composites, aerospace
- Expand research connections/invest in pre-commercial activities
- Work more with industry – coordinating activities/$
- Invest in natural sciences and engineering, and social sciences and humanities
- Invest in social innovation
- Targeted research calls based on issues of particular importance to Manitoba
- Partner with different organizations to find solutions
- Encourage a greater multidisciplinary approach, an example of which is the work around composites where research institutions have worked with other sectors to identify and realize practical applications of discoveries in materials research
- Consolidate major innovation and commercialization supports into a single facility, which could co-locate relevant services from all levels of government and integrate the service offerings of many existing programs and facilitator organizations.

## 4. Threats

- Matching funds requirements, e.g. from national funding agencies
- Funding sources (national, provincial, not for profit) have fixed research budgets
- Escalating indirect costs
- Strong competition for federal dollars
- Overlapping mandates, lack of coordination and cooperation among facilitator-organizations in Manitoba

## Appendices

**Appendix 1. The Canadian Academy of Health Sciences impact model***




* This is being adapted to be applicable to research in the natural sciences and engineering, and social sciences and humanities.

**Appendix 2. Distinctive competencies (areas of research strengths)***

| Authors (University of Manitoba) | Keywords | Subject area |
|---|---|---|
| Bernstein C.N., Blanchard J.F., Nugent Z.J. | Inflammatory Bowel Diseases; Crohn Disease; Colitis, Ulcerative | Medicine |
| Leslie W.D., Targownik L.E., Metge C.J. | Osteoporosis; Bone Density; Hip Fractures | Medicine |
| Nyachoti C.M., Woyengo T.A., Kiarie E.G. | Diet; Anesthesia; Intraoperative Awareness | Biochemistry, Genetics & Molecular Biology |
| Zhanel G.G., Karlowsky J.A., Hoban D.J. | Anti-Bacterial Agents; Vancomycin; Methicillin-Resistant Staphylococcus aureus | Medicine |
| Barber D.G., Stern G.A., Papakyriakou T.N. | Sea ice; ice; ocean | Agricultural and Biological Sciences; Earth and Planetary Sciences |
| Aluko R.E., Pierce G.N., Udenigwe C.C. | Linoleic Acids, Conjugated; Flax; Diet | Biochemistry, Genetics & Molecular Biology; Immunology and Microbiology |
| Kumar A., Fowke K.R., Juno J.A. | Influenza, Human; Influenza A Virus, H1N1 Subtype; Pandemics | Medicine |
| Sareen J., Cox B.J., Bolton J.M. | Alcohols; Anxiety Disorders; Diagnostic and Statistical Manual of Mental Disorders | Medicine |
| Lovetri J., Pistorius S., Zakaria A. | Microwaves; Imaging techniques; Imaging systems | Engineering |
| Hershcovis M.S., Turner N., Reich T.C. | Transformational leadership; Workplace; Leadership | Social Sciences |
| Berkes F., Sinclair A.J., Davidson-Hunt I.J. | knowledge; management; adaptive management | Environmental Science; Energy; Engineering; Earth and Planetary Sciences; Agricultural and Biological Sciences |
| Gumel A.B., Kliewer E.V., Demers A.A. | Papillomavirus Infections; Papillomavirus Vaccines; Condylomata Acuminata | Medicine; Pharmacology, Toxicology & Pharmaceutics |
| Halayko A.J., Ghavami S., Yeganeh B.K. | Muscle, Smooth; Asthma; Cells | Medicine |
| Netticadan T.J., Thandapilly S.J., Louis X.L. | Anthracyclines; Antineoplastic Agents; Heart Failure | Medicine |
| Simons F.E.R., Simons K.J., Rachid O. | Anaphylaxis; Epinephrine; Hypersensitivity | Medicine |
| Hawthorne F.C., Sokolova E.V., Černý P. | pegmatite; mineral; tourmaline | Environmental Science; Energy; Engineering |
| Rush D.N., Nickerson P.W., Ho J. | Acute Kidney Injury; Kidney Transplantation; Graft Rejection | Medicine |
| Jones P.J.H., MacKay D.S., Rideout T.C. | Phytosterols; Cholesterol; Cholesterol, LDL | Medicine |
| Dean H.J., Sellers E.A.C., Wicklow B.A. | Obesity; Diabetes Mellitus, Type 2; Insulin Resistance | Medicine |
| Blanchard J.F., Moses S.S., Ramesh B.M. | HIV; HIV Infections; Sex Workers | Medicine |
| Becker A.B., Kozyrskyj A.L., Yang X. | Asthma; Obesity; Child | Medicine |
| Torabi M., Li H., Wang L. | Small area estimation; Area; Model | Mathematics; Physics and Astronomy |
| Tachie M.F., Paul S.S., Agelinchaab M. | Reynolds number; Velocity; Turbulence | Engineering |
| Atrey P. K. (U of Winnipeg) | Algorithms; Cameras; Target tracking | Engineering; Materials Science |

All authors are from the University of Manitoba except Dr PK Atrey of the University of Winnipeg

*Competencies (distinctive or emerging) are research areas where the institution has a leading position in a) the number of publications, b) number of highly cited publications, or c) innovativeness, measured in terms of the recentness of the cited publications. A competency is distinctive when it is a significantly large field of research. This means that the worldwide publication output in the field over a five-year period exceeds a threshold. Additionally, the field must one meet one of the following criteria: a) the institution is ranked #1 in this field of research in terms of publication output; b) the institution is ranked #1 in this field of research based on the number of highly cited publications; or c) the institution is ranked #1 in this field of research in terms of innovativeness.

Source: SciVal (http://scival.com/overview/competencies/browse?uri=Institution/501054) accessed 7 April 2015. Only 1 distinctive competency was identified for University of Winnipeg