



RESEARCH PAPER 6/2015

# The economics of metrology

Kristel Robertson and Jan A. Swanepoel

September 2015

## Abstract

All major economies support a metrology infrastructure given its role in technological advances and its public good characteristics. This paper highlights the key economic concepts and arguments from the literature behind measurement and the standards and institutes that are associated with it. It provides an overview of Australia's measurement system and details the role of measurement in the economy by reviewing the literature on the economic rationale for measurement and standards, the economic benefits of measurement as well as the associated costs. It also summarises the empirical findings of a number of international studies that analysed the economic impact of standards. The paper highlights that measurement plays an important role in science, industry and commerce given its role as providing a basis for fair and accurate trade, optimisation of production, fostering consumer and business confidence in products and in the development of new technologies and innovation.

**JEL Codes:** A12, H41

**Keywords:** Metrology, standards, public goods



---

For further information on this research paper please contact:

Kristel Robertson

Economic and Analytical Services Division

Department of Industry, Innovation and Science

GPO Box 9839

Canberra ACT 2601

Phone : +61 2 6102 9147

Email: [Kristel.Robertson@industry.gov.au](mailto:Kristel.Robertson@industry.gov.au)

---

#### Disclaimer

The views expressed in this report are those of the author(s) and do not necessarily reflect those of the Australian Government or the Department of Industry, Innovation and Science.

© Commonwealth of Australia 2015.

This work is copyright. Apart from use under Copyright Act 1968, no part may be reproduced or altered by any process without prior written permission from the Australian Government.

Requests and inquiries concerning reproduction and rights should be addressed to [chiefeconomist@industry.gov.au](mailto:chiefeconomist@industry.gov.au). For more information on Office of the Chief Economist research papers please access the Department's website at: [www.industry.gov.au/OCE](http://www.industry.gov.au/OCE)



---

#### Creative Commons Licence

With the exception of the Coat of Arms, this publication is licensed under a Creative Commons Attribution 3.0 Australia Licence.

Creative Commons Attribution 3.0 Australia Licence is a standard form license agreement that allows you to copy, distribute, transmit and adapt this publication provided that you attribute the work. A summary of the licence terms is available from <http://creativecommons.org/licenses/by/3.0/au/deed.en>. The full licence terms are available from <http://creativecommons.org/licenses/by/3.0/au/legalcode>.

The Commonwealth's preference is that you attribute this publication (and any material sourced from it) using the following wording:

Source: Licensed from the Commonwealth of Australia under a Creative Commons Attribution 3.0 Australia Licence. The Commonwealth of Australia does not necessarily endorse the content of this publication.

## Key points

- Metrology, the science of measurement, is driven by continued development of science, technology and industrial production.
- The importance of measurement in supporting the economy is well recognised in the mission statements of various national measurement institutes, including Australia's National Measurement Institute.
- Measurement plays an important role in providing a basis for fair and accurate trade, optimisation of production, fostering consumer and business confidence in products and in the development of new technologies and innovation.
- International studies that quantified the impact of a 1 per cent increase in the stock of standards on total factor productivity produced estimates that ranged from 0.1 per cent to 0.17 per cent.
- The estimated impact of a 1 per cent increase in the stock of standards on labour productivity ranged from 0.05 per cent to 0.36 per cent, while the impact on Gross Domestic Product ranged from 0.17 per cent to 1 per cent.
- A wide range of US economic impact studies since the 2000s point to the fact that benefit-cost ratios vary significantly between industries, ranging from 4:1 for Building Technology (commercial construction system integration & automation technologies) to 249:1 for Information Technology (computer security), with an average benefit-cost ratio of 47:1.
- It is important to point out that the importance of metrology extends well beyond economic benefits such as in the fields of health and safety, the environment, law and order, defence and security, and leisure and trade.

# 1. Introduction

Metrology, the science of measurement, is driven by continued development of science, technology and industrial production. While the importance of measurement in areas such as engineering, construction and manufacturing is well known, the important role it plays in the economy can be easily overlooked. The objective of this paper is to highlight the key economic arguments and principles from the literature on the concept of measurement and the standards and institutes that are associated with it, as well as to identify studies that quantify the economic impact of measurement.

The next section provides a brief overview of Australia's measurement system, followed by a short description of the role of measurement in a modern economy. This is followed by sections that highlight the theoretical economic arguments for measurement and standards, the key economic benefits associated with measurement activity, standardisation, accreditation or national measurement institutes as well as costs associated with metrology and measurement. Finally, a summary of the papers identified from the literature that quantify the economic impact of measurement is provided.

# 2. Australia's measurement system

Commercial transactions rely on the support of standards and conformance infrastructure comprising metrology, documentary standards, laboratory accreditation and quality systems and certification. The national measurement system is a coherent formal system that ensures that measurements can be made on a consistent basis throughout the country. Australia's standards and conformance infrastructure is made up of four national organisations (and complemented by legal metrology authorities). The National Measurement Institute (NMI) is responsible for the national measurement infrastructure and for maintaining Australia's units and standards of measurement. The National Association of Testing Authorities (NATA) is responsible for laboratory accreditation. Standards Australia is responsible for documentary standards, while the Joint Accreditation System of Australia and New Zealand is responsible for certification of management systems, products and personnel. Each organisation has a key role to play in ensuring that a high level of quality and accuracy is delivered that is accepted by users.

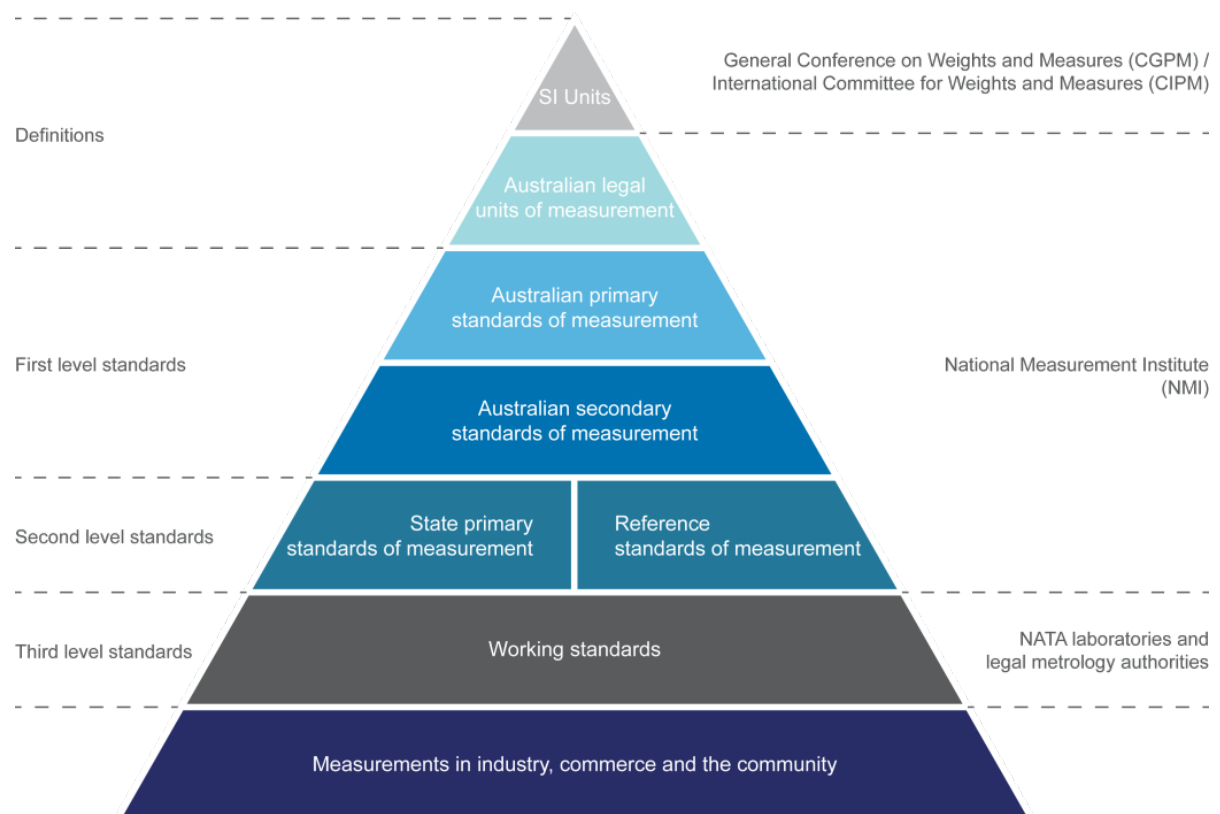
Measuring devices are calibrated by standards. Figure 2.1 illustrates the hierarchy of standards by which a physical measurement can be related back through the national metrological pyramid to the relevant International System of Units (SI) embodied in Australia's national standards of measurement. This process is known as 'traceability'. To ensure traceability to national standards, it is essential to maintain the reliability of calibration, in which a standard device is calibrated by a higher standard device.

At the first level of standards, the NMI is responsible for realising, maintaining and disseminating Australia's national physical standards. Due to the fact that the primary standards for the SI base units and derived units may be inconvenient for everyday use as they are generally used strictly in

measurement laboratories, the NMI also holds Australian secondary standards (calibrated in terms of the primary standards) which are more convenient to use when calibrating lower-level standards or instruments.<sup>1</sup>

As it is impractical for the NMI to handle all of the measuring standards and instruments that require calibration in order to demonstrate traceability of measurement, the NMI calibrates higher accuracy standards held by government calibration laboratories, verifying authorities and private sector calibration laboratories accredited by NATA at the second level of standards. These second-level laboratories calibrate a wide range of lower accuracy standards and measuring instruments used in industry and commerce.

Figure 2.1: Hierarchy of measurement standards in Australia



Source: National Measurement Institute (2013)

The NMI is therefore a key measurement partner for government, industry and the wider community. It plays an important role as the ‘calibrator’s calibrator’ for realising the SI standards as practical standards of measurement and maintaining and providing the peak level infrastructure that facilitates dissemination of these standards to Australian industry. The full range of products and services offered by the NMI include the provision of certified

<sup>1</sup> NMI has delegated responsibility for maintaining standards relating to ionising radiation to the Australian Nuclear Science and Technology Organisation and the Australian Radiation Protection and Nuclear Safety Agency.

reference material, analysis and testing, consultancies and contract research, time and frequency dissemination, pattern approval examination and training.<sup>2</sup>

### 3. Measurement and the economy

The importance of measurement in a modern economy is highlighted by the mission statements of various national measurement institutes. Australia and the United States of America are used as examples below.

The mission statement of Australia's National Measurement Institute is "*To meet the nation's needs for world class measurement infrastructure based on scientific excellence that will support innovation, facilitate fair competition, promote international trade, underpin regulation and deliver social and economic benefit to all Australians*".

In the United States, the mission statement of the National Institute of Standards and Technology (NIST) is: "*To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life*".

At the core, metrology links science and economic activity closely as measurement is a cornerstone for economic transactions, optimisation of production, consumer and business confidence and innovation. Without an agreed system of measurement, it would not be possible to trade accurately and fairly, firms will find it difficult to innovate and compete and government regulation will be ineffective.

National measurement institutes play a key role in managing and developing national measurement systems and providing measurement standards and calibration-testing facilities to stimulate good measurement practice and enabling businesses to make accurate and traceable measurements. It is possible to buy access to standards from overseas measurement bodies, but without domestic provisions competitors could take competitive advantage through pricing or by delaying access. Moreover, from a trade perspective, it is important to enhance the capacity of the domestic economy to meet international standards and client quality and safety requirements.

#### 3.1 Literature review on the economics of metrology

The topics on the economics of measurement, national measurement systems and national measurement institutes are covered in various academic articles, published reports and papers and were not only confined to Australia. A review of the literature highlighted the work of three pioneering economists; namely Gregory Tasse, Albert Link and John Barber. The most influential pieces of work from these authors are listed in Box 3.1. Further to these contributions include later work by G.M. Peter Swann. Together these economists have made significant and influential contributions to this field of study. From the literature

---

<sup>2</sup> See <http://www.measurement.gov.au/Services/Pages/default.aspx> for more information.

review, a number of papers have been identified as important, which have formed the basis of this note.<sup>3</sup>

---

Box 3.1: Most influential work of Tassej, Link and Barber

Barber J M (1987) *Economic Rationale for Government Funding of Work on Measurement Standards*, Annex 5 in R. Dobbie, J. Darrell, K. Poulter and R. Hobbs, Review of DTI Work on Measurement Standards, London: Department of Trade and Industry, April

Link AN (1996) *Evaluation Public Sector Research and Development*, Westport, CN: Praeger

Link AN and Scott JT (1997) *Evaluation technology-based public Institutions: lessons from the National Institute of Standards and Technology*, in Policy evaluation in innovation and technology towards best practices, Paris: Organization for Economic Cooperation and Development

Link AN and Scott JT (2006) An economic evaluation of the Baldrige National Quality Program, *Economics of Innovation and New Technology*, vol. 15, no. 1, pp. 83–100

Link AN and Scott JT (2011) *Public Goods, Public Gains: Calculating the Social Benefits of Public R&D*, Oxford University Press

Link AN and Tassej G (1993) The Technology Infrastructure of Firms: Investments in Infratechnology, *IEEE Transactions on Engineering Management*, vol. 40, no. 3, pp. 312–315

Tassej G (1982a) *Infratechnologies and the Role of Government*, *Technologies Forecasting and Social Change*, vol. 21, no. 2, pp. 163–180

Tassej G (1982b) The Role of Government in Supporting Measurement Standards for High-Technology Industries, *Research Policy*, vol. 11, pp. 311–320

Tassej G (1991) The Functions of Technology Infrastructure in a Competitive Economy, *Research Policy*, vol. 20, pp. 345–361

Tassej G (1999) Lessons learned about the methodology of economic impact studies: the NIST experience, *Evaluation and Program Planning*, vol. 22, pp. 113–119

Tassej G (2000) Standardization in Technology-based Markets, *Research Policy*, vol. 29, pp. 587–602

Tassej, G (2005) Underinvestment in Public Good Technologies, *Journal of Technology Transfer*, vol. 30, no. 1, pp. 89–113

---

Source: Various

---

<sup>3</sup> Key publications are listed under references.

### 3.2 Economic benefits of measurement

There are economic benefits associated with measurement activity, standardisation, accreditation or national measurement institutes. As highlighted in the introduction, this note aims to highlight a few key economic benefits that clearly illustrate the economic rationale behind its importance.

According to the literature, measurement and the activities and institutes associated with it provide a considerable number of benefits. Four key economic benefits include limiting market failure, reduced transaction costs, increased economic efficiency and supporting innovation.

Firstly, measurement and standards play an important role in the efficient functioning of markets. Markets cannot operate efficiently or effectively if buyers and sellers have inadequate information about the products in a market. Asymmetric information between buyers and sellers is one of the most common sources of market failure, which occurs when the buyer cannot determine the quality of a product and as a result does not purchase the product.<sup>4</sup> Through the provision of measurement and standards, buyers can measure the quality of products given there are agreed standards and they can therefore differentiate between lower and higher quality products.<sup>5</sup> This then eliminates the asymmetric information, as well as corrects the market failure present, thus increasing the efficiency of the market.

Secondly, measurement and standards can reduce the transaction costs associated with participating in an economic exchange. Transaction costs arise as a result of the information between consumers and producers being asymmetric and incomplete. By having an agreed standard of measurement, a buyer can spend less time searching for goods and incur fewer costs associated with checking that the product conforms to the quality requirements. In addition to this, producers can also reduce their transaction costs by producing a product that complies with the standard. By producing a product in accordance with the standard, a producer can incur fewer costs associated with correcting defects to meet specifications, which allows for the product to be certified and also leads to trust regarding the certification and performance of the product compared to a competitor's product.<sup>6</sup> Thus, standards assist in providing safe outcomes for buyers and assist producers with risk management in reducing undesirable outcomes. Consequently, by reducing transaction costs, measurement and standards can reduce the likelihood of market failure.

Thirdly, measurement increases economic efficiency by creating economies of scale. In the context of economies of scale, measurement standards have the ability to reduce variety in that standards can set limits to a fixed number of

---

<sup>4</sup> Akerlof G A (1970) 'The Market for "Lemons": Quality Uncertainty and the Market Mechanism', *The Quarterly Journal of Economics*, vol. 84, no. 3, pp. 488–500

<sup>5</sup> Swann GMP (2009) *The Economics of metrology and Measurement*, Report for National Measurement Office, Department for Business, Innovation and Skills, October

<sup>6</sup> Goncalves J & Peuckert J (2011) *Measuring the Impacts of Quality Infrastructure*, Report for the German Federal Ministry for Economic Cooperation and Development, April



product characteristics.<sup>7</sup> By limiting the number of characteristics a product has, this lowers the costs associated with the production of one unit of the good for suppliers, since they do not need to produce a heterogeneous good<sup>8</sup> for different consumers.<sup>9</sup> Thus, by producing a homogenous good, suppliers can therefore operate on a larger, more efficient scale of production and produce goods at lower per unit costs. In addition to economies of scale, this reduction may also allow economies of learning,<sup>10</sup> as a reduction in the variety of products being produced may also improve the safety and functionality of the product.<sup>11</sup>

Fourthly, measurement plays a role in supporting and stimulating innovation, collaboration and commercialisation. Measurement is considered to be one of the infratechnologies, thus one of the technologies that provide the technical infrastructure and tools necessary for further innovation.<sup>12</sup> Measurement and standards do this by providing a platform on which new technologies and processes can be built on and demonstrated.<sup>13</sup> In a world with no measurement or standards, an innovator of a new product would find it very difficult to demonstrate and convince a potential buyer what their product does, its benefits and its superiority over the competition.<sup>14</sup> On the other hand, if the product characteristics could be measured and verified through the provision of a measurement system, this then would decrease the risk to buyers purchasing new products and increase the rate at which new products are diffused into the market. Thus, measurement plays a significant role in innovation, innovation requires measurement standards and without such measurement standards market failure would be inevitable for innovative new products.

### 3.3 Costs associated with metrology

While there are a number of economic benefits, metrology and measurement also entail costs. A significant amount of resources must be expended to develop and implement measurement standards. Measurement standards may also lead to market failure and thus impose costs on the economy, if it is not regularly maintained or appropriately regulated. Thus, metrology and

---

<sup>7</sup> Stokes F, Dixon H, Generosa A & Nana, G ( 2011) *The Economic Benefits of Standards to New Zealand*, Report for The Standards Council of New Zealand and the Building Research Association of New Zealand, August

<sup>8</sup> A heterogeneous good is a good which differs in specifications or quality, thus are not homogenous.

<sup>9</sup> Ibid.

<sup>10</sup> Economies of learning is the increase in efficiency associated with the skills and experience gained by being focused on products with fewer technical variations.

<sup>11</sup> Goncalves J & Peuckert J (2011) *Measuring the Impacts of Quality Infrastructure*, Report for the German Federal Ministry for Economic Cooperation and Development, April

<sup>12</sup> Tassef G (2005) 'Underinvestment in Public Good Technologies', *Journal of Technology Transfer*, vol. 30, no. 1, pp. 89–113

<sup>13</sup> Swann GMP (2000) *The Economics of Standardization*, Final Report for Standards and Technical Regulations Directorate, Department of Trade and Industry, December

<sup>14</sup> Swann GMP (2009) *The Economics of metrology and Measurement*, Report for National Measurement Office, Department for Business, Innovation and Skills, October

measurement can create costs, which include switching costs and excess inertia or lock in and can also result in a free rider problem. These issues are explained in more detail below.

There are costs associated with switching from one measurement standard to another. Producers and consumers face switching costs when they invest into a particular standard of measurement.<sup>15</sup> Thus, they are no longer relatively free to choose between different standards and will find it increasingly expensive to switch to a different measurement standard. Switching costs may also make some producers and consumers cautious and even reluctant about changing measurement standards. Consequently, excess inertia occurs when users of measurement standards are reluctant to switch to another, unless they can be sure that all others will too resulting in lock-in occurring as it has become too difficult to switch.<sup>16</sup>

### 3.4 The economic rationale for public support of measurement and standards

A widely held view in the literature is that public policy is needed to support some parts of the measurement system, in particular metrology.<sup>17</sup> From the literature on the economics of measurement, there are three key arguments that consistently appear for having public policy support towards metrology and measurement.<sup>18</sup> Firstly, measurement standards and conformance infrastructure exhibit the principal characteristics of public goods.<sup>19</sup> Secondly, privately funded metrology projects have positive externalities,<sup>20</sup> which are hard to internalise. Thirdly, the ratio of fixed costs to marginal costs in some metrology projects is high; hence there are issues around economies of scale<sup>21</sup> and scope.<sup>22</sup> Together these three arguments form the basis for government policy support towards metrology and measurement and will each be explained in more detail below.

---

<sup>15</sup> Swann GMP (2000) *The Economics of Standardization*, Final Report for Standards and Technical Regulations Directorate, Department of Trade and Industry, December

<sup>16</sup> Stokes F, Dixon H, Generosa A & Nana G 2011, *The Economic Benefits of Standards to New Zealand*, Report for The Standards Council of New Zealand and the Building Research Association of New Zealand, August

<sup>17</sup> Swann GMP (2009) *The Economics of metrology and Measurement*, Report for National Measurement Office, Department for Business, Innovation and Skills, October.

<sup>18</sup> Lambert R (2010) *Economic Impact of the National Measurement System*, Prepared for the Measurement Board, July

<sup>19</sup> A public good is a good that is both non-excludable and non-rivalrous in that individuals cannot be effectively excluded from using a particular good and where use by one individual does not reduce its availability to another individual. The textbook example is a lighthouse.

<sup>20</sup> A positive externality exists when an individual or firm making a decision does not receive the full benefit of the decision. The benefit to the individual or firm is less than the benefit to society.

<sup>21</sup> Economies of scale are factors that cause the average cost of producing a product to fall as the volume of its output increases. Economies of scale arise because of the inverse relationship between the quantity produced and per-unit fixed costs.

<sup>22</sup> Economies of scope are factors that make it cheaper to produce a range of products together than to produce each one of them on its own.

## Public goods

The development and maintenance of measurement standards have a strong public good character. They exhibit two principal characteristics of a public good — non-rivalry and non-excludability.<sup>23</sup> The former refers to the situation, that when an individual user uses a given standard of measurement, their use of that particular standard does not preclude another individual user from using that same standard. The latter refers to the situation, that once a measurement standard has been developed and implemented, it is virtually impossible to prevent anyone from using that standard.

There is a cost associated with the provision and maintenance of an open measurement standard, which will generally lead to insufficient private investment in measurement standards. A firm will typically be unable to appropriate a significant proportion of the economic benefits of any investment they make in developing measurement standards. It is these un-appropriable benefits which cause the social rate of return to the development of measurement standards to be significantly higher than the private rate of return to the investing firm. Consequently, the private sector by itself will devote fewer resources to the development of measurement standards than is desired by the economy as a whole. It is for these reasons that it is argued government is required to support the development and maintenance of measurement standards.<sup>24</sup>

## Externalities

Metrology projects generate many potential benefits and externalities for both developers and for other potential users. However, a problem associated with externalities whether positive or negative is that they drive a wedge between the private and social benefits from a private investment.<sup>25</sup> As measurement standards are considered to be a public good, public goods often create positive externalities. Thus, when an individual firm makes an investment to develop a measurement standard hence a privately funded metrology project, other firms benefit at the expense of the individual firm. This can result in a free rider problem.<sup>26</sup> However, even if it were possible to exclude those who did not

---

<sup>23</sup> Swann GMP (2005) 'John Barber's Pioneering Work on the Economics of Measurement Standards', *Workshop in Honour of John Barber*, University of Manchester, 2<sup>nd</sup> December. <http://www.cric.ac.uk/cric/events/jbarber/swann.pdf>

<sup>24</sup> Swann GMP (2005) 'John Barber's Pioneering Work on the Economics of Measurement Standards', *Workshop in Honour of John Barber*, University of Manchester, 2<sup>nd</sup> December. <http://www.cric.ac.uk/cric/events/jbarber/swann.pdf>

<sup>25</sup> Swann GMP (2000) *The Economics of Standardization*, Final Report for Standards and Technical Regulations Directorate, Department of Trade and Industry, December

<sup>26</sup> The free rider problem occurs when a person or organisation benefits from a public good, but neither provides it nor contributes to the cost of collective provision. Thus, they free ride on the efforts of others.

contribute to the development of the standard, it is not desirable to do so as it could potentially lead to a misallocation of resources.<sup>27</sup>

Generally speaking, an individual firm is only able to capture the internal benefits and is unable to capture the external benefits. Consequently, whenever there are positive externalities present, some socially desirable investments will not appear privately profitable, as the social benefit exceeds the private benefit and private funding will generally entail under-investment.<sup>28</sup> This private funding under-investment is what drives government policy to support measurement standards, as without government policy the social benefits from a measurement standard would not be realised.

### Economies of scale and scope

Metrology projects are subject to economies of scale and scope. Hence, there are large fixed costs associated with the development of some metrology projects, while the marginal cost of spreading the acquired knowledge to a broad and diverse group of users is relatively small.<sup>29</sup> In general, these fixed costs exceed the benefit that the individual user would receive by investing in a private metrology project. The literature argues that this ratio of fixed costs to marginal costs is what determines the need for government intervention, the higher the ratio the increased likelihood of intervention.

The argument of under-investment is most relevant to metrology research projects due to the high fixed costs and highly generic results from metrology research projects. In contrast, the argument is less relevant to the construction of measurement tools and to the everyday uses of measurement, since fixed costs are generally lower and the value of the measurement activity is specific to an individual user as opposed to a group of users. Thus, in the case of metrology research projects externalities can be very widespread and the difference between the social and private benefits is generally very large. On the other hand, externalities are much more limited and the difference between the social and private benefits is generally quite narrow in the case of the construction of measurement tools or in the everyday uses of measurement. Consequently, as the risk of under-investment in metrology research projects and the associated loss of externalities is seen to be relatively higher there is greater need for government support as without government support the social benefits from metrology research would not be realised.<sup>30</sup>

There might also be some other barriers to market provision such as the infrequency of some service requests that might impact on profitability as well as

---

<sup>27</sup> Stokes F, Dixon H, Generosa A, & Nana G (2011) *The Economic Benefits of Standards to New Zealand*, Report for The Standards Council of New Zealand and the Building Research Association of New Zealand, August

<sup>28</sup> Swann GMP (2005) 'John Barber's Pioneering Work on the Economics of Measurement Standards', Workshop in Honour of John Barber, University of Manchester, 2nd December. <http://www.cric.ac.uk/cric/events/jbarber/swann.pdf>

<sup>29</sup> Swann GMP (2009) *The Economics of metrology and Measurement*, Report for National Measurement Office, Department for Business, Innovation and Skills, October

<sup>30</sup> Swann GMP (2009) *The Economics of metrology and Measurement*, Report for National Measurement Office, Department for Business, Innovation and Skills, October

geographical challenges (particularly relevant to the testing of large equipment) when utilising overseas testing facilities.

### Measurement standards

Measurement standards can assist in correcting market failures that arise due to externalities and lack or asymmetries of information. Although the private sector plays an important role in providing near-market accreditation, testing and measurement services that rest upon national measurement infrastructure, market incentives alone are not sufficient to produce an optimal degree of standardisation as would be most economically beneficial to the industry or to society in general. In principle any two firms could develop their own measurement standard, but it would be impossible for them to develop a standard for every firm that they trade with. National measurement institutes also provide services in areas where no markets exist. Given the expertise, specialised equipment and unique facilities, national measurement institutes do not typically have competitors for many activities such as for statutory pattern approvals for instruments or calibration and testing services for high voltage instruments for example.

## 4. Empirical literature on the economic impact of measurement

A number of international studies analysed the economic impact of standards. The empirical literature on the economic impact of measurement in Australia, however, is very limited. A range of methodologies have been adopted internationally to quantify the economic impact of measurement including economic modelling, case studies, cost-benefit analysis and interviews. In general, these studies measure the impact of an increase in the stock of standards on productivity and Gross Domestic Product (GDP).

Table 4.1 summarises the methodologies and empirical findings of various international studies that quantified the economic impact of measurement by means of economic modelling. International studies that quantified the impact of a 1 per cent increase in the stock of standards on total factor productivity produced estimates that ranged from 0.1 per cent to 0.17 per cent. The estimated impact of a 1 per cent increase in the stock of standards on labour productivity ranged from 0.05 per cent to 0.36 per cent, while the impact on GDP ranged from 0.17 per cent to 1 per cent.

A recent UK study by the Centre for Economics and Business Research,<sup>31</sup> which analysed both the macroeconomic and microeconomic impact of business standards across the UK economy, is the most comprehensive. The empirical results of this study show that standards contribute towards 28.4 per cent of annual GDP growth and 37.4 per cent of annual labour productivity growth over the period 1921 to 2013. This can be ascribed to their role as diffusers of technology and promoters of business efficiency. The study found that standards support on average 3.2 per cent of additional exports per year, indicating that it is a facilitator of trade. Standards reduce technical barriers to trade, link companies to global supply chains and strengthen the basis for non-price competition. It is argued that companies that use standards are twice as likely to export relative to the average firm of the same size in the whole economy.

The results also show that the most productive sectors are the most intensive users of standards. Survey results reflect that the majority of respondents perceive that standards enhance the quality of products, optimised their compliance with regulation, enhanced their reputation, allow them greater control of environmental problems, support the effective functioning of supply chains and facilitate the efficient distribution of technical information.

It is also argued that standards are a catalyst for innovation by reducing the time to market for new products, promoting the diffusion of innovative products, levelling the innovation playing field between big and small firms and providing the basis for innovation in network industries. Survey results showed that half of firms stated that standards encouraged innovation through the diffusion of new knowledge. Overall, around a half of respondents (48 per cent) reported a net

---

<sup>31</sup> Centre for Economics and Business Research (2015) The Economic Contribution of Standards to the UK Economy, June

benefit from standards, with larger businesses more likely to report a net benefit relative to SMEs.

A wide range of US economic impact studies since the 2000s point to the fact that benefit-cost ratios vary significantly between industries, ranging from 4:1 for Building Technology (commercial construction system integration and automation technologies) to 249:1 for Information Technology (computer security), with an average benefit-cost ratio of 47:1.

Table 4.2 reflects findings based on Australian case studies in relation to standards in the mining, water and electrical, and agriculture industries. It points to benefits such as increased accuracy and precision of products, higher productivity of particular activities, an enhancement of trade and improvements in risk management.

Table 4.1: International studies that quantifies the economic impact of measurement

<i>Publication</i> <sup>32</sup>	<i>Country / Region focus</i>	<i>Methodology</i>	<i>Quantification of impacts</i>
CIE (2006)	Australia	Statistical approach and case studies	A 1 per cent increase in the stock of standards is associated with a 0.12 per cent to 0.17 per cent increase in economy-wide productivity.
Standards Australia (2013)	Australia	Economic modelling	A 1 per cent increase in the production of standards is associated with a 0.17 per cent increase in GDP, which translates to approximately \$2.8 billion in 2009.
Haimowitz and Warren (2007)	Canada	Economic modelling and interviews	A 10 per cent increase in the number of standards would lead to a 3.56 per cent increase in labour productivity. Over the period of 1981–2004, standardisation accounted for 17 per cent of the growth rate in labour productivity, which translates into approximately 9 per cent of the growth rate in output (real GDP). In 2004, the level of economic output (real GDP) would be expected to be \$62 billion lower if there had been no growth in standards over the 1981–2004 period.
Williams (2002)	EU	Econometric estimation, Cost-Benefit Analysis and Case Studies	Measurement produces returns equivalent to 2.7 per cent of GDP with a benefit-to-cost ratio of nearly 3:1.
Miotti (2009)	France	Economic modelling and interviews	The elasticity coefficient of 0.12 indicates that a positive variation in the stock of standards of 1 per cent induces an increase of 0.12 per cent in the growth of TFP. The impact of standards for the period 1950–2007 on TFP (and consequently on the total growth of the French economy) is 0.81 per cent per year on average. Over 66 per cent of the companies interviewed stated that standardisation contributes to the generation of profits.
Jungmittag et. al. (2011)	Germany	Econometric modelling	The economic benefit of standardisation is equivalent to 0.72 per cent of GDP per year.
Stokes et. al. (2011)	New Zealand	Econometric estimation (incl. CGE modelling) and case studies	A 1 per cent increase in the stock of standards leads to a 0.1 per cent increase in total factor productivity and a 0.054 per cent increase in labour productivity. Thus, in turn, lead to a 0.3 to 1 per cent addition to GDP over a 10-year period.
UK DTI (2005)	UK	Economic modelling	The elasticity of labour productivity with respect to the number of standards

<sup>32</sup> See references for full details



<i>Publication</i> <sup>32</sup>	<i>Country / Region focus</i>	<i>Methodology</i>	<i>Quantification of impacts</i>
National Measurement Office (2009)	UK	Economic modelling	<p>of 0.05 suggests that a 1 per cent increase in the standards catalogue is associated with a 0.05 per cent increase in labour productivity.</p> <p>Additional government investment of £6 million (an additional 10 per cent investment) in the National Measurement System would produce a return of £300 to £400 million for the UK economy.</p>
Centre for Economics and Business Research (2015)	UK	Econometric analysis, surveys, interviews and case studies.	<p>Standards contribute towards 28.4 per cent of annual GDP growth and 37.4% of annual labour productivity growth. It support on average 3.2 per cent of additional exports per year. Companies that use standards are twice as likely to export relative to the average firm of the same size in the whole economy. The most productive sectors are the most intensive users of standards. Standards are shown to be a catalyst for innovation. At the sectoral level, impacts on annual turnover ranged from 1.7 per cent to 5.3 per cent. Survey results reflect that the majority of respondents stated that standards enhance the quality of products, optimised their compliance with regulation, enhanced their reputation, allow them greater control of environmental problems and made technical information more accessible. Around half of companies surveyed reported a net benefit from standards.</p>
US NSIT (2000–2011)	US	Laboratory economic impact studies based on benefit-cost analysis.	<p>Over the 11-year period, 2000–2011, 16 economic impact studies (covering a wide range of technologies and industries) reflect an average benefit-cost ratio of 47:1. Others measures include the social (internal) rate of return, the social (implied) rate of return and net present values.</p>

Source: Various

Table 4.2: Australian case studies

<i>Publication</i> <sup>33</sup>	<i>Type / Industry</i>	<i>Economic Benefits</i>	<i>Quantification of impacts</i>
CIE (2006)	Sampling standards in the mining industry	Increase accuracy and precision in the knowledge of the true mineral content of shipments of ores and concentrates. Enhances trade.	Total average annual benefits of \$58 million per year, ranging between \$24 million and \$100 million per year. The largest components of this are in iron ore (\$22 million per year) and coal (\$29 million per year).
	Variety of standards associated with the water and electrical industries	Increase the effectiveness of the water and electrical providers in using various inputs to their operations, i.e. they help in establishing the networks and increase the effectiveness of the water and electricity users in accessing the networks. Enhances the productivity of particular activities.	Total average annual economy wide benefits of around \$1.9 billion per year, with a range from \$850 million to \$3.6 billion. This includes benefits of improvements in input efficiency by the water industry itself (\$230 million per year), improvements in the efficiency of the use of water by other industries (\$440 million per year), improvements in input efficiency by the electrical industry itself (\$430 million per year) and improvements in the efficiency of electricity use by other industries (\$850 per year).
	Risk management standard	Collate and transmit valuable information. Allows better decision making through the anticipation and adaption to future expected risks.	Risk management in relation to droughts could prevent/mitigate an expected annual productivity loss of 2 per cent in Australian agriculture, equivalent to a loss in national income of \$1.7 billion.

Source: Various

<sup>33</sup> See references for full details

## 5. Conclusion

Measurement plays an important role in science, industry and commerce. Metrology standards and the traceability of measurement to those standards provide the basis for fair and accurate trade, optimisation of production, consumer and business confidence in products, the development of new technologies and innovation. All major economies support a metrology infrastructure given its role in technological advances and its public good characteristics that justify public intervention.

This paper highlighted the key economic concepts and arguments from the literature behind measurement and the standards and institutes that are associated with it. Measurement standards improve the efficiency of markets by creating economies of scale and reducing transaction costs. Measurement standards also prevent market failure by preventing information asymmetry and supporting and stimulating innovation.

Whilst the theory is important from an economic perspective for the justification of the economic rationale for measurement systems and institutes, and the associated economic benefits and costs, the literature review identified only a handful of studies that analysed the economic impacts and/or benefits of measurement and the standards and institutes that are associated with it.

A broader understanding of the economic benefits of measurement and an assessment of the associated economic benefit could improve a country's understanding particularly at the political level about the relevance of metrology institutions to the functioning of their innovative systems, how they enhance the performance of economic agents and improve the outcomes of social, economic and environmental policies.<sup>34</sup>

The importance of measurement in supporting the economy is nevertheless well recognised and highlighted in the mission statements of various national measurement institutes. It is important to understand that the importance of metrology extends well beyond economic benefits. Metrology for example plays an important role in generating benefits to many aspects of quality of life in fields such as health and safety, the environment, law and order, defence and security, leisure and trade and consumer protection.

---

<sup>34</sup> Goncalves J & Peuckert J (2011) *Measuring the Impacts of Quality Infrastructure*, Report for the German Federal Ministry for Economic Cooperation and Development, April

## References

- Akerlof GA (1970) The Market for “Lemons”: Quality Uncertainty and the Market Mechanism, *The Quarterly Journal of Economics*, vol. 84, no. 3, pp. 488–500
- Birch JAM (2002) *Benefit of Legal Metrology for the Economy and Society*, A study for the International Committee of Legal Metrology
- Centre for Economics and Business Research (2015) *The Economic Contribution of Standards to the UK Economy*, June
- Centre for International Economics (2006) *Standards and the economy*, Report for Standards Australia, July
- Goncalves J and Peuckert J (2011) *Measuring the Impacts of Quality Infrastructure*, Report for the German Federal Ministry for Economic Cooperation and Development, April
- Haimowitz J and Warren J (2007) *The Economic Value of Standardization*, Report Produced by The Conference Board of Canada for the Standards Council of Canada, July
- Hoon CS and Hoffmann R (2004) *The Evolution of Measurement Standards*, Nottingham University Business School, The University of Nottingham, 13 February. <http://www.nottingham.ac.uk/~lizecon/RePEc/pdf/measurement.pdf>
- Jungmittag A, Blind K and Mangelsdorf A (2011) The Economic Benefits of Standardisation, DIN
- Lambert R (2010) *Economic Impact of the National Measurement System*, Prepared for the Measurement Board, July.
- Miotti H (2009) *The Economic Impact of Standardization*, Marketing and Innovation Department, AFNOR Group, June
- National Measurement Institute, viewed 12 August 2013, <http://www.measurement.gov.au/Pages/default.aspx>
- National Measurement Office (2009) *Economic Impact Report: Metrology Investment Impact on Innovation and Productivity*, May
- Standards Australia (2013) *The Economic Benefits of Standardisation*, Business Management Research Paper, January
- Stokes F, Dixon H, Generosa A and Nana G (2011) *The Economic Benefits of Standards to New Zealand*, Report for The Standards Council of New Zealand and the Building Research Association of New Zealand, August
- Swann GMP (2009) *The Economics of metrology and Measurement*, Report for National Measurement Office, Department for Business, Innovation and Skills, October
- Swann GMP (2000) *The Economics of Standardization*, Final Report for Standards and Technical Regulations Directorate, Department of Trade and Industry, December

Swann GMP (2005) John Barber's Pioneering Work on the Economics of Measurement Standards, *Workshop in Honour of John Barber*, University of Manchester, 2<sup>nd</sup> December

<http://www.cric.ac.uk/cric/events/jbarber/swann.pdf>

Tassey G (2005) Underinvestment in Public Good Technologies, *Journal of Technology Transfer*, vol. 30, no. 1/2, pp. 89–113

UK Department of Trade and Industry (2005) The Empirical Economics of Standards, *DTI Economics Paper No. 12*, June

US National Institute of Standards and Technology, viewed 3 September 2013, <http://www.nist.gov/director/planning/summary-studies.cfm>

Williams G (2002) *The Assessment of the Economic Role of Measurements and testing in modern society*, Final report on the European Measurement Project, July.