National Metrology Institute – Its Value to Canadian Economy and Society

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Abstract

The Institute for National Measurement Standards, the Canadian National Metrology Institute, has recently completed its five-year strategic plan. The Institute's contributions to the Canadian innovation system, economy, and the health and safety of Canadian society have been reviewed and evaluated within this planning process. A study on the economic impact of the Institute's activities was commissioned from a consulting company, KPMG. Methodologies, assumptions and findings of this study will be presented at the meeting.

Introduction

The Institute for National Measurement Standards (INMS) is Canada's National Metrology Institute (NMI). It is one of 22 Institutes and Technology Centres of the National Research Council of Canada (NRC), the premier science and technology research organization of the Canadian federal government. The role of INMS is defined in an Act of the Canadian Parliament which empowers NRC to undertake "*the investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time, heat, light, electricity, magnetism and other forms of energy, and the investigation and determination of physical constants and the fundamental properties of matter*". This role places NRC firmly at the centre of the Canadian national measurement system with close links to other organizations such as Industry Canada (which is responsible for legal metrology), the Standards Council of Canada (which is responsible for the accreditation of testing and calibration laboratories) and the Department of National Defence.

Like most NMIs in industrialized nations, INMS performs six major core functions.

- *Development and maintenance of primary measurement standards*
- *Industry-driven measurement research*
- *Dissemination of calibration and measurement services*
- *Participation in international metrology activities*
- *Leadership in the national measurement system*
- *Measurement science outreach and education*

The INMS strategic planning process has identified challenges and opportunities that must be addressed if INMS is to meet Canada's needs. Such internal identification of the Institute's role and of desirable projects within each core function is only a first step however. Although in the past INMS, as with many other NMIs, has operated with unquestioned continuing and often increasing resources, this is no longer the case. Today it is necessary to justify in some detail the need for new resources and, indeed, to justify even the maintenance of resources at traditional levels. For this reason, INMS has devoted considerable effort to measuring the economic and social impact of its work.

Measuring the Value of an NMI

At the highest levels of an NMI's work, the development of primary standards, scientific excellence is a common yardstick by which we can be compared to other high-level scientific research institutes. The current representations of the volt and the ohm are both based on Nobel Prize-winning research so no one can doubt that metrology involves science that compares favourably with the very best. Traditional measures such as refereed publications, peer recognition, invitations to collaborate in research or to present keynote papers at conferences, and national and international awards can all be used to evaluate the quality of an NMI's basic research.

The value of industry-driven measurement research is also usually clear. For example, the development of super-pure materials would not be possible without top-class chemical metrology. In such areas the willingness of industry to pay for new measurement techniques can be used to gauge the value of the work that goes into developing the techniques.

The value of an NMI's calibration and measurement services might be considered easy to measure because clients pay fees for these services. INMS does approximately 850 calibrations per year for an income of roughly $850 000 (Canadian) per year. However, this does not tell the full story. A survey of about 20 of our clients showed that for every instrument or artifact calibrated by INMS, there are between 500 and 4000 calibrations done by the clients. INMS therefore directly supports a very large number of calibrations at a secondary level in the Canadian measurement system. Unfortunately, the ultimate number and value of these calibrations is almost impossible to determine accurately and traditionally has been done only by case studies and by anecdote.

Another aspect of an NMI's dissemination activities is direct technology transfer. INMS undertakes various technology transfer activities chiefly comprised of collaborative projects and the licensing of intellectual property. One example is the Monte Carlo software developed in the Ionizing Radiation Standards laboratories and licensed to MDS Nordion to be used in their oncology protocols for the treatment of cancer. Another is the success of AT Plastics in commercializing a deterioration resistant insulation for high voltage polymer insulated underground cables that was the outcome of research activities in the Electrical Power Measurements Group. INMS expertise has also contributed to the success of NRC's objective to spin technology off to the private sector. For example, Ionalytics Corporation has commercialized a chemical analysis system for instrumentation used in areas of biotechnology such as proteomics and drug discovery, in security protocols such as the detection of chemical and biological agents, and in the monitoring of environmental waste sites. Royalty income that INMS receives from these ventures can be used as a measure of the value of the INMS work but,

again, a large and unknown multiplier is needed to convert the direct INMS income into a figure that represents the value to the Canadian economy.

Unfortunately, most methods of evaluating an NMI's activities tend to be qualitative or, if quantitative, have a very large uncertainty. Quantitative analysis of the value of an NMI's activities is very difficult because there is often a long chain leading from an NMI's work to a product that can be sold and whose value can thus be measured easily. Companies know how much income they receive from sales of their products or services but cannot readily measure what portion of this income can be traced back to the measurement infrastructure provided by the NMI. It is easy to make the qualitative statement that accurate, reliable and repeatable measurements play a key role in assuring the quality of manufactured products, just as it is easy to acknowledge qualitatively that a modern network of roads plays a key role in getting the products from the manufacturer to the consumer. Quantitative statements are however not so easy. Measurement systems and transportation systems are both indispensable infrastructures whose value, both in economic terms and in terms of the general feeling of safety and security in a country, is usually taken for granted but whose exact monetary impact is difficult to measure.

In the past this was not a major problem for NMIs as their funding was relatively secure. However, the old notion of unquestioned entitlement to resources no longer exists. In today's political climate a much more stringent economic analysis is needed not only to obtain new resources but also to justify the continuation of existing funding levels. For this reason, as part of its recent strategic planning process, INMS hired KPMG Consulting to conduct an *INMS Economic Impact Study*.

Economic Impact Study

The Study was designed to support the goals of the INMS Strategic Plan, by presenting an objective, independent measure of the current and expected economic impact of INMS activities on the Canadian economy. The report was submitted in September 2001 and presented a positive analysis of the direct and indirect impact that INMS has on a variety of economic functions in Canada. Current economic impact was calculated through the use of traditional case studies that focussed mainly on technology transfer and direct support to industry, and by a newly developed measure of the direct impact that maintaining national metrology standards has on Canadian economic activity. Throughout, the focus was on determining a calculable estimate of economic impact, and no effort was made to extend this calculable estimate to a summary prediction of the actual *total* impact that INMS has on the Canadian economy. Thus the study errs on the side of a conservative – although clearly justifiable – estimate of INMS economic impact.

The results of the Study were reported in the form of a matrix in which three types of economic impact were listed for the each of the six core functions of INMS. Three core economic benefits of INMS work were identified to isolate the different types of economic benefit that INMS provides:

- Market maintenance (Public good) – Public good benefits associated with establishing, and aiding in the enforcement of, national measurement standards. In a general sense, market maintenance benefits take the form of reduced measurement (transaction) costs.

- Quality of life (Public good) – Public good benefits associated with social welfare effects as a result of measurement/metrology.

- Direct benefits to industry/consumers (Private good) – Private good benefits accruing directly to industry/consumers as a result of INMS service provision, or second order effects due to activities such as technology transfer or licensing.

Three research methods were used as indicated in Table 1. These were document review, case studies and a newly developed model described as the "ISO Proxy Model".

Core Benefit / Core Function	Market Maintenance Impact (public good)	Quality of Life Impact (public good)	Direct Benefits to Industry and Consumers (private good)
Maintain primary standards	ISO Proxy Model	Document Review	Case Study
Research & development	Document Review	Case Study	Case Study
Calibration & metrology services	Document Review	Case Study	Case Study
International negotiations & standards setting	Document Review	Document Review	Case Study
Consultation & collaboration	Document Review	Case Study	Case Study
Outreach & education	Document Review	Case Study	Case Study

Table 1. Matrix of research methods.

ISO Proxy model

The basic premise of the ISO Proxy Model is straightforward. The overall market maintenance impact of INMS functions for maintaining primary metrological standards is high, and likely represents the greatest real impact of any INMS function. However, as has been the case in other studies, establishing a reasonable estimate for this impact remains a significant challenge, mainly because there is no direct way to measure the market's willingness to pay for primary metrological standards. The current investigation advances the study of total economic impact by applying a proxy model for market maintenance impact. The willingness of organizations to pay for registration to the ISO 9000 and ISO 14000 series of standards is used as a proxy for their willingness to pay for the maintenance of primary metrological standards.

The two ISO standards are primarily a set of specifications about quality management. For all industries except those involved in management or engineering consulting, this involves a degree of attention to the requirements of metrology. In particular, all ISO 14000 registrants have a dependence on metrology given that environmental performance indicators and legislation require monitoring of air emission, waste water characteristics, and so on, and all ISO 9000 registrants must meet requirements for the control of inspection, measuring and test equipment. Given that the hierarchy of measurement uncertainty is ultimately governed by primary national standards developed and maintained by INMS, it is reasonable to assume that commitment to traceable uncertainty is de facto a commitment to national metrological standards. It is also reasonable to suggest that all organizations that have invested in ISO 9000 and 14000 series registration have revealed their willingness to pay for well-defined technical uncertainty in measurement. Implicitly, this suggests willingness to pay for national metrological standards. This suggests that the willingness of organizations to pay for ISO registration can be used as a proxy for organizations' willingness to pay for the maintenance of primary metrological standards. In turn, this allows for an estimation of a reasonable lowest bound of the market maintenance impact of INMS' functions in relation to primary standards.

It is assumed that one-quarter (25%) of the total cost associated with ISO registration is directly traceable to the system of metrological standards and uncertainty (i.e., organizations invest approximately 25% of the cost of ISO registration on demonstrating traceability and accuracy in measurement). A proxy for the market maintenance impact of INMS maintaining primary metrological standards is therefore represented by one-quarter of the total level of resources that organizations invest in ISO registration/certification.

The ISO Proxy Model provides a lower bound constraint for the real impact of maintaining national measurement standards for a variety of reasons:

- ISO registration is voluntary. As a result, the number of registrations represents only that proportion of a given industrial sector that deems it necessary to publicly demonstrate commitment to metrological standards. This implies that ISO registration is indicative of the impact of INMS primary standards, but is not an exclusive measure. Indeed, it is reasonable to suggest that the real market maintenance impact is significantly higher than that represented through use of the ISO database.

- ISO registration is biased to certain industrial sectors (e.g., manufacturing), and thus does not capture evidence of metrological dependence across the economy as a whole. As a result, important sectors of the economy will be under-represented by the ISO proxy (e.g., agricultural industries).

- ISO registries are incomplete. Just as ISO registration is voluntary, so too is reporting a registration. While it is reasonable to suggest that ISO registries provide excellent coverage, by their own admission, they will not capture all ISO registered organizations.

- The ISO proxy model calculates only the willingness to pay for metrological standards. It does not calculate the second-order impact that standards have on economic activity (i.e., the 'return on standards investment'). This impact is likely to be significantly larger than simple 'willingness to pay' measures can reveal. In addition, the current calculation utilizes a conservative estimate of the minimum cost of registration.

- The ISO model captures only the 'external' costs of accreditation, not the organization's total internal investment (e.g., time, equipment).

Case Studies

The most common approach to investigating the economic impact of NMIs takes the form of case studies. Indeed, this is the standard approach taken elsewhere, and can be viewed as a response to the challenges associated with estimating economic impact of NMIs, in that it tends to focus directly on specific forms of technology or service provision. For purposes of the current study, a total of 17 cases were investigated – some representing an update to a previous report, and the remainder representing new cases. In each circumstance, cases were chosen on the basis of the following criteria:

- The cases represented a sample of primary INMS clients. "Big winners" were identified and represent specific individual functions, products, and services in a limited number of program areas, for specific groups of clients. Very detailed questions were asked to reflect exactly how these specific INMS items served each industry's needs.

- The cases were aligned with the matrix of Table 1 so that benefits were investigated on the basis of INMS core functions.

- The cases established a calculable estimate of INMS economic impact. No attempt was made to extrapolate individual case impacts to the level of INMS as a whole. This approach reduced the potential for validity problems, by ensuring a conservative, realistic estimate was presented.

Results

The results of the Study are presented in Table 2 and show that, even with the very conservative methodology, the benefits of INMS activities exceed the costs by a factor of about 13.

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Core Benefit / Core Function	Market Maintenance Impact (Public good)	Quality of Life Impact (Public good)	Direct Benefits to Industry and Consumers (Private good)	Sub-total Benefits
Maintain primary standards	$18.9 million	Not examined	$100 thousand	$19 million
Research & development	Not examined	Not examined	$50.5 million	$50.5 million
Calibration & metrology services	Not examined	Not examined	$21.2 million	$21.2 million
International negotiations & standards	Not examined	Not examined	$33 million	$33 million
Consultation & collaboration	Not examined	Not examined	$33.3 million	$33.3 million
Outreach & education	Not examined	Not examined	$2.8 million	$2.8 million
Sub-total	$18.9 million	Not examined	$140.8 million	$159.7 million

Table 2. Current economic impact of INMS activities (all figures in Canadian dollars).