



economics

Report to:

**The Standards Council of New Zealand and
The Building Research Association of New Zealand**

**THE ECONOMIC BENEFITS OF STANDARDS
TO NEW ZEALAND**

Prepared by

Fiona Stokes

Hugh Dixon

Dr Amapola Generosa

Dr Ganesh Nana

August 2011

Copyright© BERL

BERL ref #4958

The Economic Benefits of Standards to New Zealand

1 Summary	4
2 Acknowledgements	7
3 Standards and the prevention of market failure	9
3.1 Standards and the prevention of market failure	10
3.2 The economic costs of Standards	16
4 Comparable international studies	19
4.1 Germany	19
4.2 The United Kingdom	20
4.3 Australia	20
4.4 Canada	21
4.5 France	21
4.6 ISO methodology	22
5 New Zealand Standards	23
5.1 The Standards Council and Standards New Zealand	23
5.2 The New Zealand Standards catalogue	25
5.3 Standards adoption	26
6 Econometric analysis of New Zealand Standards	28
6.1 Methodology employed	28
6.2 Stock of Standards	29
6.3 Cobb-Douglas production function	29
6.4 Analysis	32
6.5 The link between Standards and productivity	35
7 Sector analysis of New Zealand Standards	37
7.1 The link between Standards and productivity at a sector level	37
7.2 Overview of case study Standards	37
7.3 NZS 3910:2003 Conditions of Contract for Building and Civil Engineering Construction	39
7.4 NZS 4246: 2006 Incorporating Amendment 1 Energy Efficiency – Installing Insulation in Residential Buildings	43
7.5 The AS/NZS 1170 series of Standards	51
8 Productivity and New Zealand Standards	59
8.1 The CGE model	59
8.2 The CGE model ‘shock’ simulations	59
8.3 The CGE model simulation results	60
8.4 Comparing economic studies on Standards	61
8.5 Concluding comments on Standards in New Zealand	65
9 Appendix 1: Sources	67

10 Appendix 2: Variability in the dataset.....	70
---	-----------

11 Appendix 3: The BERL CGE Model	72
--	-----------

11.1 Key model structure.....	72
-------------------------------	----

Tables

Table 1 Econometric estimation of the impact of Standards on TFP	35
--	----

Table 2 CGE model results.....	60
--------------------------------	----

Table 3 Comparative summary.....	62
----------------------------------	----

Table 4 General unrestricted specification of error-correction models.....	71
--	----

Figures

Figure 1 Number of Standards created and withdrawn each year, 1970 to 2010	26
--	----

Figure 2 Relationship between total factor productivity, knowledge indicators and output, 1978-2009	33
---	----

Figure 3 Annual growth in Standards and productivity, 1978-2009	70
---	----

1 Summary

Over the last 10 years, Standards setting bodies in countries such as Germany, England, Canada, Australia and France have researched the benefits of Standards. A useful categorisation of these benefits has been as an economic effect. Although Standards do not fall mutually exclusively into a single category, as many Standards contain several purposes, this categorisation is a useful starting point (Swann, 2000).

Economic benefits are not necessarily the key drivers behind Standards development. However, the resources devoted to the production of Standards and the ways in which Standards change peoples' behaviour, inevitably has an economic effect. Similarly, many Standards are not designed with a specific economic outcome in mind, but to increase safety or manage risk. To the extent that accidents or risks lead to economic costs then their prevention through the use of Standards has an economic effect (The Centre for International Economics, 2006).

This project has measured the economic effects of Standards on the New Zealand economy. It has done this in three stages. The first stage of the project involved a literature review to examine the economic benefits and costs of Standards, and to find a suitable methodology to adopt in the second and third stages. Overall, the literature concluded that Standards prevent market failure by preventing information asymmetry, and allowing and encouraging innovation. Standards also improve efficiency of markets by creating economies of scale, allowing network externalities, and reducing transaction costs.

The econometric estimation undertaken in the second stage of our project established the nature and quantum of the link between Standards and productivity in New Zealand. The results indicate that:

- The contribution of the stock of Standards to total factor productivity (TFP) growth in New Zealand between 1978 and 2009 is positive and statistically significant, with a coefficient of value 0.10.
- A coefficient of 0.10 suggests that a 1.0 percent increase in the stock of Standards at the margin leads to a 0.10 percent increase in TFP. This estimate ranges from 0.07 percent to 0.12 percent, which is comparable with estimates undertaken in Australia and France.¹

¹ The statistical performance of the current estimate appears acceptable, but there is still the risk that the estimates are spurious, which should be kept in mind in the interpretation of the current findings.

- A 1.0 percent increase in Standards at the margin leads to a 0.054 percent increase in labour productivity. This is similar in magnitude to the results of another estimation of this kind undertaken in the United Kingdom.²

To understand how Standards prevent market failure and improve efficiency in New Zealand, we focused on a group of Standards within the building and construction sector. BERL interviewed key stakeholders and industry representatives to explore what the economic benefits (and costs) of Standards are from the point of view of this sector. These interviews analysed how Standards help the sector to reduce costs and risks, and increase the quality of the goods and services produced.

The evidence provided in these interviews was qualitative not quantitative.³ Despite this, the interviews provide a rich insight into how Standards are referred to and used on a daily basis in this sector, and the impact Standards have on behaviour, tastes and decision-making.

The insights provided in the interviews were also used to develop the scenarios for economic modelling.

Data from our econometric analysis and the three case studies on Standards in the building and construction sector was then fed into the third stage of our project. This stage used the BERL Computable General Equilibrium (CGE) model to illustrate the link between productivity and wider economic performance, in particular, Gross Domestic Product (GDP). Two scenarios were modelled using the CGE model.

- Scenario A compared a picture of the New Zealand economy in 2021 where TFP was 0.10 percent higher for each year over the 10 year period, with a business as usual picture.⁴ This scenario included, as per the definition of TFP, labour productivity being 0.056 percent higher.
- Scenario B simulated an improvement in labour productivity only. This scenario allowed us to estimate how much the economy-wide gains tabulated for scenario A were from labour productivity improvements alone, and how much were from the impact of TFP.

² For a more detailed discussion on Standards and long-run growth, see Temple, P., Witt, R. and Spencer, C. Institutions and Long-run Growth in the UK: the role of Standards. University of Surrey: 2004.

³ At this point we would note the limitations illustrated in the Conference Board of Canada study (2007) regarding the difficulties of quantifying, in an economic sense, the benefits of Standards through case studies.

⁴ We then compared the outcome of this additional productivity to the baseline (or business as usual) picture of the New Zealand economy in 2021. This baseline picture assumed ongoing growth in productivity (and so implicitly, Standards) as per historical trends. Growth in world demand for New Zealand export products, global commodity prices, and policy settings for the comparative business as usual picture was also assumed to be unchanged as per the historical experience.

The results for scenario A indicate a \$2.4 billion gain in GDP in 2021, or the equivalent of \$505 per capita, compared with the business as usual outcome. Both of these figures are expressed in real 2010 dollar values. This represents an improvement of 1.0 percent in annual GDP in 2021 above that achieved under the business as usual outcome.

This improvement in productivity is transmitted through the New Zealand economy via the additional \$564 million achieved in export volumes. This is a 0.8 percent improvement compared to the business as usual outcome. These additional exports enable real wages (i.e. inflation-adjusted wages) to grow 1.9 percent above those in the business as usual situation. This improvement in real wages income assists households to consume more – to the tune of \$1.7 billion in total, or 1.2 percent in addition to the baseline.

The results for scenario B indicate a \$660 million gain in GDP in 2021, or the equivalent of \$137 per capita, compared with the business as usual outcome. Both of these figures are expressed in real 2010 dollar values. This represents an improvement of 0.3 percent in annual GDP in 2021 above that achieved under the business as usual outcome.

Again, the improvement in productivity is transmitted through the economy via the additional export volumes achieved, but this scenario provides an improvement of 0.3 percent compared to the business as usual. In contrast to scenario A, real wages in scenario B are 0.2 percent below those registered in the baseline. The relatively lower real wages in this scenario indicate a relative increase in the demand for capital. This is consistent with an improvement in labour productivity, which consequently requires more capital in order to take advantage of the relatively more productive labour.

The results of the two CGE model simulations therefore indicate that a 0.10 percent increase in TFP over a 10 year period could lead to a 1.0 percent addition to annual economy-wide GDP, comprising a 1.2 percent addition to household consumption and a 0.8 percent addition to export volumes. In turn, a 0.056 percent increase in labour productivity only for 10 years leads to a 0.3 percent addition to annual economy-wide GDP, comprising a 0.3 percent addition to household consumption and export volumes.

The greater impact of Standards on GDP and the wider economy subsequently arises from its impact on TFP – implicitly both labour and capital productivity. A key assumption in our econometric estimation and modelling is that the stock of Standards in New Zealand is of a high quality and that Standards are appropriately applied in order to impact on TFP. If this situation holds true, then Standards can prevent market failure and increase the efficient allocation of resources. Standards can be a powerful economic level; however, they are only one factor of production and in real world situations we need to look at other factors and how they interact and impact on Standards.

2 Acknowledgements

BERL wish to thank the following individuals and groups for their assistance during this project:

Alistair Fussell, Senior Structural Engineer, Steel Construction New Zealand

Amanda Lynn, Chief Executive, Business and Economic Research Limited

Andrew Brickell, Director of Project Management Asia-Pacific, MWH

Cameron Smart, Engineering Practice Manager, The Institution of Professional Engineers of New Zealand (IPENZ)

Debbie Chin, Chief Executive, Standards New Zealand

Gleb Speranski, Head of Sales and Marketing, InsulPro Manufacturing Limited

Godfrey Hall, President, Insulation Association of New Zealand

Graeme McVeery, GNS Science

Hagen Kerr, Manager Solutions, Standards New Zealand

Jack Lyons, Manager, Advisory Services, Building Controls and Facilities, BRANZ

Jeremy Sole, Chief Executive, New Zealand Contractors' Federation

Louise Townsend, Operations Manager, Building Officials Institute Training Academy

Peter Degerholm, Calderglen Associates Limited

Richard Quinn, Project Services Manager, New Zealand Transport Agency

Rob Gaimster, Chief Executive Officer, Cement & Concrete Association of New Zealand

Rob Warner, General Manager, Strategic Development and Innovation, Standards New Zealand

Rod Fulford, Executive Director, Precast New Zealand Inc.

Sonia van Ree, Project Manager Standards New Zealand

Stuart Ng, Senior Manager Solutions, Standards New Zealand

Tim Mahar, Technical Advisor, Energy Efficiency and Conservation Authority (EECA)

Malcolm Abernethy, Executive Officer, New Zealand Contractors' Federation

Wolfgang Scholz, Director, HERA

However, no member (or group of members) of any of the above groups have been asked to endorse the contents of this report. Our acknowledgement of their assistance should not be read as such. The contents of this report are the sole responsibility of the authors and BERL.

3 Standards and the prevention of market failure

Standards can be defined as a statement of 'how to' go about building or designing things for a purpose, or 'how to' behave in certain circumstances (Centre for International Economics, 2006). Standards can also be defined as a source of codified knowledge, such as documents that provide technical specifications adhered to by a producer (DTI, 2005).

There are many different types of Standards, and the following list illustrates this variety.

- *Public Standards* are open and available on an equal basis to all competitors. They are credible, which creates confidence that a Standard may achieve widespread use (DTI, 2005). In the development of public Standards, and their subsequent use, it is assumed that everyone's interests have been taken into account when the Standard was set and that externalities (such as those related to the environment or public health) have been factored into the decision-making (WTO, 2005).
- *Private Standards* only take into account the profits of a firm, and are not open and available on an equal basis to all competitors (WTO, 2005). Private Standards are by definition voluntary, while public Standards can be either mandatory or voluntary.
- *Prescriptive Standards* specify the technical details of the products or processes that are recommended (Centre for International Economics, 2006).
- *Performance Standards* provide information about what to look for when choosing a particular technical application, and provide 'how to' guidelines that can be more flexibly applied in a variety of circumstances (Centre for International Economics, 2006).
- *Measurement and management Standards* provide a common language to communicate key ideas (Centre for International Economics, 2006).
- *Product Standards* specify the characteristics of a product. Economists distinguish between two types of product differentiation – vertical and horizontal. In vertical differentiation the characteristics of the product can be differentiated on an objective scale such as larger, safer etc. and therefore price. In horizontal differentiation, the characteristics of a product cannot be ranked due to being the same product but a different colour, flavour etc. However, many products are differentiated vertically and horizontally (WTO, 2005).
- *Process Standards* specify the characteristics of a production process. These processes are typically not traded but the goods they produce are (WTO, 2005). Process

Standards are introduced because they affect the goods that are produced (e.g. hygiene Standards), the efficiency of the production process (e.g. network externalities), or the environment (pollution Standards). These Standards help to expand market opportunities because they increase externalities (Swann, 2000).

- The concept of a *minimum Standard* implies that products only reach a certain level of quality or attainment, or higher, if they meet the relevant Standard. Vertically differentiated products may have minimum Standards (WTO, 2005).

Standards perform a range of useful functions in a modern economy. The International Standards Organization (ISO) believes it is valuable to quantify the economic and social benefits of Standards and encourage people to use them (ISO, 2010; DTI, 2005).

Over the last 10 years, Standards setting bodies in countries such as Germany, England, Canada, Australia and France have researched the benefits of Standards. A useful categorisation of these benefits has been as an economic effect. Although Standards do not fall mutually exclusively into a single category, as many Standards contain several purposes, this categorisation is a useful starting point (Swann, 2000).

Economic benefits are not necessarily the key drivers behind Standards development. However, the resources devoted to the production of Standards, and the ways in which Standards change people's behaviour, inevitably has an economic effect. Similarly, many Standards are not designed with a specific economic outcome in mind, but to increase safety or manage risk. To the extent that accidents or risks lead to economic costs then their prevention through the use of Standards has an economic effect (The Centre for International Economics, 2006).

The provision of Standards also contributes to economic growth by increasing the volume of trade, and promoting innovation through the dissemination of research and technology. Standards help companies to reduce costs and increase the quality of the goods and services they produce. They can also allow companies to develop new markets for existing goods and services, as well as create new goods and services.

3.1 Standards and the prevention of market failure

Overall, the literature on the economic benefits of Standards concludes that Standards prevent market failure. Standards do this by:

- Preventing information asymmetry.
- Allowing and encouraging innovation.

Standards also improve efficiency by:

- Creating economies of scale.
- Allowing network externalities.
- Reducing transaction costs.

3.1.1 Preventing information asymmetry

Information provided by Standards and standardisation documents can reduce the problem of information asymmetry, which can lead to market failure. Through the provision of Standards further information is available to the consumer regarding the product, and lower quality goods or services can or will be eventually driven out by higher quality goods or services (Swann, 2000). This corrects any market failure that is present.

Information asymmetry is most acute when the goods or service is infrequently bought; long lags in the detection of the quality of the goods or service exists; the reputation of a company providing the goods or service is slow to be updated, or it is difficult to detect the quality attributes of the goods or service (Blind et al., 2007)

Examples of the ways in which Standards can reduce the problem of information asymmetry include:

- The identification of minimum admissible attributes through the establishment of safety Standards or minimum quality Standards.
- The provision of information and product descriptions through technical reference Standards that include Standards of measurement and grades of a product.
- The facilitation of international trade through Standards that focus on compatibility, product information and measurement (The Conference Board of Canada, 2007).

Blind et al (2007) has argued that Standards can prevent information asymmetry within companies – in regards to company owners or management concerns regarding the performance of employees – and as mentioned above, between consumers and suppliers of goods and services. In the case of employee performance, the principal-agent theory is drawn on. Here, a situation exists where an agent (the employee) can undertake actions that are costly to monitor and may not be aligned with those of the principal (the company owner or management). These actions therefore do not always result in the best outcome for the principal. Blind et al (2007) argues that the harder it is to monitor the quality of a product or service delivered by an employee, the higher the pressure to introduce a system

of Standards that monitor each phase of the production or ensure a minimum quality is guaranteed.

In two of the case studies examined in this project, NZS 3910:2003 Conditions of Contract for Building and Civil Engineering Construction and NZS 4246:2006 Incorporating Amendment No 1. Energy Efficiency – Installing Insulation in Residential Buildings, the use of Standards has reduced the problem of information asymmetry, including resolving the dilemma caused by the principal-agent theory. Here, Standards can create a transparent situation that may be helping to establish the “rules of the game” and eliminate players who fail to comply (AFNOR, 2009).

NZS 3910:2003 is a Standard widely used by large and small companies in many building construction, engineering, and roading sector contracts. This Standard draws on agreed specifications for processes, services, and performance and was developed by industry consensus. Drawing on the economic theory above, in regards to information asymmetry and the principal-agent theory, it may be difficult for the contract holder to monitor the construction, engineering, and roading projects being completed. However, the presence of this Standard ensures a system that is perceived to be fair and aligns with the needs of the “principal” and the “agent”.

NZS 4246:2006 is a Standard regarding the installation of insulation in residential buildings. Currently, the Government is investing \$347 million over four years in a programme called Warm Up New Zealand: Heat Smart. For householders and installers to qualify for this programme, insulation products must be installed according to NZS 4246:2006 and the manufacturer’s instructions. This Standard therefore provides householders and the Government with some certainty in regards to the correct installation of the insulation product and the level of service provided by installers. Swann (2000) has argued that if Standards like this exist, and are well understood, then the buyer can be confident before they make a purchase. Why do customers want Standards in the first place? Because of the degree of reassurance they give. Thus Standards are an effective means of overcoming Gresham’s law – that bad drives out good⁵ – and again reduces the chances of imperfect information.

3.1.2 Allowing and encouraging innovation

Other international studies completed on the economic benefits of Standards argue that Standards play a role in stimulating innovation. They do this by providing a platform on which new technologies and processes can be built on (DTI, 2005; DIN 2000; Swann, 2000).

⁵ Swann, P. The Economics of Standardization: Final Report for Standards and Technical Regulations Directorate Department of Trade and Industry. University of Manchester: 2000.

DIN, in their study on the macroeconomic benefits of standardisation, have argued that Standards not only stimulate innovation but efficiently diffuse it (DIN, 2000). Blind et al also argue that Standards are an effective diffusion of technology, and that they have substantially contributed to economic growth in Germany (Blind et al, 1999). This contribution has been further promoted through research and development activities within Germany and the “import of know-how from abroad”.

In New Zealand, the importation of knowledge and/or “know-how”, and the effective diffusion of technology through Standards, can occur through formal international networks that Standards New Zealand, the Standards Council, industry bodies, universities and research institutions are members of. It may also occur through more informal networks such as industry publications, seminars and conference discussions, email and blogs, and social marketing networks. Standards can therefore allow the benefits of research and innovation that is occurring in New Zealand and internationally to be captured and disseminated.

This knowledge transfer also captures best practice and intellectual property. The presence of Standards can subsequently allow industry to make better informed, quality decisions off a strong platform of new technologies and processes, best practice and intellectual property. The technical work of the ISO, for example, is published as international Standards that are developed in cooperation to encourage scientific, technological and economic activity (Blind et al, 2003).

However, international literature on the economics of Standards also argues that Standards may hinder innovation if the timing of the development or maintenance of a Standard is inappropriate and leads to economic inefficiencies. If the Standard is introduced too early it may prevent new ideas or technology from entering the market. Alternatively, if the Standard is introduced too late then the transition costs of adopting the Standard may be too high. In addition, if the maintenance of the Standard is introduced too late, the transaction costs of amending or revising the Standard may be too high.

There is also a non-linear relationship between the constraining role of Standards and the number of Standards – as the number of Standards relevant to a sector increases, producers may be less likely to find Standards an impediment. However, after a certain point, more Standards may increase the constraints on innovation and may add to the issues associated with an ageing Standards catalogue (DTI, 2005). Some studies have found that Standards can constrain innovation most when they are very old or very new. Standards may therefore be least useful and most harmful in industries with a rapid turnover in technology (The Conference Board of Canada, 2007; DTI, 2005).

Consequently, different types of Standards may be needed at each stage of “technology maturity”. Anticipatory Standards may be required to specify the production system of the new technology, enabling Standards may help to refine the production system, and responsive Standards may codify knowledge already established in practise through precursor products or services (International Electrotechnical Commission, 2009). In addition, each type of Standard will need to be maintained, through amendments and revisions to ensure it remains relevant, and this maintenance should occur at different points in a Standards lifecycle.

3.1.3 *Creating economies of scale*

Standards may efficiently reduce variety, which can lower the costs associated with the production of one unit of goods, and lead to economies of scale. Businesses can therefore operate on a larger, more efficient scale of production, and produce goods at a lower per unit cost (The Centre for International Economics, 2006; DTI, 2005). A reduction in the variety of products or systems being produced may also improve their functionality or safety, as well as lower the associated costs.

The Association Française de Normalisation (AFNOR) found that one of the main economic benefits of Standards in France was product interoperability. Interoperability between products or systems can increase compatibility and reduce variety, thereby creating economies of scale.

Product or process interoperability can lower costs, as each new product does not have to be designed for each new system, particularly if products are designed and manufactured to a Standard. This lower cost may be beneficial to the producer and/or the consumer. In the case of the producer, they are able to demonstrate the interoperability of their products with other manufacturers, while in the case of the consumer they can be reassured that the product conforms to a Standard. Overall, AFNOR concluded that Standards lead to increased productivity and improvements in the quality of the systems used.

The process of developing Standards may also add economically valuable user information. This can create a bandwagon effect where the adoption and use of the Standard may encourage others to be involved. This can in turn substantially increase the rate of interaction among the potential Standards “adopter population” (DTI, 2005). This can result in cost effects similar to those arising from economies of scale. The bandwagon effect also makes it possible to eliminate companies who are not complying with “the rules of the game” thereby adding to the transparency and ethics that Standards can establish.

3.1.4 Allowing network externalities

The Conference Board of Canada (2007) argues that a major economic benefit of Standards is network externalities. Network externalities are particularly important in the communication and information technology sectors. Network externalities arise due to every new user in a network increasing the value of being connected to a network. Producer and consumer choices can be influenced by network externalities; this is particularly the case when a system becomes more desirable as it becomes more widely known and used by others.

The problem with network externalities is that they require compatibility. This is where Standards step in, as they can provide this level of compatibility. Subsequently, developments in the communication and information technology sectors have demonstrated the economic benefits of Standards in improving compatibility and interfaces and the desirability of being connected to a network (Swann, 2000).

3.1.5 Reducing transaction costs

Transaction costs are the costs not directly related to an economic exchange. Similar, to information asymmetry, transaction costs often grow due to consumers and producers trying to gain a better understanding of the goods or services. By reducing transaction costs, Standards can prevent market failure.

Standards can reduce transaction costs between producers and consumers by reducing the amount of time consumers spend searching for goods they want to buy, improving technical recognition i.e. ensuring consumers understand what the technical specifications of a product are, and avoiding consumer dissatisfaction. For producers, transaction costs can be reduced due to compatibility of products, and common expectations in regards to the performance of a competitor's products.

The Centre for International Economics (2006) argues that by reducing transaction costs, Standards help to provide safe outcomes for consumers and assists producers with risk management. Subsequently, Standards should be able to reduce undesirable outcomes (Swann, 2000).

In the United Kingdom, it has been argued that new products gain greater acceptance and adoption in a market if they meet already established Standards. Further, conforming to a

known Standard helps to establish the credibility of a new product, and once it is established, helps to further develop the market for this product.⁶

3.1.6 The age of Standards

The publication of a Standard does not in itself generate an economic benefit. It is the use of the Standard that adds value to the economy (Swann, 2000). As a Standard ages its use, and in turn economic benefit, may decline leading to market failure. This is a growing area of concern for standardisation bodies such as Standards New Zealand, where greater than 50 percent of the Standards in the New Zealand Standards catalogue are more than 10 years old.⁷

The interdependency of Standards also illustrates issues around the age of a Standard. For example, in the building construction industry in New Zealand many Standards are empowered through their referencing and basic premising in other Standards. These Standards often work together and draw on other Standards relevant to a particular sector within the industry, or to Standards relevant in the wider building construction industry. This means the age of a Standard is very important, particularly if a Standard starts to get out of alignment with related Standards and their maintenance, or relevant legislation or regulations.

Standards in the New Zealand building construction industry centre on the performance that building elements need to achieve rather than specify the requirement of particular products. In this way, these Standards may encourage innovation as research focuses on devising new ways of achieving the performance required. Standards, in turn, also reflect the research, development and innovation occurring within the industry, and the influences of changing customer preferences, tastes and requirements. However, Standards can also hinder this process if they do not keep up to date with changing customer preferences, tastes or requirements, or fall too far behind the research process.

3.2 The economic costs of Standards

As well as economic benefits, Standards can create costs. These can include switching costs, excess inertia or lock-in. Standards can also result in a free rider problem whereby some companies are unwilling to participate in or contribute to the development of Standards but still have access to them.

⁶ CBI. Standards: Productivity driver or regulatory burden? A Discussion Paper on the Future of the UK Standardisation Infrastructure. London: 2002. (<http://www.cbi.org.uk>).

⁷ In Australia, the entire stock of Standards is modified approximately once every 12 years (Centre for International Economics, 2006).

The development and maintenance of Standards involves fixed costs, and the gains may not be appropriable to the individuals (or the business/sector) they represent. Together, these fixed costs can give Standards a series of properties that are similar to those of a public good (DTI, 2005). The following are some of the effects of Standards on consumers and producers:

- Standards can affect the willingness of consumers to pay for a product meeting the Standard as they change consumers' perception or appreciation of these varieties.
- Standards can imply a fixed cost to producers if they switch products.
- Standards may involve a change in variable costs if it is more expensive to produce a good that meets the Standard than one that does not.
- Standards may affect production costs if producers run additional product lines.
- Standards can generate costs related to assessing if the production process or product is conforming to the required Standard.

Interviews completed by the Conference Board of Canada (2007) highlighted concerns in Canada about the cost of complying with Standards. "As the market moves towards more and more specific Standards, the cost of compliance increases, which is particularly difficult for small companies. The administrative costs associated with compliance may also be a barrier." In addition, according to the World Trade Organisation, the costs faced by exporters in complying with the requirements of an importing country are one of the biggest complaints against product Standards in international trade (WTO, 2005).

3.2.1 *Switching costs, excess inertia and lock-in*

The cost of Standards may also create market failure if the Standard does not undergo regular maintenance such as revisions or amendments. In this situation, innovation may be negatively impacted as Standards can be ignored or treated as rigid procedures, and another more up-to-date Standard may be used or referenced.

There is a cost associated with switching from one Standard to another, and this may also make some businesses hesitant to change Standards. Excess inertia also occurs when users of Standards are reluctant to switch to another, and lock-in occurs when switching becomes too difficult.

From an economic point of view, the problems associated with switching costs, excess inertia and lock-in is that the economic value of Standards can start to fall if the stock of

available Standards becomes too large, if they are renewed too often, or if the Standard is allowed to age (DTI, 2005).

3.2.2 Free rider problem

As mentioned earlier, New Zealand Standards are developed by expert committees using a consensus-based process. Some companies are unwilling to participate in or contribute to the development of Standards but still have access to them. This is known as a free rider problem, and it is difficult to eliminate.

The Centre for International Economics (2006) argues significant resources are devoted to developing Standards. The time devoted to Standards committees is volunteered but there is a cost to the economy as these individuals could be doing something else. This is also why the free rider problem has developed in Standards.

However, the free rider problem is also related to a positive aspect of Standards – public good. Standards are a public good that have a positive externality (which prevents market failure). This positive externality is that, once a Standard is developed, it is difficult to exclude those companies who were unwilling to participate in or contribute to its development from using this Standard. However, even if it was possible to exclude these companies once the Standard has been developed, it would no longer be desirable to do so because it could potentially lead to market failure. Standards can therefore help to solve some externality problems (Centre for International Economics, 2006).

This section of our report has focused on Standards and their prevention of market failure. The next section discusses comparable international studies on the economic benefits of Standards. Overall, these studies have concluded that, in addition to preventing market failure, the greatest economic impact of Standards is in improving labour productivity.

4 Comparable international studies

The rationale for our analysis on the economic benefits of Standards to the New Zealand economy is based on the methodologies employed by Jungmittag, Blind and Grupp (1999), the German Institute for Standardization (DIN, 2000), the British Department of Trade and Industry (DTI, 2005), the Centre for International Economics (2006), the Conference Board of Canada (2007), and the Association Française de Normalisation (AFNOR, 2009).

To undertake this analysis we split our project into three stages. The first stage included a literature review and provided a description of the methodology that was adopted in the second and third stages of the project. The second and third stages involved examining the economic benefits of Standards to the New Zealand economy from a macro and microeconomic perspective.

The macroeconomic analysis measured the contribution of the stock of Standards in New Zealand to Total Factor Productivity (TFP)⁸ between 1978 and 2009, and used Computer General Equilibrium (CGE) modelling to illustrate the benefits, costs and opportunities that Standards could have on the New Zealand economy.

The microeconomic analysis examined the economic benefits of Standards at a sector level, notably in the building construction sector. Here, three case studies were undertaken that examined in detail the economic benefits and costs of Standards, and how Standards impact on decision-making at an individual, firm and industry level.

4.1 Germany

Jungmittag, Blind and Grupp (1999) used German data from 1961 to 1996 to illustrate that Standards may be an important factor in determining aggregate economic activity and, as a result, productivity growth.

Following on from this study, the German Institute for Standardization (DIN, 2000) contracted the Fraunhofer Institute for Systems and Innovation Research Karlsruhe (ISI Karlsruhe) and the Departments of Market-Oriented Business Management and of Political Economics and Economic Research at the Technical University Dresden to jointly carry out a research project in Germany, Austria and Switzerland. This project examined the role of standardisation in the economies of these three countries.

⁸ Total Factor Productivity measures how effectively capital and labour can be combined to produce an output. Some sources define Total Factor Productivity as Multi-Factor Productivity.

This study concentrated on the link between standardisation and technological change, and the relationships between standardisation, economic growth and exports. It also completed a survey in Germany, Austria and Switzerland where over 4,000 companies were selected at random and sent a questionnaire. Interviews were also completed with 10 experts that represented households and the Governments in Germany and Austria.

The survey focused on the effects of Standards on a company, as well as the company's interactions with its immediate business environment. The effects examined included the effects of Standards on costs in general, on research and development, and on safety; and in terms of the immediate business environment the focus was on potential competitive advantages over other companies and the formation of strategic alliances. Then, focusing only on Germany, the study further examined the reactions and motivations of businesses, households, and the state to become involved in standardisation.

4.2 The United Kingdom

In 2005, the British Department of Trade and Industry (DTI) used British data from 1948 to 2002 to illustrate that Standards may be an important factor in determining aggregate economic activity and, as a result, productivity growth (DTI 2005).

This project provided benchmark estimates of the impact of public Standards on technology change, considered Standards and the international transmission of technology, and questioned do Standards enable or constrain innovation.

It used an econometric model (Cobb-Douglas) to show that there is a measurable association between the catalogue of Standards and productivity growth in the United Kingdom.

4.3 Australia

The Centre for International Economics (2006) used data from 1962 to 2003 to assess the role of Standards in the Australian economy.

This study reviewed macroeconomic data to determine if a statistical relationship existed between the stock of Standards in Australia and productivity, and completed four case studies on Standards or groups of Standards in the mining, water and electrical industries, and the risk management Standard.

The data sets used were the annual number of new and revised Standards published each year, and the total stock of current Standards.

4.4 Canada

The Conference Board of Canada (2007) undertook a study to examine the impact of standardisation on the Canadian economy. This study reviewed Standards-oriented economics literature and undertook an empirical analysis of the impact of Standards on Canadian labour productivity. A series of interviews and two case studies were also undertaken.

The interviews involved 15 Canadian business leaders and were completed over the telephone. These interviews provided further evidence of the benefits and costs of Standards and standardisation. Interview questions were based around the following framework:

- Benefits of participating in the Standards development process (private sector and public interest).
- The strategic importance of Standards.
- The development of new markets.
- Cost savings.
- Innovation.
- Public safety.
- Standardisation bodies.
- Challenges to standardisation.

The case studies examined the benefits of specific aspects of standardisation in two companies. In particular, the case studies explored the challenges and rewards of achieving and maintaining certification and accreditation to ISO and IEC Standards.

This research methodology was based on that used in Germany and the United Kingdom, and adapted to the Canadian situation.

4.5 France

One of the latest studies to be completed was in 2009 by the Association Française de Normalisation (AFNOR). This study aimed to measure the effects of voluntary Standards on economic activity and fill in some of the gaps in current research. AFNOR found that standardisation is a powerful economic lever from a macro and a microeconomic viewpoint,

and it argued that the contribution of Standards to macroeconomic performance has been under-researched in France.

In their macroeconomic analysis, a similar methodology to that employed in the Conference Board of Canada (2007) and the British Department of Trade and Industry (2005) studies was employed.

In the microeconomic analysis a survey measured the perceptions of various companies regarding the impact of standardization. This survey included 1,790 respondents, of which 30 percent had less than 20 employees, 47 percent were SMEs with 250 or less employees, and 23 percent were large companies with more than 250 employees. In terms of sectors, 51 percent of the respondents were in the services sector, 37 percent were in industry, eight percent in trade, and four percent in construction.

4.6 ISO methodology

Given the large number of economic studies that have been completed on this subject, in 2010 ISO developed a methodology for assessing the economic benefits of consensus-based Standards.

This methodology was designed to assess the economic benefits of standardisation to an organisation, and an example was developed to illustrate this – the economic benefits of standardisation in the global automotive industry. It therefore provides guidance on developing studies to assess the benefits of Standards within a particular industry sector.

5 New Zealand Standards

5.1 The Standards Council and Standards New Zealand

In New Zealand, the Standards Council defines Standards as agreed specifications for products, processes, services, or performance. It argues New Zealand needs Standards as a means to:

- Keep people safe and prevent accidents and injuries.
- Support quality regulation.
- Minimise the impact of potential disasters, improve the quality of goods and services, protect the environment, and boost economic growth and trade opportunities by connecting New Zealand to international markets.
- Minimise unnecessary duplication, confusion and inconsistencies.
- Support policy development and implementation.
- Aid user understanding by writing highly technical information in a document.

The Standards Council is the governing body of Standards New Zealand and a Crown Entity. It is autonomous and self-funded, and as an appointed body, has a wide range of community sector representatives. Standards New Zealand develops and publishes Standards and Standards-based solutions. Standards New Zealand was established after the 1931 Hawke's Bay earthquake to ensure that natural disasters do not result in the same loss of life.

Government policy settings determine that Standards New Zealand has to be a self-funded independent body that is cost neutral. Subsequently, Standards New Zealand supports its work by securing service funding, often through industry sponsorship, for the development and maintenance of Standards and through the sales of developed Standards.

5.1.1 *Representation in the international Standards community*

As New Zealand's representative for the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), Standards New Zealand ensures that New Zealand has a voice in the international Standards community and can draw on international best practice and intellectual property. New Zealand representation also allows others in the international Standards community to draw on research and innovation being

undertaken in New Zealand, and our knowledge and experience of standardisation, Standards development, and intellectual property.

Representation in international Standards community work and alignment with international Standards is important for New Zealand as an export-orientated economy. The ISO, for example, consists of the national Standards bodies of 91 countries (including New Zealand) and is made up of approximately 180 technical committees that include New Zealand representatives. In the context of global value chains, Kaplinsky has argued that producer (exporter) and government awareness and knowledge of Standards, and their alignment with global Standards, is important for international trade and global value chains.⁹

What has been termed the “internationalisation” and “harmonisation” of Standards has increasingly been a focus of Standards and standardisation activity internationally. In the United Kingdom for example, in 2005 the British Standards Institute (BSI) catalogue included less than 26 percent of British Standards, while in 1990 64 percent of the catalogue fell into this category. This “internationalisation” and “harmonisation” has increased the number of Standards in the BSI catalogue; but many existing national Standards have been replaced by European Standards.¹⁰

In New Zealand, Standards can be divided into three main types: those developed in New Zealand (NZS), those developed in partnership with Australia (AS/NZS), and those developed by the ISO or the IEC (ISO/IEC).

Since 1950, around 5,200 Standards have been developed in New Zealand and 2,500 Standards have been withdrawn. In terms of the extent of the internationalisation and harmonisation of our Standards, of the 5,200 Standards developed in New Zealand since 1950, around 3,900 Standards have been developed in partnership with Standards Australia, 1,100 Standards have been developed by Standards New Zealand, and around 250 have been developed by the ISO, the IEC, or both, and adopted by Standards New Zealand.

5.1.2 Joint Standards with Australia

More joint Standards are now being developed in partnership with Standards Australia. These Standards have the status of a New Zealand Standard (NZS) and an Australian Standard (AS) and are recognised as part of a Memorandum of Understanding (MoU) between the two Standards setting bodies. This dual recognition assists trans-Tasman trade

⁹ Kaplinsky, R. The Role of Standards in Global Value Chains. Policy Research Working Paper 5396. The World Bank: August 2010.

¹⁰ DTI Economics. The Empirical Economics of Standards. June 2005

as manufacturers, importers, retailers and consumers benefit from having common Standards and standardisation documents.

The development of Standards with Australia is another example of Standards creating economies of scale as they reduce variety and lower the cost of production.

The use of Standards to reduce trade barriers and facilitate trade between New Zealand and Australia is growing in recognition. An example of significant trade benefits are the joint Electrical Appliance Standards, which are cited by regulators in Australia and New Zealand. Manufacturers such as Fisher & Paykel can produce appliances that automatically meet all the regulatory requirements to enter the New Zealand or Australian market. This makes importing and exporting easier and more efficient. Standards in this case are therefore reducing transaction costs as both parties are mutually aware of the technical characteristics, regulatory requirements and potential market.

The MoU between Standards Australia and Standards New Zealand allows for regular interaction at a governance and management level between the two organisations. It also allows for the electronic approval of joint Standards in a way that ensures the need for a joint standard is clearly established and the amount of administration is minimised.

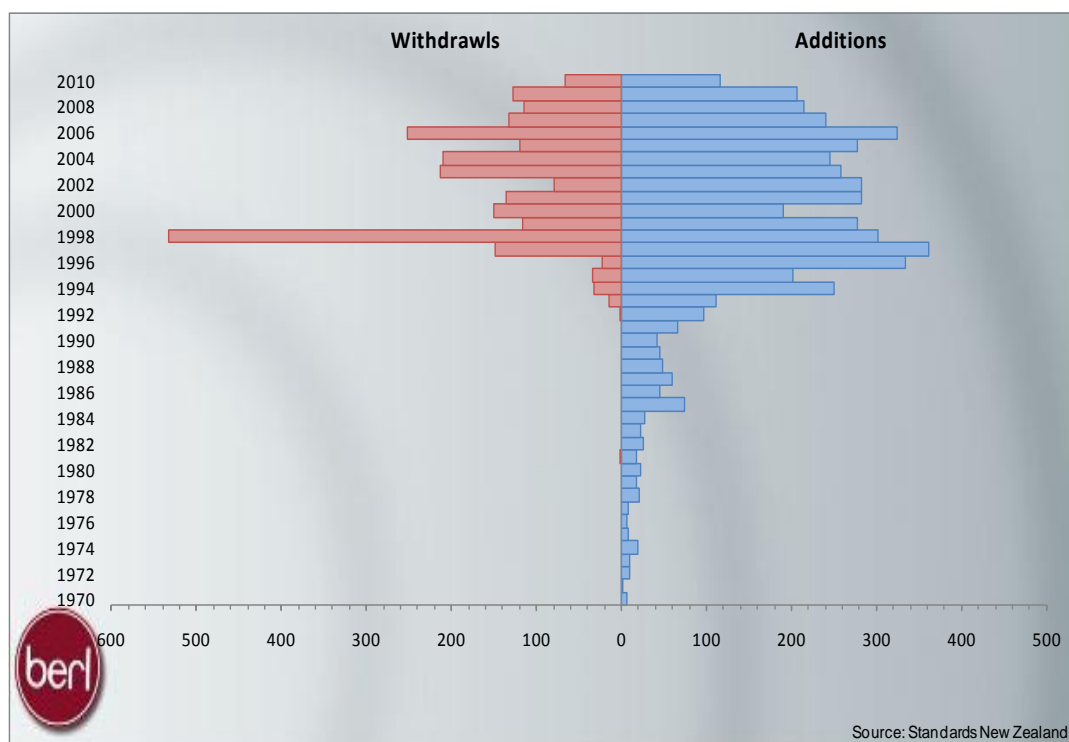
5.2 The New Zealand Standards catalogue

The New Zealand Standards catalogue contains all currently active Standards. The catalogue lists the catalogue number, a brief description, and the cost of the Standard. At the end of 2010, there were approximately 3,600 Standards in the New Zealand Standards catalogue. The catalogue has grown substantially since 1970, when there were approximately 930 Standards in the catalogue.

Figure 1 shows the number of Standards added and withdrawn each year since 1970. This figure clearly shows that the number of additions generally outnumbers the number of withdrawals with one exception in 1998.

In 1998, 533 Standards were withdrawn from the Standards catalogue. These Standards had spent, on average, 13 years in the catalogue with some having been in the catalogue for 45 years. This points to a general clean up of older Standards by Standards New Zealand, as the number of newly developed Standards grew substantially in the five years prior to 1998. Also, 53 of the withdrawn Standards were connected to methods of tests paints and related materials.

Figure 1 Number of Standards created and withdrawn each year, 1970 to 2010



The demand for new Standards, or the maintenance of existing Standards through revisions or amendments, is driven by industry, industry organisations or associations, companies, education institutions or the general public. In general, this process happens through the identification of an issue with a Standard or the need for a new Standard. This need is communicated to Standards New Zealand, and if there is sufficient evidence to support this need, approval is given by the Standards Council for the development of a new Standard, or revision or amendment of an existing Standard. This approval is given with support from industry, the Government and other stakeholders involved in the Standards and standardisation process.

5.3 Standards adoption

The New Zealand Standards catalogue can tell us how many Standards are available in New Zealand but it does not tell us the uptake of Standards. Sales figures on Standards provide some indication of the extent to which a particular Standard is used but are only an indicative measure.

Little is available in the international literature on the rate of Standards uptake internationally. This may be because it is difficult to systematically measure across each sector the extent to which a particular Standard is used (Swann, 2000). Literature on the adoption of Standards instead focuses on the function and use of Standards as a social and economic well-being.

In terms of social well-being, it has been argued that the adoption of Standards arises for safety and health related reasons (Centre for International Economics, 2006). Safety and the prevention of adverse incidents has been a primary concern in the development of Standards to date, but now that concern has expanded to consider other aspects such as a product's life cycle and the environment (The Conference Board of Canada, 2007).

In terms of economic well-being, the World Trade Organisation argues “[s]tandards are necessary for the smooth functioning of anonymous exchanges – and therefore, for the efficient functioning of the market” (WTO, 2005). The adoption of Standards also ensures the compatibility of inputs, parts and components in industries where the final product is assembled (WTO, 2005).

Standards adoption can therefore distil knowledge, provide a common language for discussion, and help solve some externality problems (Centre for International Economics, 2006). Standards can also work in tandem with innovation – they provide the means to disseminate innovation and good market practices to companies (AFNOR, 2009). Standards therefore facilitate the efficient functioning of markets and prevent market failure

6 Econometric analysis of New Zealand Standards

The methodologies employed by Jungmittag, Blind and Grupp (1999), the German Institute for Standardization (DIN, 2000), the British Department of Trade and Industry (DTI, 2005), the Centre for International Economics (2006), the Conference Board of Canada (2007), and the Association Française de Normalisation (AFNOR, 2009) examined the relationship over time between changes in labour productivity and the number of Standards. These studies also argued that to fully assess the economic benefits of Standards it is necessary to undertake interviews, surveys or case studies.

We have replicated this analysis using data from the New Zealand Standards catalogue to obtain a comparable measure with other international studies completed in this area. In particular, we tested the hypothesis that there has been a positive relationship over time between the number of Standards and the level of labour productivity in New Zealand. In this approach, the net benefit to the economy was measured by the number of Standards published in a particular year, rather than considering the net benefit of individual Standards.

We then undertook interviews with key stakeholders. The evidence provided in these interviews was qualitative not quantitative.¹¹ Despite this, these interviews provide a rich insight into how Standards are referred to and used on a daily basis in this sector, and the impact Standards have on behaviour, tastes and decision-making. The insight provided in these interviews was also used to develop the scenarios for economic modelling, as discussed in Section 7.

6.1 Methodology employed

In our approach we focused on what previous studies have termed the 'Standards Catalogue Index (SCI)'. Here, the economic contribution of Standards is measured by the number of Standards appearing in the Standards catalogue at a given point in time.

To calculate the SCI for the United Kingdom, DTI combined two data sources: the BSI 'History Book' of Standards, and the PERINORM, a digital database of Standards from the United Kingdom, Germany and France. This approach was considered an appropriate measure of standardisation activity and its impact on productivity, as it is symmetrical (DTI, 2005).

¹¹ At this point we would note the limitations illustrated in the Conference Board of Canada study (2007) regarding the difficulties of quantifying, in an economic sense, the benefits of Standards through case studies.

Having measured standardisation activity, studies completed by DIN (2000), DTI (2005), the Conference Board of Canada (2007), and AFNOR (2009) then used a Cobb-Douglas production function model to test the impact of this standardisation activity on productivity. This model illustrated there was a measurable statistical relationship between the catalogue of Standards and productivity growth.¹² We have therefore replicated this approach using a Cobb-Douglas production function model of production that focuses on capital (K) and labour (L) inputs and total factor productivity (TFP).

The following discussion explains in detail how the model works, the various tests we ran, and the findings of related studies. In Section 6.4 we discuss the analysis we undertook to see if the model and the findings of related international studies held true for the situation in New Zealand.

6.2 Stock of Standards

The stock of Standards used in determining productivity gains came from data supplied by Standards New Zealand. Standards New Zealand was able to provide the date each Standard was either added or withdrawn from its catalogue since January 1950 until the end of December 2010, and the number of Standards in the catalogue at the start of 1950. This allowed us to calculate the number of Standards added or withdrawn each year, and the annual size of the stock of Standards.

A major assumption in undertaking this analysis is that the *number* of Standards is a legitimate proxy for the *quality* of Standards that are being produced. This assumption, while consistent with that adopted by other studies, should be clearly noted. Ideally, this assumption should be verified or tested through external information. However, this was outside the scope of this project. An intermediate option would be to modify the number of Standards by their age, to provide an 'age-adjusted' measure of Standards. This approach should also be considered for further investigation.

6.3 Cobb-Douglas production function

In a Cobb-Douglas production function model the economy-wide output is assumed to be a function of capital inputs, labour inputs and multifactor productivity. This is represented by the equation:

¹² It is worth noting that the AFNOR study completed in 2009 differed from the other studies in that it argued that standardisation (Standards, technical documents, etc.) can be considered as a specific form of technology transfer and measured this in the context of the French economy.

In the Cobb-Douglas model the economy-wide output is assumed to be a function of capital inputs, labour inputs and multifactor productivity. This is represented by the equation:

$$Y(t) = F(K(t), L(t))$$

Where $Y(t)$ = output at time t , $K(t)$ = capital input at time t , $L(t)$ = labour input at time t .

Here, the key sources of economic and labour productivity growth are improvements in multifactor productivity, the stock of capital, and the quantity of labour. In turn, multifactor productivity growth is a combination of technology and efficiency, and is a measure of how effectively capital and labour can be combined to produce an output.

In our analysis, labour productivity or output per hour worked is the dependent variable, and the key assumption we make, similar to previous studies, is that standards enhance multifactor productivity by promoting technological advancement and improving efficiency. Multifactor productivity growth is therefore assumed to be a function of a time trend and the collection of standards.

In their study, Jungmittag et al (1999) assumed the multifactor productivity portion of the production function was a function of the collection of standards, a measure of spending on foreign technology licenses, and variables that captured structural shifts in the German economy due to movements in labour productivity. In their study, output was the dependent variable (as a function of the capital stock, quantity of labour utilised, stock of patents, spending on licenses of foreign technology, the collection of standards, a time trend, and variables indicating important changes in the structure of the German economy).

In the DTI study (2005) conducted in the United Kingdom, the estimate of the stock of innovations was based on the number of patents granted in the United States rather than domestically. In our study, we examined the number of patents granted in New Zealand.

These combined outputs, and multifactor productivity, is therefore represented by the following equation:

$$Y(t) = a + \alpha k(t) + \beta l(t) + \gamma pat(t) + \delta lex(t) + \epsilon std(t) + \lambda t + u(t)$$

Where, in addition to the previous factors:

- $k(t)$ = log (capital input at time t),
- $l(t)$ = log (employment input at time t)
- $pat(t)$ = log (domestic patent stock at time t)

- $lex(t) = \log$ (imports of licenses, patent royalties etc)
- $std(t) = \log$ ('effective or quality adjusted' stock of standards)
- $t = \text{time}$
- $u(t) = \text{normally distributed error term.}$

The DTI (2005) study found there was a number of limitations in using this equation – such as a shortage of data points, and patents and standards turned out to be highly co-linear - so it was necessary to impose constant returns to scale on the underlying production function. This lead DTI (2005) to conclude that the elasticity estimates that this equation produced would be the upper bound on the estimated contribution of standards to the growth of labour productivity.

Therefore, DTI (2005) extended this equation to consider the potential endogeneity of the stock of standards – i.e. in what direction does the causality between labour productivity and standards run? Does it run from productivity to standards or vice-versa? This lead DTI (2005) to devise the following equation:

$$Y(t) - l(t) = \eta + \mu(k(t) - l(t)) + v std(t) + \sigma t + \tau(t)$$

Where, in addition to the variables already identified:

- $Y(t) - l(t) = \text{labour productivity}$
- $k(t) - l(t) = \text{the ratio of capital to employment.}$

Finally, to avoid any spurious correlations that may result due to the non-stationary time series properties of the variables, the DTI (2005) study also completed Augmented Dickey-Fuller (ADF) tests. These tests found that a co-integrating relationship exists between the variables labour productivity, the capital-employment ratio, and the stock of Standards. This finding is important because only one co-integrating relationship should exist between the variables in order for the study to argue that an X percent increase in the stock of Standards is associated with a Y percent increase in labour productivity.

To test this, the DTI (2005) study ran regressions where the capital-employment ratio and the stock of Standards variables were each treated as the dependent variable. The regression results indicated that a single relationship does exist between labour productivity and the stock of Standards variable, and between labour productivity and the capital-employment ratio.

This regression also allowed DTI to calculate the extent to which Standards are associated with long-term productivity growth and to conclude that the short-term impact of Standards is minimal (DTI, 2005). These findings also supported research completed in conjunction with this study, which found that ‘the informative role of Standards depends on their widespread diffusion, and that diffusion takes time’ (DTI, 2005).

DTI used a Chow test to test the stability of the model from the point of view of checking if the Standards catalogue was inflated through the internationalisation of the catalogue. This test found that the internationalisation of the catalogue had not diminished the impact of Standards on productivity in the United Kingdom.

6.3.1 *Other studies and alternative approaches*

The Centre for International Economics (2006) adopted the DTI (2005) approach outlined above in the context of Australia. This study did not yield significant or positive results. It found that there is no direct relationship between the annual change in Standards and the annual change in multifactor productivity.

An alternative approach was therefore adopted that used the multifactor productivity portion of the production function as the dependent variable. This approach then attempted to explain the results with a range of determining variables, such as the estimated stock of knowledge emerging from research and development (R&D) spending.

6.4 Analysis

In our analysis, the Cobb-Douglas production function is represented as:

$$Y_t = A_t K_t^\alpha L_t^{(1-\alpha)} \quad (1)$$

with

$$A_t = c + \beta_1 Standards_t + \beta_2 Patents_t + \beta_3 Royalties_t + \sum_1^n f_i x_i + \varepsilon_t \quad (2)$$

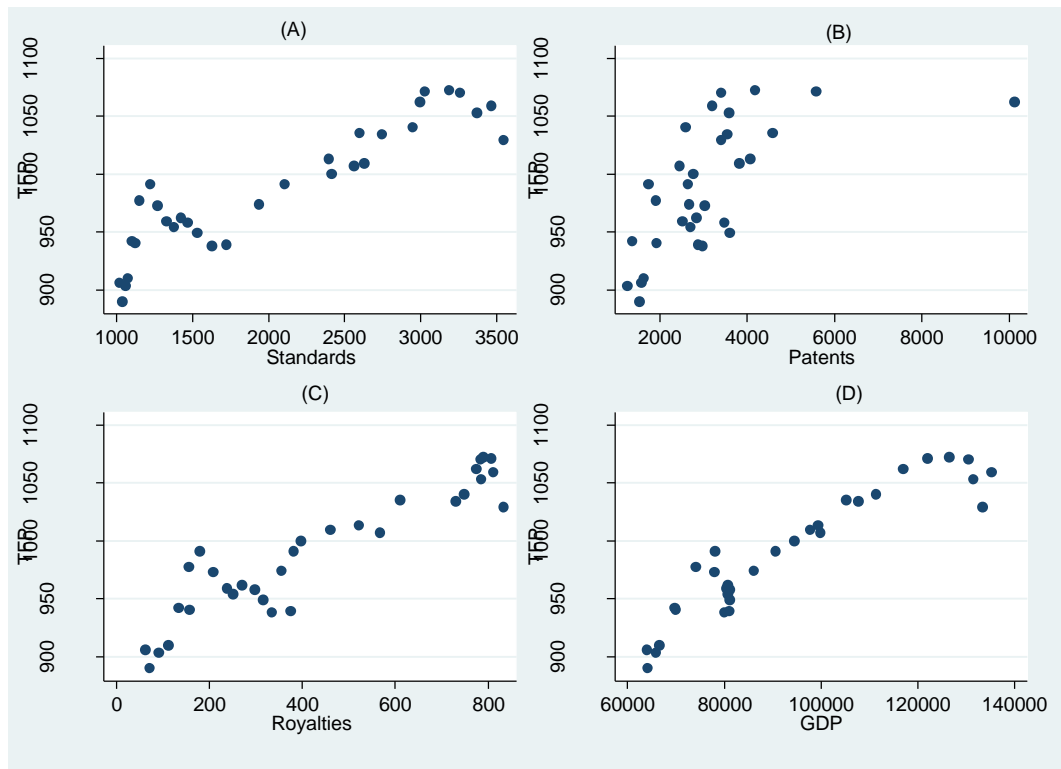
here Y is production, K is capital input, L is labour input and A is total factor productivity (TFP). This describes the rate of knowledge accumulation or the proportion of productivity not accounted for by labour and capital inputs into production. The rate of knowledge accumulation is defined as a portfolio of Standards, patents, royalties and other factors.¹³

¹³ Patents and royalties are used as proxy variables for scientific and technical knowledge.

The variables α and $(1 - \alpha)$ stand for the proportion of wages and profits in the value added section of a competitive market. In this model, growth depends on the rate of capital and knowledge accumulation, and employment trends.

Figure 2 shows how trends in the number of Standards, royalties and granted patents are associated with TFP in New Zealand.

Figure 2 Relationship between total factor productivity, knowledge indicators and output, 1978-2009



The scatter plots suggest that there is a positive association between scientific and technical knowledge and TFP, with standards playing a key role in this relationship. Panel (D) displays a positive correlation between TFP and output (as measured by GDP) in New Zealand.

Having established these trends, our next step was to undertake a preliminary analysis to verify the associations observed in Figure 2 and infer the impact of Standards on productivity growth. Economic theory suggests that economic growth (an increase in GDP or GDP per capita) depends on the use of different production factors (labour, natural resources, capital) and productivity (the efficiency with which these different factors are used). Thus, economic growth should occur or is induced when factors that affect labour productivity increase.

6.4.1 Preliminary analysis

In our preliminary analysis, we expressed the standard Cobb-Douglas production function in its logarithmic form and deduced the labour productivity equation as:

$$\ln Y = \ln A + (1 - \alpha)\ln L + \alpha \ln K + u$$

$$\ln Y - \ln L = \ln A + \alpha(\ln K - \ln L) + u. \quad (3)$$

This labour productivity equation (equation (3)) expresses the rate of growth of labour productivity in terms of changes in TFP and variations in the capital to labour ratio. The two-stage ordinary least-square (2SLS) procedure¹⁴ is then used to statistically measure the impact of standards on labour productivity growth.

The data used in this analysis includes:

- Real GDP (in million of \$NZ).
- The number of people employed.
- The labour and capital productivity index.
- The number of published standards, as defined by the Standards Council of New Zealand.
- The number of patents granted, as reported by the Intellectual Property Office New Zealand (IPONZ).

Due to limitations on data availability, the period covered in this analysis is 1978 to 2007. The use of number published Standards is used as proxy variable for changes in the stock of knowledge. This proxy variable cannot capture the complexity of TFP because there are several determining factors in productivity. As such accumulation of scientific and technological knowledge cannot be embodied in Standards (or in the number of patents). Thus, the data available does not permit us to completely infer the immediate effects of Standards on productivity. To do this we had to undertake further analysis.

¹⁴ A method used in the analysis of structural relationships between a measured variable (output) and latent construct (TFP). In the current study, the TFP (as shown in equation (2)) feeds into the output function (equation (1)). This method is preferred because it estimates the multiple and interrelated dependence in a single analysis, and is very useful when there are feedback loops in the model. Two types of variables are used as endogenous variables (outputs) and exogenous variables (labour, capital, and the knowledge indicators) in the analysis. Endogenous variables are equivalent to dependent variables and exogenous variables are equal to the independent variable.

6.5 The link between Standards and productivity

The results of the econometric estimation are given in Table 1.¹⁵ The findings report that:

- The contribution of the stock of Standards to TFP growth between 1978 and 2009 is positive and statistically significant.
- An elasticity coefficient of 0.10 suggests that a 1.0 percent increase in the stock of Standards at the margin leads to a 0.10 percent increase in TFP. This estimate ranges from 0.07 percent to 0.12 percent, which is comparable with the estimates in Australia and France.¹⁶
- A 1.0 percent increase in Standards at the margin leads to a 0.054 percent increase in labour productivity. This is similar in magnitude to the results of another estimation of this kind undertaken in the United Kingdom.¹⁷

Table 1 Econometric estimation of the impact of Standards on TFP

	2SLS	Coef.	Std. Err.	t	P>t
Labour productivity (LP)					
TFP		0.5389	0.00228	236.16	0.000
Capital to labour ratio		0.1234	0.00687	17.98	0.000
TFP					
Patents		.01801	.01396	1.29	0.202
Standards		.10141	.01384	7.33	0.000
Constant		5.9865	.07859	76.17	0.000
R²			F-stat		
LP		0.99		569734	
TFP		0.84		75.50	
Number of observations		32			

Although the reported elasticity of labour productivity with respect to Standards may appear low, this needs to be set against the high rate of growth in the stock of Standards and the impact of Standards on labour productivity seen in previous studies undertaken in the United Kingdom and Germany.

¹⁵ Equation. (2) is also expressed in logarithmic form for estimations in the 2SLS procedure. Given the limitation of the available dataset, particularly on royalties, we conducted a correlation analysis of the knowledge indicators. These findings suggest that royalties and Standards are highly correlated (0.97), suggesting that we could drop royalties in the TFP estimation.

¹⁶ The statistical performance of the current estimate appears acceptable, but there is still the risk that the estimates are spurious, which should be kept in mind in the interpretation of the current findings.

¹⁷ For a more detailed discussion on Standards and long-run growth, see Temple, P., Witt, R., and Spencer, C. Institutions and Long-run Growth in the UK: the role of Standards. University of Surrey: 2004.

Table 4 shows the annual growth in Standards and productivity in New Zealand from 1978 to 2009. In New Zealand, growth in the stock of Standards has been faster relative to labour productivity and TFP. The average annual growth in Standards has been 4.1 percent, compared with less than one and two percent for labour productivity and TFP, respectively.

This trend suggests there is large variability in the data set for Standards and the capital to labour ratio, and the results presented in Table 1 required further tests for verification. This verification was undertaken (as reported in the appendix) and confirmed the validity of the above results.

Further verification of our econometric analysis was also sought through interviews with key stakeholders in the building and construction sector. These stakeholders represent industry associations, trades associations, employers and employees. They also work in research environments as universities or for BRANZ. Our analysis of Standards and their use at a sector level focused on the building construction sector due to:

- The large number of Standards within this sector.
- The history and age of the Standards, with many building construction Standards undergoing numerous revisions and amendments.
- The wide variety of performance and prescriptive Standards.
- The relationships between the Standards within this sector.

7 Sector analysis of New Zealand Standards

7.1 The link between Standards and productivity at a sector level

Interviews, surveys or case studies can provide further evidence of Standards, including their use and impact on productivity. However, the difficulty in using these types of methodologies is in examining all Standards and their economic effects. A better approach is to focus on a particular aspect of the economic effects of a Standard, rather than attempt to be representative.¹⁸ This focus can allow analysis of how the behaviour, tastes and decision-making of individuals and businesses are influenced by Standards and the standardisation process.¹⁹

Learning from the findings of previous international studies, we focused on a group of Standards within the building construction sector. Interviews were undertaken with key stakeholders and industry representatives to explore what the economic benefits (and costs) of a Standard were from the point of view of this sector. These interviews analysed how a Standard or group of Standards could help the sector to reduce costs and risks, and increase the quality of the goods and services produced.

7.2 Overview of case study Standards

There are approximately 650 Standards related to the building construction sector in New Zealand.²⁰ Bearing this in mind, we selected the following Standards to examine the economic benefits of Standards from the perspective of an industry sector:

- NZS 3910:2003 Conditions of Contract for Building and Civil Engineering Construction
- NZS 4246:2006 Incorporating Amendment No 1. Energy Efficiency – Installing Insulation in Residential Buildings
- The 1170 series, structural design actions, which comprises the following parts, each of which has an accompanying commentary published as a supplement:
 - AS/NZS1170.0:2002 General principles

¹⁸ See for example research completed in Australia by the Centre for International Economics (2006).

¹⁹ See for example research completed by DIN (2000), DTI (2005), the Centre for International Economics (2006), the Conference Board of Canada (2007) and AFNOR (2009) using this methodology.

²⁰ Standards New Zealand. About New Zealand Standards relating to buildings. Retrieved from <http://Standards.co.nz/news/New+Zealand+Standards+and+earthquakes+FAQs/About+New+Zealand+Standards+related+to+buildings.htm>. Retrieved 24 March 2011.

- AS/NZS 1170.1:2002 Permanent, imposed and other actions
- AS/NZS 1170.2: 2002 Wind actions
- AS/NZS 1170.3:2003 Snow and ice actions
- AS 1170.4 Earthquake loads
- NZS 1170.5: 2004 Earthquake actions – New Zealand

NZS 3910:2003 is a Standard widely used by large and small companies in many building construction, engineering, and roading sector contracts. Horizontal and vertical construction companies, principals and engineers draw on the agreed specifications for processes, services, and performance outlined in this Standard.

NZS 3910:2003 includes all the essential commercial provisions required in a contract of this nature, and may be used for engineering construction and building work with a variety of administrative arrangements. As such, this Standard is used across the building construction sector.

In contrast, NZS 4246:2006 is a Standard closely related to a particular sector within building construction, the installation of insulation in residential buildings. Currently, the Government is investing \$347 million over four years in a programme called Warm Up New Zealand: Heat Smart. This programme is being administered by the Energy Efficiency and Conservation Authority (EECA) and it aims to retrofit ceiling and underfloor insulation in at least 188,000 houses nationwide.

For householders and installers to qualify for the programme, insulation products must be installed according to NZS 4246:2006 and the manufacturer's instructions. This Standard is not mandatory, as it is not cited in legislation or regulations, but the insulation product must meet the Building Act 2004 and Building Code requirements.

The AS/NZS 1170 series of Standards are mandatory as they are cited in legislation and regulations such as the Building Act 2004 and the Building Code. This series of Standards, in various forms, has been part of the New Zealand Standards catalogue since 1935, where it originated as NZS.S95:1935.

Over time – through engineering research and development, the incorporation of technology and modification of material changes, changes in legislation, and various amendments and revisions – the multiple documents that this Standard consists of has evolved into a series of joint Standards with Standards Australia. This series of Standards, AS/NZS 1170, focuses

on structural design actions, which is not far from the original focus of the Standard - basic loads to be used in design and methods of application.²¹

All Standards in New Zealand are voluntary; but a standard moves from being voluntary to mandatory when it is cited in legislation or regulations such as the Building Act 2004 or the Building Code. Standards may also be cited in regulations as a means of compliance without being mandatory.²² This is an important feature of many Standards in the building construction sector, as they are empowered by being cited in the Building Act 2004 or the Building Code.

As Standards are voluntary it is up to the regulator, in this case the Department of Building and Housing (DBH), to determine whether a standard should be cited as mandatory or as a means of compliance. DBH may then cite the entire standard, parts of the standard, or cite the standard subject to certain modifications.²³ In summary, the Building Act 2004 and the Building Code are part of law, while Standards and cited Standards are a means of compliance.²⁴

7.3 NZS 3910:2003 Conditions of Contract for Building and Civil Engineering Construction

NZS 3910:2003 Conditions of Contract for Building and Civil Engineering Construction is the Standard used in many building construction, engineering, and roading sector contracts. Many large public and private sector companies in the vertical and horizontal construction sector, such as Telecom and the New Zealand Transport Agency (NZTA), use this Standard.

²¹ For further details on the timeline of this standard see, http://www.Standards.co.nz/NR/rdonlyres/A6FEE8C3-D2F6-43B0-97B7-5B2BFC3B847D/0/SNZ_Overview_timeline_of_Standards_2011.pdf. Accessed 30 May 2011.

²² Standards New Zealand. Standards Development Committees. Retrieved 24 March 2011.

²³ Standards New Zealand. About New Zealand Standards relating to buildings. Retrieved from <http://Standards.co.nz/news/New+Zealand+Standards+and+earthquakes+FAQs/About+New+Zealand+Standards+related+to+buildings.htm>. Retrieved 24 March 2011.

²⁴ The Building Code sets out the minimum performance requirements for buildings. It does not prescribe how building work should meet these requirements but states how buildings and their components must perform. The focus of the Code is on the necessary requirements for health and safety, and what are the essential aspects required of a building. For further information see, Department of Building and Housing. Retrieved from <http://www.building.dbh.govt.nz>. Retrieved 24 March 2011.

NZS 3910: 2003 currently has the following objectives. To be

- A straightforward, flexible document that includes all essential commercial provisions.
- Used for all types of engineering construction and building work with a variety of administrative arrangements.
- Ensure the continuation of the dual role of the Engineer, as an expert adviser to and representative of the Principle.
- Compatible with the Construction Contracts Act 2002.

7.3.1 Potential revision of the Standard

This Standard was last published in 2003; however, in late 2010 the Engineering Leadership Forum (ELF) approached Standards New Zealand in regards to revising the Standard. Feedback from the sector indicated that there was a lack of clarity around some aspects of the Standard and that the Standard was increasingly being used with the addition of special conditions. As a result, ELF members identified the NZS 3910 clauses they recommended should be reviewed, and subsequently a scoping committee was formed to look into this.

This scoping committee agreed NZS 3910 could be made clearer and more straightforward to use. It discussed how some new concepts such as duty of care and good faith could be incorporated into the Standard, and the need to make the Standard more even-handed for all users - the Principal, Engineer or Contractor. The usability of the Standard is an important aspect of it, and despite any revisions, all members of the committee wanted this to stay being a key aspect of the Standard.

Potentially, the revision of NZS 3910: 2003 could include the following:

- A rationale regarding special conditions: sometimes these are appropriate as the Standard can only go so far to accommodate every likely scenario.
- Allowance for changing legislation, including the GST Act, Building Act, and the Construction Contracts Act.
- Provisions for the clear identification of risk allocation.

NZTA spends approximately \$1.5 billion per annum in the horizontal construction sector, and two-thirds of this spend involves contracts using NZS 3910. As a big stakeholder in this sector we have a big interest in ensuring our contracts are fair and reasonable, that there is a clear allocation of risk, and that the risk is appropriate in regards to the supplier and client. The Standard helps in terms of risk allocation, and being fair and reasonable.

Richard Quinn, Project Services Manager, New Zealand Transport Agency

- Assurance of fair treatment for the Contractor and the Principal.
- Clearer insurance requirements.

7.3.2 Solutions driven Standard

Increasingly, the building construction sector and others in industry are looking for ‘solutions driven’ Standards that are focused on the entirety of their business needs rather than independent or stand-alone Standards (CBI, 2002). NZS 3910 provides the ‘how to’ in regards to behaviour in certain circumstances, and specifies the processes that are recommended. It focuses on the whole project, rather than certain aspects of it, and the relationships that are involved in contracting in the roading, building and engineering sectors.

Many in the building construction sector consider NZS 3910 as a good way of managing risk as the standard minimises unnecessary duplication, confusion and inconsistencies. Again, this supports one of the arguments put forward by the Standards Council as to why New Zealand sets Standards.

7.3.3 Prevents information asymmetry

An important element of a competitive market is perfect information. In economics, perfect information can be defined as anything that may impact on a buyer or seller's decision-making – it is assumed that all information is known and understood. However, in the real world, transactions between buyers and sellers often involve incorrect or incomplete information and this is often termed imperfect information or information asymmetry.

Imperfect information may lead to market failure because the party that has better information has a competitive advantage. Information provided by Standards reduces the problem of information asymmetry, as it reduces the chances of imperfect information – which may lead to market failure.

NZS 3910 does not decrease the risk but makes it clear who carries the risk, who is in control and who has to mitigate the risk. The key things the Standards does is that it says, once the project starts most things that happen are at the contractor's risk. They are on-site and know the business of construction, so a Standard like that passes the care of the works to the contractor but it can't pass all that risk as there are certain things that the principal must carry – the accepted risks – things like the design works, decisions that have been made about the materials that will be used. The principal carries this risk as they made that decision. These risks also include things that the contractor can't take out insurance to protect themselves from. Those care of the works provisions are a large part of the Standard.

Andrew Bricknell, Director of Project Management Asia-Pacific, MWH

NZS 3910 encourages people to use the same methods, processes and forms. The industry believes the Standard is fair and has standing, which I think is reflected in its widespread use. It is the basis for most contracts between engineers and contractors, and is the foundation document in the roading, building and engineering sectors.

Project Manager, Standards New Zealand

The information provided in NZS 3910 helps to reduce the problem of information asymmetry as people that use this Standard know the rules of the game, or engagement, and believe a level playing field has been created. The principal focus of the Standard is on what happens when the contract is let and underway, there are 15 sections within the Standard and each has a principal focus. While NZS 3910 does not specify what is to be built, that is the role of the drawings and specifications, it sets the rules of the game under which these documents fit together.²⁵

The Standard is therefore solutions driven. It aims to provide each party with clarity around the risks involved; communicate expectations, payment delivery and timing; indicate the timing and delivery of the project; provide solutions or suggest options for when one party is not performing; and identify how to get the project back on track.

AFNOR found that Standards create transparency and ethics that help to establish the rules of the game and eliminate players who fail to comply (AFNOR, 2009). The information provided in NZS 3910, due to its wide adoption by industry players, is now well understood in the building construction industry. Similar to the examples in the AFNOR study, this Standard has created transparency in the industry and decreased transaction costs as efficiencies have been gained through each party being familiar with the format and various conditions of the contract.

7.3.4 Reduce transaction costs

From the point of view of contractors, NZS 3910 reduces transactions costs.

I am very supportive of the Standards process and think it is robust. Every single clause of NZS 3910: 2003 was reviewed word-by-word by the entire committee, and that committee represents a range of stakeholders. That process takes time and adds to the cost of developing the standard, but it is a very important process and it is what makes the standard robust.

Malcolm Abernethy, Executive Officer, New Zealand Contractors' Federation

²⁵ Interview with Andrew Brickell, Director of Project Management Asia-Pacific, MWH. 18 April 2011.

Similar to information asymmetry, transaction costs often grow due to buyers and sellers trying to gain a better understanding of the goods or services being supplied. Buyers and sellers spend time gathering information to aid their decision-making, and this time has a cost. The longer buyers and sellers spend gathering information, the greater the transaction costs and the higher probability of market failure. By reducing transaction costs, Standards prevent market failure.

Standards can reduce transaction costs by improving technical recognition. In the case of NZS 3910, each party is familiar with the format and various conditions of the contract; therefore transaction costs are reduced due to this recognition. It is also important to remember that transactions costs are the costs not directly related to an economic exchange. As Peter Degerholm notes, “with NZS 3910 people know the baseline information they are working from. It provides a very good platform for lifting the game in the industry, and I think the more we can get the underlying rules or processes clear than that has got to be good for the industry”.²⁶

Process Standards and management Standards such as NZS 3910:2003 codify best practice. The presence of this Standard enables businesses (or buyers and sellers) in the building construction sector to make use of the knowledge and experience of experts in contracts management, legislation, insurance, arbitration and mediation, and engineering and construction, rather than undergo the time, cost and uncertainty of developing their own protocols from scratch (CBI, 2002).

7.4 NZS 4246: 2006 Incorporating Amendment 1 Energy Efficiency – Installing Insulation in Residential Buildings

NZS 4246: Installing Insulation in Residential Buildings was first published in December 2006, and reprinted incorporating Amendment No 1 in April 2010.²⁷ This Standard is an agreed specification for a process – the method to correctly install insulation in residential buildings to ensure the thermal performance of the building is optimised.

²⁶ Interview with Peter Degerholm, Managing Director, Calderglen Associates Limited, 8 April 2011.

²⁷ No 1 included modification of clauses, the addition of a new clause, additions to the list of exclusions, clauses deleted or modified, and additional information added to the special considerations.

Prior to the standard there was no guidelines about how to install insulation, so while there were set requirements in terms of certain levels of energy efficiency, there was no standard in terms of the process that you go through to install the insulation to meet that level. BRANZ had done research in this area but their guidelines at the time were more focused on new homes and putting insulation into new buildings. The standard was a huge leap for the industry, and it lead to a lot of re-thinking in terms of installation practices.

Gleb Speranski, Head of Sales and Marketing, InsulPro Manufacturing Limited

Insulation refers to material that provides substantial resistance to heat flow once it is installed. When insulation material is installed in the ceiling, floor and walls of a building, heat transfer is reduced, and the need for heating or cooling is minimised.²⁸

NZS 4246 is a voluntary Standard so it is not cited as being mandatory or as a means of compliance. It is however a widely used and supported technical solution to installing insulation materials in residential buildings.²⁹

7.4.1 Insulation installation

In New Zealand, there are a variety of insulation products on the market and various methods of installing these products. For example, mineral wool, loose-fill, blankets, in-situ foam, rigid sheet insulation, and semi-rigid sheet insulation are insulation products that can be installed in residential buildings.³⁰

The installation of bulk insulation products traps pockets of still air or other gases within its structure. These air pockets resist heat flow or transfer, and all insulation materials are rated for their performance in restricting heat flow or transfer. This is known as an R value, or the thermal resistance.

The Insulation Council of Australia and New Zealand argues that the case for improving energy efficiency through the use of insulation is compelling.³¹ They state, that if installed

²⁸ Sustainable Energy Authority. Insulation Benefits. Information Fact Sheet. www.sustainability.vic.gov.au, Accessed 24 March 2011; Home Seal. The Benefits of Insulating Your Home. Accessed www.homes seal.co.nz, 7 March 2011.

²⁹ NZBC Clause H1 sets an energy performance level for housing – an acceptable solution for housing and other small buildings is provided through the NZBC compliance documents.

³⁰ For further examples and explanations regarding insulation products see the Definitions section of NZS 4246:2006 Incorporating Amendment No 1. Energy efficiency – Installing insulation in residential buildings. Standards New Zealand. Wellington. 30 April 2010.

³¹ See for example, Energy Conservation Management, Alliance to Save Energy, and Barakat & Chamberlin Inc., Green and Competitive – The Energy, Environmental and Economic Benefits of Fiber Glass and Mineral Wool

correctly, bulk insulation products will continue to deliver their rated thermal performance for the remaining life of the building. Insulation therefore provides a cost-effective, energy saving measure for householders.³² However, despite this compelling evidence, the Council also found that in 2009, 83 percent of householders had installed insulation into their homes for comfort rather than to save energy (four percent).³³

A study completed in 2004 by the Housing and Health Research Programme at the Wellington School of Medicine and Health Sciences found that the benefits from installing home insulation include tangible health benefits and energy savings:

- Health benefits included a reduction in the number of visits to GPs, hospitalisations, days off school, and days off work.
- Energy benefits include a reduction in energy spend per household and additional economic benefits can accrue to electricity network companies due to the reduction in peak electricity demand.³⁴

The benefit-cost ratio of home insulation installation was calculated to be two in this study. This means that the benefits accrued over time in terms of health and well-being and energy savings were in excess of the costs of installing insulation into the houses in the study. The cost of installing the insulation was around \$1,800 per house, while the total benefits excluding GP visit savings was \$3,110 per household. These figures are based on the present value of the benefit to the household.³⁵

7.4.2 Warm Up New Zealand: Heat Smart

As part of the 2009 Budget, and the New Zealand Energy Efficiency and Conservation Strategy, the Government is investing \$347 million over four years to retrofit at least 188,000 homes. This investment is now known as the Warm Up New Zealand: Heat Smart

Insulation Products. Accessed 24 March. <http://www.naima.org>; Sustainable Energy Authority. Insulation Benefits. Information Fact Sheet. Accessed 24 March 2011.

³² Insulation Council of Australia and New Zealand. Submission by the Insulation Council of Australia and New Zealand to Senate Standing Committee on Environment, Communications and the Arts Inquiry into the Energy Efficient Homes Package. December 2009. http://www.aph.gov.au/senate/committee/eca_cte/eehp/submissions.htm. Accessed March 28 2011.

³³ Insulation Council of Australia and New Zealand. Submission by the Insulation Council of Australia and New Zealand to Senate Standing Committee on Environment, Communications and the Arts Inquiry into the Energy Efficient Homes Package. December 2009. http://www.aph.gov.au/senate/committee/eca_cte/eehp/submissions.htm. Accessed March 28 2011.

³⁴ Chapman, R, Howden-Chapman P, and O'Dea, D. A Cost-Benefit Evaluation of Housing Insulation: Results from the New Zealand 'Housing, Insulation and Health' Study. Wellington: 2004.

³⁵ Chapman, R, Howden-Chapman P, and O'Dea, D. A Cost-Benefit Evaluation of Housing Insulation: Results from the New Zealand 'Housing, Insulation and Health' Study. Wellington: 2004.

programme that is run by the Energy Efficiency and Conservation Authority (EECA).³⁶ Anyone who has a home built before 2000 is eligible for 33 percent off the cost of installing ceiling and under floor insulation up to a maximum of \$1,300. Community Service cardholders can get 60 percent off the cost of installing insulation.

Under the Warm Up New Zealand: Heat Smart programme, ceiling and under-floor insulation products must be installed by an approved service provider to the Standard NZS 4246:2006 Incorporating Amendment No. 1. Energy Efficiency – Installing Insulation in Residential Buildings to receive EECA funding.³⁷

The types of insulation included in this programme are: wool, polyester, fibreglass, mineral fibre and polystyrene. EECA has a policy on insulation product, and these products must meet seven criteria to qualify to be used under this programme.

- Insulation products must meet the Building Act and New Zealand Building Code requirements.
- Insulation products must perform to their stated R-value. The product must meet the testing and labelling requirements of AS/NZS 4859.1:2002.
- Insulation products must be able to be installed correctly. The product must be able to be installed to NZS 4246 and the manufacturer's instructions. EECA will not accept a product that cannot be shown to be able to be installed consistently to achieve its stated R-value.
- Insulation products must perform over their stated lifetime.
- Product as installed must be amendable to independent check testing.
- Insulation product during installation and as installed must not endanger the health and safety of installers and occupants.
- Product should not cause deterioration or damage to any part of the house.

³⁶ EECA. Energywise Homes. New Zealand Energy Efficiency and Conservation Strategy. 2007.

³⁷ EECA. Getting Insulation Installed Under the Warm Up New Zealand: Heat Smart Programme. Accessed 28 March 2011 <http://www.eeca.govt.nz/eeca-programmes-and-funding/programmes/homes/insulation>.

EECA may at their discretion remove an already eligible product from the List of Accepted Insulation Products if serious concerns are raised about the product's performance, it's NZS 4859.1:2002 compliance is not maintained, or if in EECA's view it fails to perform in situ.³⁸

EECA may also at their discretion remove an approved service provider if they fail the audit or checking process. This process ensures that service providers follow the correct procedure and that the installation of the insulation is done properly and safely. This audit and checking process requires the service provider to abide by EECA's "strict installation requirements".³⁹

To meet EECA requirements, approved service providers undertake training through the Insulation Association of New Zealand. This training programme includes classroom-based learning as well as practical learning and workplace assessments.⁴⁰ The training programme and qualifications are not just offered to EECA approved service providers but all players in the industry who are association members. A key part of this training programme is NZS 4246:2006 Incorporating Amendment No. 1. Energy Efficiency – Installing Insulation in Residential Buildings, which is referred to and used as part of a training programme.

When people were brought together to develop the Standard we realised there was no industry body, so the Insulation Association of New Zealand was formed as a part of developing NZS 4246:2006. It was relatively easy for us to form this strategic alliance and set benchmarks as an association due to the Standard being core to what we do. We knew we had to collectively lift the game and work together to do this.

Godfrey Hall, President Insulation Association of New Zealand

The Insulation Association considers NZS 4246 a practical and well written installation guide. The generic nature of the Standard allows the association to use and refer to it as part of their training, ensuring their installers are aware of how and where to place insulation products safely and correctly.⁴¹

7.4.3 Allow network externalities

A major economic benefit of Standards is network externalities (The Conference Board of Canada, 2007). Externalities occur when a person undertakes an activity and other people

³⁸ EECA. Warm Up New Zealand: Heat Smart Insulation Product Policy. Accessed 28 March 2011.

³⁹ EECA. Approved Service Providers. <http://www.energywise.govt.nz/node/18452>. Accessed 28 March 2011.

⁴⁰ Insulation Association of New Zealand. Training. <http://www.iaonz.co.nz/training.html>. Accessed 28 March 2011.

⁴¹ Interview with Godfrey Hall, President, Insulation Association of New Zealand, 25 March 2011.

bear the benefit or cost of that activity. In network externalities, every new user in a network increases the value of being connected to the network. This is particularly important in sectors such as communications, but it requires compatibility.

Between July 2009 and March 2011, 91,506 households have taken advantage of the home insulation and heating scheme. At least 10 percent of these households have been audited. There has been a huge increase in the quality of the installation of the insulation due to training by the Insulation Association of New Zealand related to NZS 4246:2006.

Tim Mahar, Senior Technical Advisor, Energy Efficiency and Conservation Authority

In the case of NZS 4246, a government funded energy efficiency programme has been put in place and a positive externality is potentially occurring as others are benefitting from the correct installation of insulation products in residential buildings. These others include health providers and employers through a reduction in the number of visits to GPs, hospitalisations, days off school, and days off work, and electricity network companies through a reduction in peak electricity demand.

NZS 4246 provides the compatibility required for network externalities to occur in the insulation sector. The greater the number of installers undertaking training using the Standard, and in turn installing insulation product to meet the Standard, the better the insulation product will be installed and the greater the R value or thermal resistance of the product, and the better insulated households in New Zealand will be.

This compatibility is being assisted by the formation of the Insulation Association of New Zealand, the training programme it has put in place, and the benchmarking it is undertaking. Others such as the Building Officials Institute are now looking to the Insulation Association of New Zealand for guidance in developing training programmes for building officials in regards to inspecting the installation of insulation products.

The Building Officials Institute is in the early stages of developing training with BRANZ and the IANZ. We are just in the scoping stage and are trying to determine what training is required and what it should cover. Generally we bring in industry participants and draw on their expertise when developing and running training. This is why we are working with the Insulation Association. We are developing this training due to feedback received from our members. They are interested in understanding what is going on in the industry.

Louise Townsend, Operations Manager, Building Officials Institute Training Academy

7.4.4 Prevent information asymmetry

As mentioned in the previous discussion on NZS 3910, information provided by Standards reduces the problem of information asymmetry, as it reduces the chances of imperfect information – which creates market failure.

Examples of the ways in which Standards reduce the problem of information asymmetry include:

- The identification of minimum admissible attributes through the establishment of safety Standards or minimum quality Standards.
- The provision of information and product descriptions through technical reference Standards that include Standards on measurement and grades of a product. (The Conference Board of Canada, 2007)

As more information is available to the consumer regarding the product, in this case insulation products and their installation in residential buildings, then the more likely it is that lower quality goods or services will eventually be driven out by higher quality goods or service providers. It can be argued that information asymmetry is being prevented through the use of NZS4246 in the Warm Up New Zealand: Heat Smart programme being administered by EECA. As more insulation installers join the programme and become approved service providers through abiding by the conditions set out by EECA, then information asymmetry is prevented through the use of the Standard, which in turn prevents market failure.

Discussing Standards and standardisation in the United Kingdom, CBI found that products adhering to a set standard are able to demonstrate quality and reliability, which in turn inspires trust and confidence (CBI, 2002). Similar to the situation with the EECA programme, CBI found that buyers use Standards when procuring a component, product or service, which decreases the need to undertake separate quality and performance checks. In addition, safety and other Standards help reassure customers that the product is safe, reliable and high quality, even though the product and manufacturer may be unknown to the customer (CBI, 2002). This also increased product acceptance and the overall size of the market (CBI, 2002).

7.4.5 Australian example

In August 2009 a Home Insulation Program (HIP) was introduced in Australia. The HIP was a component of the Energy Efficient Homes Package and the Australian Commonwealth

Government's \$42 billion National Building and Jobs Plan. The HIP therefore had two objectives: to generate employment and to improve the energy efficiency of homes.⁴²

The programme was originally designed to provide insulation to 2.7 million homes, at the time the programme closed on 19 February 2010, over one million homes had been insulated, but four installers had died, over 100 house fires had been linked to the installation of insulation, and serious concerns had been raised by the public and the industry in regards to poor quality workmanship and materials, and high levels of fraud.⁴³

Literature on the adoption of Standards focuses on the function and use of Standards as a social and economic well-being. In terms of social well-being, it has been argued that the adoption of Standards arises for safety and health related reasons (Centre for International Economics, 2006). To date safety and the prevention of adverse incidents, such as the fatalities and fires that occurred as a consequence of the HIP introduced in Australia, has been a primary concern in the development of Standards (The Conference Board of Canada, 2007).

Several key issues were highlighted in a review of the administration of the HIP programme in 2010. One of these issues was that the insulation industry was disparate – insulation products, business models, and industry organisations – and largely self-regulated. Added to this disparity was the large number of programme guidelines and installer advice brochures issued over the course of the programme. Prior to the start of the programme, at industry roundtable discussions, the need for product Standards and installer training was agreed on. Despite this at the peak of this programme in November 2009, over 10,000 installers were registered but training had only been provided to 3,700 people via the national training programme.

Installer registration required installers to meet minimum Standards and the guidelines required insulation be installed appropriately. Installers were also provided with safety information and warnings during the program. However, there was no established pathway for national HIP delivery, and heavy reliance was placed on state and territory regulatory authorities to carry out occupational health and safety checks, product compliance, and complaints handling.

⁴² Hawke, A. Review of the Administration of the Home Insulation Program. 6 April 2010. <http://www.climatechange.gov.au/~media/publications/energy-efficiency/Home-Insulation-Hawke-Report.ashx>. Accessed 28 March 2011.

⁴³ Hawke, A. Review of the Administration of the Home Insulation Program. 6 April 2010. <http://www.climatechange.gov.au/~media/publications/energy-efficiency/Home-Insulation-Hawke-Report.ashx>. Accessed 28 March 2011.

The review of the HIP programme in Australia was undertaken due to issues regarding safety, quality and fraud. Public opinion on energy efficiency and the potential savings from insulation also declined as a result of this programme. This was largely due to questions regarding the use of substandard insulation products.

In New Zealand, NZS 4246 supports quality regulation in the insulation installation industry, and attempts to keep people safe, and prevent accidents and injuries. The objective of this Standard is to provide guidance to insulation installers in order to achieve the design thermal performance and durability of building elements, as well as minimise the risk to them as installers.⁴⁴

In addition, through processes and audits that draw on NZS 4246, EECA can reassure the public that the insulation materials and products and their installation meet a minimum Standard. NZS 4246 however remains a voluntary standard; it is not cited in the Building Code and as such is not enforceable by the Building Control Authorities (BCAs) or Territorial Authorities (TAs). It is however a widely used and supported technical solution to installing insulation materials in residential buildings.

7.5 The AS/NZS 1170 series of Standards

The AS/NZS 1170 series, structural design actions, comprises the following parts, each of which has an accompanying commentary published as a supplement:

- AS/NZS 1170.0 General principles
- AS/NZS 1170.1 Permanent, imposed and other actions
- AS/NZS 1170.2 Wind actions
- AS/NZS 1170.3 Snow and ice actions
- AS 1170.4 Earthquake loads
- NZS 1170.5 Earthquake actions – New Zealand.

As well as being a joint standard with Australia, the AS/NZS 1170 series of Standards, and the engineering principles that this series of Standards are based on, are internationally recognised due to being based on ISO Standards. It could be argued that at a macroeconomic level, the joint development of New Zealand Standards and their

⁴⁴Standards New Zealand. NZS 4246:2006 Incorporating Amendment No 1. Energy efficiency – Installing insulation in residential buildings. Wellington: 2010.

international recognition increases our trade volumes, promotes innovation and the development of intellectual property, and contributes to economic growth.

Many Standards are not designed with a specific economic outcome in mind, and the AS/NZS 1170 series of Standards is a good example of this. The objective of these Standards is to provide designers with general procedures and criteria for the structural design of structures, including buildings. The accompanying commentary therefore provides background material and guidance to help the designer meet the requirements of the Standard. The use of this series of Standards has an economic impact in that they increase safety and reduce cost through the prevention of accidents or mitigation of risks (The Centre for International Economics, 2006).

Risks are mitigated as the Standards in this series enable the designer to confirm the design of a structure. This confirmation means that the proposed structure will resist “known or foreseeable types of action”, and that the level of resistance is appropriate to the intended use and design working life of the structure.

- This resistance means that a structure and its parts will be designed to remain stable in a variety of conditions such as wind, snow and ice, and earthquakes, and that instability due to overturning, sliding or uplift will be prevented.
- The known or foreseeable types of action on a structure and its parts include a combination of actions that are the most common in Australian and New Zealand conditions.
- The intended use of a building and its design working life are important considerations. The general principles given in the Standard may not be sufficient for some structure types because their design is more complex or involves loadings that are not covered by the Standard.
- The intended use of a building also relates to the level of acceptance that structures within a structure must have, or the structure itself may fail if the limit state is exceeded.⁴⁵

The intention is that the AS/NZS 1170 series of Standards are applied by a suitably qualified professional. The design methodology outlined in this series of Standards is therefore applied in accordance with established engineering principles, and covers load combinations (referred to as combinations of actions) and general design and analysis clauses. The

⁴⁵ New Zealand Standard. AS/NZS 1170.0:2002 (Incorporating Amendment Nos 1, 2 & 4). Wellington: 2005.

AS/NZS 1170 series of Standards do not include values of actions (referred to as permanent or imposed actions) as they are agreed specifications for design processes and structural performance.

The AS/NZS 1170 series of Standards, and their economic benefits, support the position of the Standards Council that New Zealand needs Standards. This series of Standards firstly aid user understanding of highly technical information, but of equal importance these Standards minimise the impact of potential disasters, and keep people safe by providing general procedures and criteria for structure design.

However, this series of Standards does not exist in a vacuum. Because the AS/NZS 1170 series of Standards assists in defining the loads for buildings, other Standards that provide engineered solutions for particular situations (such as house framing) may be based on the methods given in these Standards.⁴⁶ This means design Standards for construction materials such as timber, steel, concrete and earth-buildings need to be developed, revised and amended in alignment with this series of Standards.

7.5.1 Allow and encourage innovation

Standards play a role in allowing and encouraging innovation as they provide a platform on which new research and development, technology, products and processes can be built on (DTI, 2005). NZS 1170 Part 5: 2004 Earthquake actions is an example of how a Standard builds on new research and knowledge, innovation, and international best practice, and incorporates this into our built environment.

This standard has two core functions:

- To provide methods for structural engineers to determine earthquake loading levels and specifications.
- To determine the seismic design loads for specific areas of New Zealand.

Buildings are not designed to be earthquake proof but rarely do buildings fall over. Rather buildings have a design life and the likelihood of an earthquake occurring in that time is given as a probability. The design elements in NZS 1170 Part 5: 2004 Earthquake actions have been devised in such a way to ensure that life safety is achieved during an earthquake, but that the building might be an economic write-off because of the damage caused during shaking.

⁴⁶ New Zealand Standard. AS/NZS 1170.0:2002 (Incorporating Amendment Nos 1, 2 & 4). Wellington: 2005.

My role on Standards committees is highly technical. I bridge the gap between the earth scientists and the engineers. With my engineering background I'm aware of the way engineers need information, so there is a lot of working in with the engineering members of the Standards committee, providing information in a format that is most suitable for them.

I primarily provide input on hazards, which is what the engineers derive their design loadings from and I pull on the work of others from within GNS to do that. For example, what strength of ground shaking we could expect throughout New Zealand for various return periods. The research area that goes most directly into this is the New Zealand national seismic hazard model, which I'm one of the main developers of. Another area I develop is models for ground motion prediction equations – which given an earthquake of a certain size and type – how strong do we expect the shaking to be, mainly as a function of distance but also the type of ground shaking and various other factors. We combine those factors and come up with estimates of ground shaking. These models and equations are what the design loadings in the Standard are based on.

In New Zealand the flow is fairly quick between research and Standards because there is a small research community here. A large amount of my research is looking at what sort of things we would want in our structural design codes in five years to 10 years time. I need to be aware of what engineers needs are and do research to satisfy that. This is largely through me staying aware of what is happening internationally, but occasionally engineers through their reading or exposure to people in other earthquake-prone places come across new ideas that they bring to me.

Graeme McVeery, Engineering Seismologist, GNS Science

Non-structural elements are parts of a building that do not or are not intended to resist earthquake loads that are applied to the primary structure of a building.⁴⁷ Damage to non-structural elements may prevent a building from functioning after an earthquake, or make the building useless even if it is structurally sound. The design of these elements is therefore important as they may modify the response of the building in an earthquake in an unplanned way.⁴⁸ The importance of the design of non-structural elements is recognised in NZS 1170 Part 5:2004.

Non-structural elements must be detailed so they do not contribute in an unplanned way to the building's seismic response, and any damage that occurs should be at an acceptable level. Focusing on preventing complete structural collapse is important, because it prevents

⁴⁷ New Zealand Society for Earthquake Engineering. Architectural Design for Earthquake: A Guide to the Design of Non-Structural Elements. 2007.

⁴⁸ New Zealand Society for Earthquake Engineering. Architectural Design for Earthquake: A Guide to the Design of Non-Structural Elements. 2007.

serious injury to people within or close to buildings. What is an acceptable level of damage due to non-structural elements varies by building type, and is openly debated.⁴⁹

The intention is that buildings that house special hazards or essential public facilities will have more protection and will remain functional after a major earthquake. In contrast, a building of ordinary importance is designed for a level of shaking that has a 10 percent probability of being exceeded in its design life of 50 years.⁵⁰ NZS 1170 Part 5:2004 requires that drifts⁵¹ and their associated designs are calculated for two earthquake scenarios:

- Life safety design level – can expect to be exceeded on average once every 500 years, and this is termed the ultimate limit state.
- Serviceability design level – can expect to be exceeded on average once every 25 years, and this is termed the serviceability limit state.

Structures rarely fall over because the materials used in the structure are ductile, and the structural design of these structures behave to some degree elastically or flexible. If a structure is stiff rather than ductile, in an earthquake large loads will seek out weak points such as glazed shop fronts, and these are cracked or crushed.⁵² Ductile design means a building that is overloaded in an earthquake does not collapse but suffers controlled damage. For example, structural steel frames and reinforced concrete frames do this – there are reinforced steel beams inside the concrete and when the beams are overloaded the reinforcement can stretch.

⁴⁹ New Zealand Society for Earthquake Engineering. Architectural Design for Earthquake: A Guide to the Design of Non-Structural Elements. 2007.

⁵⁰ The Institution of Professional Engineers of New Zealand. Christchurch Earthquake: An Overview. Factsheet compiled and distributed by the Institution of Professional Engineers of New Zealand.

⁵¹ Drift is defined as the result of a building swaying in an earthquake.

⁵² New Zealand Society for Earthquake Engineering. Architectural Design for Earthquake: A Guide to the Design of Non-Structural Elements. 2007.

Shortly after the February earthquake in Christchurch, the Institute of Professional Engineers of New Zealand (IPENZ) compiled and distributed fact sheets regarding the earthquake, building safety evaluation and liquefaction. These fact sheets explained that some buildings in Christchurch experienced shaking more than two times more intense than a new building would be currently designed for but of a lesser duration than envisaged by the loading codes (NZS 1170.5).

Non-residential buildings designed before 1976 were not explicitly required to have ductility incorporated into them. In the early 1980s, the design standard for reinforced concrete was revised significantly to ensure non-brittle behaviour under design-level earthquake loadings, and the strong columns/weak beams philosophy was introduced so that life safety could be achieved under design-level earthquake shaking.

The Institution of Professional Engineers of New Zealand. Christchurch Earthquake: An Overview. Factsheet compiled and distributed by the Institution of Professional Engineers of New Zealand.

Different types of Standards are needed at each stage of “technology maturity”. In his discussion on how innovation and new research is incorporated into the Standards process, Graeme McVeery referred to how seismic data and modelling feeds into the Standards process at various points. These points have been defined by the International Electrotechnical Commission (IEC). IEC argues that anticipatory Standards are required to specify the production system of the new technology, enabling Standards refine the production system, and responsive Standards codify knowledge already established in practice through precursor products or services (International Electrotechnical Commission, 2009).

However, Standards can hinder innovation if the timing is inappropriate and leads to economic inefficiencies. If the Standard is introduced too early it may prevent new ideas or technology from entering the market. Alternatively, if the Standard is introduced too late then the transition costs of adopting the Standard may be too high.

Some studies have found that Standards constrain innovation most when they are very old or very new. Standards can also be least useful and most harmful in industries with a rapid turnover in technology (The Conference Board of Canada, 2007; DTI, 2005).

Research is being undertaken at Canterbury and Auckland universities, and we work closely with the civil engineering departments in both universities. Standards come in later and legitimise the research process. So the research is done and that gets put into the Standard. Canterbury has always had a reputation for reinforced concrete design research, particularly in the seismic area.

Rob Gaimster, Chief Executive Officer, Cement and Concrete Association of New Zealand

7.5.2 Create economies of scale

Standards efficiently reduce variety by increasing the compatibility or interoperability between products or systems. This reduction in variety can also enhance the quality of products or systems by improving their functionality or safety. The Association Française de Normalisation (AFNOR) found in their 2009 study that the main benefit of Standards was product interoperability as this lead to increased productivity and improvements in the quality of the systems used.

At a more practical level in New Zealand, this reduction in variety means that there are some decisions that engineers do not need to make as the “nitty gritty things” have been sorted out through in development of the Standard.⁵³ Cam Smart, an engineering practice manager at IPENZ argues that, while a Standard is not a recipe book, some of the difficult mathematical concepts are arranged in the engineering Standards to be simpler equations.

Efficiently reducing variety through undertaking processes like this leads to economies of scale. Economies of scale are created as Standards improve productivity by lowering the cost associated with the production of one unit of goods. Further, engineers do not have to spend large amounts of time undertaking calculations, thereby reducing their opportunity costs, and structures can be produced at a lower per unit cost.

The process of setting Standards also typically adds economically valuable user information. This creates a bandwagon effect where the adoption and use of the Standard encourages others to be involved. This substantially increases the rate of interaction among the potential Standards “adopter population” (DTI, 2005). This can result in cost effects similar to those arising from economies of scale.

The bandwagon effect also makes it possible to eliminate companies who are not complying with the rules of the game thereby adding to the transparency and ethics that Standards establish. For example, in the steel construction sector introducing a product into a market where the standard is already established often results in a greater acceptance and faster take-up of the product.⁵⁴ The producer of standard products in this sector similarly saves the effort of specifying product performance and demonstrating reliability. It only needs to show conformance to the standard.⁵⁵

⁵³ Interview with Cam Smart, Engineering Practice Manager, IPENZ. 12 April 2011.

⁵⁴ Interview with Dr Wolfgang Scholz, Director, HERA, 18 April 2011.

⁵⁵ Interview with Alistair Fussell, Senior Structural Engineer, Steel Construction New Zealand, 12 April 2011.

By designing and manufacturing to a Standard, it is possible to ensure at least a basic level of interoperability with products from other manufacturers. This saves redesigning the product for each new system that it needs to work with (CBI, 2002). The AS/NZS 1170 series is a good example of this.

CBI argued in their study on Standards in the United Kingdom, that at their simplest level, Standards enable products and services to work together; they define crucial aspects of product and service safety, reliability and quality, which reassure customers and enable markets to work effectively (CBI, 2002).

The National Standardization Strategic Framework (NSSF) has also argued that those companies who use Standards strategically not only drive their existing markets, but are often the first to understand how they can make or expand into emerging markets (NSSF, 2005). This is the case in all sectors of the building construction industry – the cement and concrete sector, steel construction sector, and in timber framing. Each of these sectors commission research and development through agencies such as BRANZ or association bodies, or through university engineering departments, and as a result of this research uses Standards strategically.

8 Productivity and New Zealand Standards

Data from our econometric analysis established the nature and quantum of the link between Standards and productivity. Interviews with key stakeholders and the development of three case studies established the link between Standards and industry. We then used an economy-wide economic model to illustrate the link between productivity and wider economic performance, in particular, Gross Domestic Product (GDP).

8.1 The CGE model

The BERL Computable General Equilibrium (CGE) model is a standard economic model of the New Zealand economy. It has a structural framework similar to input-output relationships, but contains relationships that mimic responses to demand, supply and price changes. The model includes 75 industries, 40 types of labour and 25 types of exports.⁵⁶

The CGE model allows us to consider various scenarios that illustrate the benefits, costs and opportunities that Standards could have on the New Zealand economy. The model, for example, can be used to simulate the effect of a 'shock', such as the effect of a productivity change relating to Standards, on the economy. The modelled outcomes are the changes in various economic measures, such as GDP and/or employment, caused by the 'shock' under consideration.

8.2 The CGE model 'shock' simulations

Data from our econometric analysis indicates that a 1.0 percent increase at the margin in the stock of Standards increases TFP by 0.10 percent. Included in this increase in TFP is an impact of 0.056 percent on labour productivity.

This information was used to impose a productivity 'shock' on the CGE model. This allowed us to observe the impact on the wider economy of the increase in the stock of Standards. We assumed this increase in Standards, and consequently the increase in productivity, occurred over a 10 year period.

We then compared the outcome of this additional productivity to the baseline (or business as usual) picture of the New Zealand economy in 2021. The baseline picture assumed ongoing growth in productivity (and so implicitly, Standards) as per historical trends. Growth in world demand for New Zealand export products, global commodity prices, and policy settings for

⁵⁶ See Appendix 2 for more details.

the comparative business as usual picture was also assumed to be unchanged as per the historical experience.

8.3 The CGE model simulation results

Table 2 summarises the results of the two CGE model simulations undertaken. Comparing the results of scenarios A and B emphasises that the impact of Standards on GDP arises not just from the impact of Standards on labour productivity. The greater impact of Standards on GDP and the wider economy arises from its impact on TFP (i.e. implicitly both labour and capital productivity).

Table 2 CGE model results

Joanna CGE model - summary results of productivity shocks

	BAU	SCENARIO A			SCENARIO B		
	2021	2021	% diff from BAU	\$ diff from BAU	2021	% diff from BAU	\$ diff from BAU
GDP (2010 \$m)	235,068	237,500	1.0	2,431	235,728	0.3	660
<i>%pa from 2010</i>	2.1	2.2			2.1		
GDP per capita (2010 \$)	48,834	49,340	1.0	505	48,971	0.3	137
<i>%pa from 2010</i>	1.2	1.3			1.2		
Consumption	139,848	141,538	1.2	1,690	140,299	0.3	450
Exports	66,958	67,522	0.8	564	67,170	0.3	212
<i>%pa from 2010</i>	2.2	2.3			2.3		
Real wage rates	107.4	109.5	1.9	na	107.2	-0.2	na
Trade balance (%GDP)	1.13	1.12	0.0	na	1.13	0.0	na

Baseline (BAU): TFP (including labour productivity) is as per historical experience

Scenario A: assumes Total Factor Productivity in each year (of a 10-year horizon) is 0.101 percent higher than in baseline

Scenario B: assumes labour productivity in each year (of a 10-year horizon) is 0.055 percent higher than in the baseline

Scenario A compares a picture of the New Zealand economy in 2021 that has TFP 0.10 percent higher for each year over the intervening 10 year period, with that of the business as usual picture in 2021. Note this scenario includes, as per the definition of TFP, the 0.056 percent higher labour productivity.

The results for scenario A indicate a \$2.4 billion gain in GDP in 2021, or the equivalent of \$505 per capita, compared with the business as usual outcome. Both of these figures are expressed in real 2010 dollar values. This represents an improvement of 1.0 percent in annual GDP in 2021 above that achieved under the business as usual outcome.

This improvement in productivity is transmitted through the New Zealand economy via the additional \$564 million achieved in export volumes. This is a 0.8 percent improvement

compared to the business as usual outcome. These additional exports enable real wages (i.e. inflation-adjusted wages) to grow 1.9 percent above those in the business as usual situation. This improvement in real wages income assists households to consume more – to the tune of \$1.7 billion in total, or 1.2 percent in addition to the baseline.

Scenario B simulates an improvement in labour productivity only. This is presented to enable an estimation of how much the economy-wide gains tabulated for scenario A are from labour productivity improvements alone, and how much is from the impact of TFP.

Thus, scenario B compares a picture of the New Zealand economy in 2021 that has labour productivity 0.056 percent higher for each year over the intervening 10 year period, with that of the business as usual 2021 picture.

The results for scenario B indicate a \$660 million gain in GDP in 2021, or the equivalent of \$137 per capita, compared with the business as usual outcome. Both of these figures are expressed in real 2010 dollar values. This represents an improvement of 0.3 percent in annual GDP in 2021 above the business as usual picture of the New Zealand economy.

Again, the improvement in productivity is transmitted through the economy via the additional export volumes achieved, but this scenario provides an improvement of 0.3 percent compared to the business as usual. In contrast to scenario A, real wages in scenario B are 0.2 percent below those registered in the baseline. The relatively lower real wages in this scenario indicate a relative increase in demand for capital. This is consistent with an improvement in labour productivity, which consequently requires more capital in order to take advantage of the relatively more productive labour.

8.4 Comparing economic studies on Standards

In summary, our econometric estimation suggests that over the last 30 years a 1.0 percent increase in the number of Standards in New Zealand can be related to a 0.10 percent increase in TFP. TFP includes both labour productivity and capital productivity. Therefore, a 1.0 percent increase in the number of Standards in New Zealand is also related to a 0.056 percent increase in labour productivity.

The results of the two CGE model simulations undertaken further indicate that a 0.10 percent increase in TFP over a 10 year period could lead to a 1.0 percent addition to annual economy-wide GDP, comprising a 1.2 percent addition to household consumption and a 0.8 percent addition to export volumes. In turn, a 0.056 percent increase in labour productivity only for 10 years leads to a 0.3 percent addition to annual economy-wide GDP, comprising a 0.3 percent addition to household consumption and export volumes.

As show in Table 3 below, the results from our econometric estimation are similar in magnitude to the results of other international studies and estimations of this kind.

Table 3 Comparative summary

	Germany	UK	Canada	Australia	France	New Zealand*	New Zealand
Year	1999	2005	2007	2007	2008	2010	2010
Period	1961-1990	1948-2001	1981-2004	1962-2004	1950-2007	1978-2009	1978-2009
Estimated function	Output	Labour productivity	Labour productivity	TFP	TFP	TFP	Labour productivity
Growth rate of standards (% p.a.)	12.9	5.1	0.7	4.6	6.8	4.1	4.1
Growth rate of labour productivity (% p.a.)	3.0	2.1	1.4	NC	3.0	1.0	1.0
Impact of stock of Standards on productivity	0.07	0.054	0.356	0.17	0.12	0.1**	0.054

*BERL Estimate

Source: Association Française de Normalisation (AFNOR), 2009

** about \$988,000 per 1% increase in standards

The Jungmittag, Blind and Grupp (1999) study found that Standards play an important role in explaining long-term movements in the economic output of the German business sector.

- Their macroeconomic analysis found that between 1960 and 1990, Standards annually contributed an estimated 0.9 percentage points to an overall growth rate of 3.3 percent per annum.

The German Institute for Standardization (DIN, 2000) found that Standards make a greater contribution to economic growth than patents or licences. In their macroeconomic analysis, standardisation was assessed by the number of published Standards and technical rules.

This study found:

- The economic benefit of standardisation was one percent of GDP (DM31.5 billion in 1998).
- Company Standards had the greatest positive effect on businesses due to helping to improve processes, while industry-wide Standards lowered transaction costs, opened up new markets, and helped technological change.

Their microeconomic analysis found that companies were generally unaware of the strategic significance of Standards. The decision to participate in the standardisation process was usually based on the costs involved and time commitments.

However, businesses that were actively involved in Standards work more frequently reaped the short and long-term benefits, in regards to a decrease in costs and an increase in competitive status, than those that did not. Having an influence on the content of a Standard was also an important factor in gaining competitive advantage.

- In contrast to what we found in the New Zealand building construction sector, German businesses believed that company Standards had more of a positive effect on their competitive status than industry-wide Standards.

The British Department of Trade and Industry study (DTI, 2005) also found that Standards and standardisation play an important role in explaining long-term movements in British labour productivity (output per hour worked).

- Between 1948 and 2002, the average rate of growth in the number of Standards was 5.1 percent while the average rate of growth in labour productivity was 2.1 percent. Standardisation accounted for 13 percent of the growth rate in labour productivity during this time.
- Between 1948 and 2002, GDP grew by 2.5 percent per annum and the accumulation of inputs – capital and labour – together accounted for 1.5 percentage points while technological change accounted for 1.0 percentage points. Standards were associated with one quarter of the one percent of technological change.

However, DTI argued that Standards act in conjunction with other factors integral to technical change - such as innovation - and that the role of Standards should therefore not be considered independent of these factors.

In Australia, the Centre for International Economics (2006) found that Standards play an important role in enhancing productivity.

- In this study, a one percent increase in the stock of Standards was associated with a 0.17 percent increase in economy wide productivity.
- If Standards were specified as contributing to the stock of knowledge jointly with research and development expenditure, then a one percent increase in this joint stock of knowledge lead to a 0.12 percent increase in economy wide productivity.

The Centre for International Economics argued that while the diversity of Standards makes it difficult to sensibly aggregate Standards into a single measure, the economy wide rather than specific effect of a Standard is the most important measure.

The Centre for International Economics also completed four case studies on Standards or groups of Standards in the mining, water and electrical industries, and risk management Standards. As this study found it difficult to construct case studies that were representative of all Standards, they chose Standards that illustrated a particular aspect of the economic effects of Standards within a sector. For example, in the mining industry the use of sampling

Standards lead the Centre for International Economics to conclude that the total annual benefits to the industry of Standards was \$58 million per annum (with an upper and lower range of \$24 million to \$100 million).

The Conference Board of Canada (2007) found that Standards play an important role in enhancing labour productivity, measured as output per hour worked, in Canada.

- Between 1981 and 2004, standardisation accounted for 17 percent of the growth rate in labour productivity, or nine percent of the growth rate in output (real GDP).
- In 2004, the level of output (real GDP) would be expected to be \$62 billion lower if there had been no growth in Standards between 1981 and 2004.

This study found that interviewees were fairly knowledgeable about Standards, but this knowledge was often limited to their specific business area rather than a broader perspective on the economic benefits of Standards. Further, while they were able to talk about the benefits and costs of Standards, it was difficult for them to quantify these benefits in an economic sense (The Conference Board of Canada, 2007). In the case studies we examined, some interviewees were also fairly knowledgeable about Standards and their impact on specific areas of their business or industry. However, similar to the situation in Canada, these interviewees were also unable to quantify these benefits in an economic sense.

The two case studies of large companies in Canada were able to provide a further level of detail, but again, it was difficult for a dollar value to be attached to many of the benefits of achieving and maintaining certification and accreditation to ISO and IEC Standards. The case studies discussed the rationale for standardisation, the challenges of implementation, and the rewards of achieving and maintaining certification and accreditation to ISO and IEC Standards. In turn, the Conference Board of Canada in their fieldwork found that standardisation is the basis for continuous improvement, innovation and new product development.

AFNOR (2009) found that in France, standardisation directly contributes to growth in the economy.

- The impact of Standards for the period 1950 to 2007 on TFP was, on average, 0.81 percent per year.
- Standardisation contributed to an average of 0.81 percent per year, or almost 25 percent of GDP growth between 1950 and 2007. This impact is comparable to that found by the Germans and Australians.

AFNOR also completed an in-depth survey as part of their research. This survey included 1,790 companies or organisations of all sizes and from all sectors of activity, over 66 percent of the companies interviewed stated that standardisation contributed to the generation of profits.

- 69.3 percent of companies consider standardisation to have a positive impact on their activity.
- 71.2 percent of respondents found that participating in standardisation enabled them to anticipate future market requirements in their own sector.
- 61.6 percent of respondents said that investing in standardisation was an efficient strategy for promoting their interests at both European and international levels.

8.5 Concluding comments on Standards in New Zealand

Our econometric estimation, case studies and use of the BERL CGE model have illustrated the link between Standards, productivity and GDP in New Zealand. In particular, we have demonstrated that the greater impact of Standards on GDP and the wider economy arises from the impact on TFP, implicitly both labour and capital productivity.

A major assumption in undertaking this analysis is that the *number* of Standards is a legitimate proxy for the *quality* of Standards that are being produced. This assumption, while consistent with that adopted by other studies, should be clearly noted. Ideally, this assumption should be verified or tested through external information.

Unfortunately, this was outside the scope of the current project. But bearing this assumption in mind, we would suggest that an intermediate option or approach for further investigation could be to modify the number of Standards by their age, to provide an 'age-adjusted' measure of Standards in New Zealand.

Another area for further investigation is to better understand how Standards are applied in the workplace and, in the context of the building and construction sector, on-site. To achieve the gains indicated in our CGE model simulations, on GDP and the wider economy, we would suggest a greater understanding needs to be acquired of the current understanding and use of Standards.

While our interviews involved key stakeholders within the building and construction sector, we did not interview employers or employees.⁵⁷ The building and construction sector in New Zealand largely consists of small and medium-sized enterprises (SMEs). Small employers tend to work in residential housing and renovations and employ between one and nine people, including themselves. This is the largest area of employment in the building and construction sector. Medium employers employ between 10 and 48 employees and predominantly work in residential housing or commercial construction, while large employers are over 49 employees and tend to work in civil or commercial construction. In New Zealand, there are less than 100 large employers in the building and construction sector, just under 1,000 medium-sized employers, and 9,000 small employers. This creates challenges for the sector, particularly in regards to training, skills and productivity.

BETA, an alliance of eight Industry Training Organisations (ITOs), has been working on various initiatives to support a highly productive building and construction sector. One of the challenges they have identified is the low level of qualifications in their sector, and the low level of literacy and numeracy among their workers, particularly document literacy. Standards are technical documents that, in the case of the building and construction sector in New Zealand, provide a 'how to' go about building or designing things. If literacy, particularly document literacy, is a challenge for many people working in this sector how do they access and use Standards. Further, how do they access and use Standards given the large number of related Standards in the building and construction sector and the complexity that the building codes add to this.

A key assumption in our econometric estimation and modelling is that the stock of Standards in New Zealand is of a high quality and that Standards are appropriately applied in order to impact on TFP. If this situation holds true, then Standards can prevent market failure and increase the efficient allocation of resources. Standards can be a powerful economic level; however, they are only one factor of production and in real world situations we need to look at other factors and how they interact and impact on Standards.

⁵⁷ However, it could be argued that many of the stakeholders we spoke to were representing their respective organisation and/or association as well as presenting their views as an employer.

9 Appendix 1: Sources

AFNOR Group. The Economic Impact of Standardization: Technological Change, Standards Growth in France. La Plaine Saint-Denis Cedex: 2009. (<http://groupe.afnor.org/economic-impact-standardization/appli.htm?onglet=&page=>). Accessed 23/12/2010.

Centre for International Economics. Standards and the Economy. Canberra: 2006. (http://www.thecie.com.au/content/publications/Economic_impact_of_Standards.pdf). Accessed 06/01/2011.

Chapman, R, Howden-Chapman P, and O'Dea, D. A Cost-Benefit Evaluation of Housing Insulation: Results from the New Zealand 'Housing, Insulation and Health' Study. Wellington: 2004.

DIN German Institute for Standardization. Economic benefits of standardization. Berlin: 2000. (http://www.din.de/sixcms_upload/media/2896/economic_benefits_standardization.pdf). Accessed 06/01/2011.

DTI. The Empirical Economics of Standards. DTI Economics Paper No. 12. June 2005. ([http://www.bsigroup.com/upload/Standards%20&%20Publications/Government/Empirical Economics.pdf](http://www.bsigroup.com/upload/Standards%20&%20Publications/Government/Empirical_Economics.pdf)). Accessed 23/12/2010.

EECA. Warm Up New Zealand: Heat Smart Insulation Product Policy. . (<http://www.energywise.govt.nz>). Accessed 20/03/2011.

ECCA. Approved Service Providers. (<http://www.energywise.govt.nz/node/18452>). Accessed 28/03/2011.

EECA. Energywise Homes. New Zealand Energy Efficiency and Conservation Strategy. Wellington: 2007.

EECA. Getting Insulation Installed Under the Warm Up New Zealand: Heat Smart Programme. (<http://www.eeca.govt.nz/eeca-programmes-and-funding/programmes/homes/insulation>). Accessed 28/03/2011.

Energy Conservation Management, Alliance to Save Energy, and Barakat & Chamberlin Inc., Green and Competitive – The Energy, Environmental and Economic Benefits of Fiber Glass and Mineral Wool Insulation Products. (<http://www.naima.org>). Accessed 24/03/2011.

Hawke, A. Review of the Administration of the Home Insulation Program. 6 April 2010. (<http://www.climatechange.gov.au/~media/publications/energy-efficiency/Home-Insulation-Hawke-Report.ashx>). Accessed 28/03/2011.

Home Seal. The Benefits of Insulating Your Home. (www.homeseal.co.nz). Accessed 7/03/2011.

Insulation Association of New Zealand. Training. (<http://www.iaonz.co.nz/training.html>). Accessed 28/03/2011.

Insulation Council of Australia and New Zealand. Submission by the Insulation Council of Australia and New Zealand to Senate Standing Committee on Environment, Communications and the Arts Inquiry into the Energy Efficient Homes Package. December 2009. (http://www.aph.gov.au/senate/committee/eca_ctte/eehp/submissions.htm). Accessed 28/03/2011.

International Electrotechnical Commission (IEC). Economic Value of Standards: PowerPoint presentation presented by the International Electrotechnical Commission. (http://www.euras.org/uploads/iecllectures/economic_value_of_Standards.pps). Accessed 7/01/2011.

International Organization for Standardization (ISO). Assessing Economic Benefits of Consensus-Based Standards: The ISO Methodology. January 2010. (<http://www.iso.org>). Accessed 6/01/2011.

Standards New Zealand. About New Zealand Standards relating to buildings. (<http://Standards.co.nz/news/New+Zealand+Standards+and+earthquakes+FAQs/About+New+Zealand+Standards+related+to+buildings.htm>). Accessed 24/03/ 2011.

Temple, P., Witt, R. And Spencer, C. Institutions and Long-run Growth in the UK: the role of Standards. University of Surrey: 2004.

The Conference Board of Canada. Economic Value of Standardization. July 2007. Submitted to the Standards Council of Canada, Ottawa. (https://www.scc.ca/en/c/document_library/get_file?uuid=a7b2360e-fa23-47c6-9eb7-ecde3d94b7df&groupId=10174). Accessed 23/12/2010/

The Institution of Professional Engineers of New Zealand. Christchurch Earthquake: An Overview. Factsheet compiled and distributed by the Institution of Professional Engineers of New Zealand.

New Zealand Society for Earthquake Engineering. Architectural Design for Earthquake: A Guide to the Design of Non-Structural Elements. Wellington: 2007.

Standards New Zealand. AS/NZS 1170.1:2002 Structural Design Actions Part 1: Permanent, imposed and other actions. Wellington: 2002.

Standards New Zealand AS/NZS 1170.0:2002 (Incorporating Amendment Nos 1, 2 & 4). Wellington: 2005.

Standards New Zealand. NZS 4246:2006 Incorporating Amendment No 1. Energy efficiency – Installing insulation in residential buildings. Wellington: 2010.

Standards New Zealand. Standards Development Committees. (www.Standards.co.nz) Accessed 24/03/2011.

Standards New Zealand. About New Zealand Standards relating to buildings. (<http://Standards.co.nz/news/New+Zealand+Standards+and+earthquakes+FAQs/About+New+Zealand+Standards+related+to+buildings.htm>). Accessed 24/03/2011.

Swann, G. M. The Economics of Standardization: Final Report for Standards and Technical Regulations Directorate Department of Trade and Industry. Manchester Business School. University of Manchester: 2000.

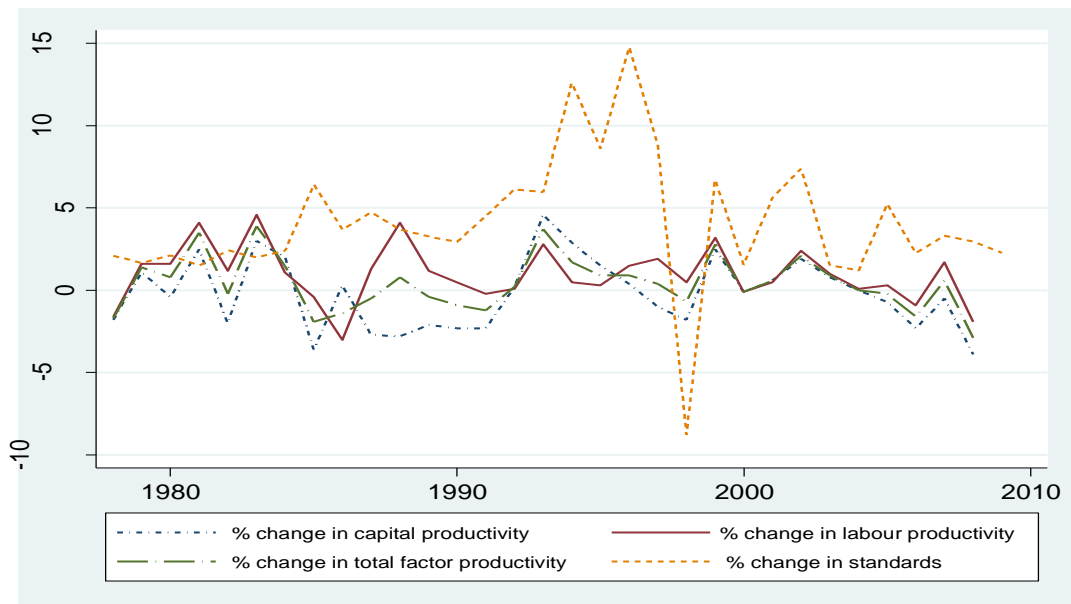
Sustainable Energy Authority. Insulation Benefits. Information Fact Sheet. (<http://www.sustainability.vic.gov.au/resources/documents/eshousingmanualch07.pdf>). Accessed 24/03/2011.

World Trade Organisation. World Trade Report 2005: Exploring the links between trade, Standards and the WTO. (http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report05_e.pdf). Accessed 06/01/2011.

10 Appendix 2: Variability in the dataset

Variability in the dataset has to be considered in the estimation as a standard ordinary least square procedure may not accurately capture the potential endogeneity of the stock of Standards, where causality may run from productivity to Standards rather than from Standards to productivity.⁵⁸ Further, based on our estimation, patents do not have a statistically significant impact on total factor productivity. We therefore dropped patents and used Standards as a proxy variable for all other knowledge indicators in our subsequent estimations of the contribution of Standards to economic growth. We also attempted to consider endogeneity in the dataset by considering the growth trend in the stock of Standards and capital to labour productivity.

Figure 3 Annual growth in Standards and productivity, 1978-2009



To infer the long run impact of Standards on productivity, we then used co-integration analysis. Co-integration analysis ensures that the non-stationary characteristics of the data set are considered in order to avoid spurious correlation. This technique involves an error-correction mechanism (ECM) that allows for non-stationary characteristics to be corrected.⁵⁹

⁵⁸ DTI found that labour productivity growth in the United Kingdom had a positive and statistically significant correlation with Standards. Further, in line with theoretical expectations, this project found that causation appeared to run from Standards to labour productivity rather than vice-versa.

⁵⁹ Co-integration analysis provides a framework for estimation, inference, and interpretation when the variables are not covariance stationary (i.e. the mean and autocovariance do not change over time). The techniques begins with testing for unit roots using the Augmented-Dickey Fuller (ADF) test (test of stationary), differencing, determination of number of co-integrating relationship, and estimation of the co-integrating relationship using the Johansen procedure. Once the co-integrating relationship is estimated, the analysis continued with measures of autocorrelation (Langrage-multiplier test) and test of stability of the vector-error correction model.

This analysis determined whether the stock of Standards, labour productivity, and capital to labour ratio shared a long-run equilibrium relationship.

We hypothesized that there is a closer relationship between innovation and technological progress, and that Standards are a specific form of technology transfer, as suggested by Equation (3) in Section 6.4.1. That is, the growth rate of labour productivity is expressed in terms of technical progress growth and the capital to labour ratio. The test of co-integration suggests two co-integrating relationships exist among the stock of Standards, labour productivity, and the capital to labour ratio.

Table 4 General unrestricted specification of error-correction models

(1) Variable	(2) log (labour productivity)	(3) log (capital-labour ratio)	(4) log(stock of standards)
ECM1	-. 4181057* (.1949625)	1.043948 (.9445695)	.6808669 (.5270833)
ECM2	.0116205 (.020758)	-.2739546** (.1005702)	-.0367116 (.0561196)
Constant	.224049** (.007831)	-.0011244 (.0379403)	.0154823 (.0211712)
Δ Log (labour productivity) t_{-2}	.2438781 (.2113659)	.186581 (1.024042)	-.4846797 (.010247)
Δ Log (capital-labour ratio)	-.0158502 (.0367031)	.2242268 (.1778222)	.0379266 (.0992273)
Δ Log (stock of standards)	-.0007336 (.0759632)	.4435275 (.3680323)	-.1496187 (.1481515)
<i>Model diagnostics</i>			
Chi-square	24.4263**	41.09986**	32.85902**
RMSE	.01516	.073451	.040987
R2	0.5044**	0.6313**	0.5779**
Time period	1980 - 2009	1980 - 2009	1980 - 2009

Standard errors are in parenthesis

*Significant at 5% level

** Significant at 1% level

The results in Table 4 indicate that although Standards impact on labour productivity in the long-term, there is no short-term influence. Note, in column (2) of Table 4, the ECM is significant. But the lack of short-term impacts supports the theory that it may take some time for the benefits of Standards to positively impact on productivity through their dissemination and widespread use. Columns (3) and (4) further suggest that there are two co-integrating relationships, running from Standards to the capital-labour ratio, and Standards to labour productivity. These findings suggest a direct link to the drivers of total factor productivity.

11 Appendix 3: The BERL CGE Model

This model has its origins in the models developed by the Project on Economic Planning at Victoria University of Wellington in the early 1980s. Early applications of these models focussed on trade policy questions, with simulations of tariff removals and General Agreement on Tariffs and Trade (GATT) outcomes contributing to the “gains to free trade” argument prevalent at that time.

Originally based on the *ORANI* (Dixon *et al.*, 1982) model of the Australian economy, its structural framework is similar, arising from input-output relationships. Since the 1980s BERL has maintained and further enhanced the model, as well as applied it to investigate numerous issues.⁶⁰ The latest version of the core model is based on the official Statistics New Zealand 2002/03 input-output data updated by BERL to a 2009/10 base year.⁶¹ It includes 75 industries, 40 types of labour, and 25 types of exports.

This model can be used to simulate the effect of a policy, world price, world demand, productivity and/or behavioural shock and solves for the equilibrium outcome in a future snapshot year.⁶² Policy simulations or experiments can be undertaken within alternative macroeconomic environments. The assumptions adopted to enforce a particular macroeconomic closure should be interpreted as relevant *ceteris paribus* assumptions.

The detailed model structure closely follows Dixon *et al.* (1982) and is also noted in Poot *et al.* (1988). A summary of key elements is provided below.

11.1 Key model structure

Each industry produces a single output via a production function that requires a fixed combination of intermediate and primary factor inputs. At the secondary level, each intermediate input is a mixture of a domestically produced item and its imported equivalent. Producers can substitute between these two sources for each intermediate input in response to shifts in the relative price of each according to a CES⁶³ mixing function. Substitution

⁶⁰ Applications using a variant modelling the New Zealand and Australian economies is described in Nana and Poot (1996) and Nana *et al.* (1995).

⁶¹ March years.

⁶² A dynamic (or inter-temporal) version has also been developed (Nana, 2000), which enables the path of an economy over time to be modelled. Comparing a baseline path to one that incorporates the response to a shock(s) enables comparative dynamic (as opposed to comparative static) analysis to be undertaken. A key assumption within this framework is in incorporating cost(s) involved in the adjustment path as the economy moves towards its general equilibrium. In particular, there are costs (and limits) involved in redirecting investment from one industry to another. The static CGE model implicitly assumes costless transition over time – or that the snapshot year is sufficiently far in the future for these costs to be negligible.

⁶³ Constant Elasticity of Substitution.

elasticities are less than infinite to reflect, in part, the degree of aggregation as well as technological limits to such substitution. Similarly, the primary factor input comprises a CRESH⁶⁴ function, mixing 40 different types of labour and one physical capital resource.

Each industry's output is either sold to other industries for use as intermediate inputs, or sold to meet final demand agents. The classification of imports is such that the output of each domestic industry competes against one imported equivalent item, subject to the substitution elasticity noted above.

Final demand agents comprise other industries for the production of investment goods, domestic households for consumption, foreign demand for export and government.

Investment good production involves a similar CES mix of imported and domestic inputs. Aggregate investment is exogenous to the model, either as a fixed amount or as a set ratio to GDP. However, investment activity is allocated across industries endogenously, so as to equate expected rates of return.

Households allocate their income according to a LES⁶⁵ function across a consumption basket containing eight consumer categories. Again, within each of these categories, consumers can shift between domestically made items and their imported equivalents in response to relative price changes given the constraints of a CES function. Aggregate consumption is linked to household income, which is predominantly determined by employment income.

Government consumption demand is exogenous to the model, either at a set figure, or at a specified ratio of GDP.

Exports are modelled as facing a less than perfectly elastic demand curve. As such, foreigners demand more or less from New Zealand sources depending on the relative price competitiveness of New Zealand-made products *vis-à-vis* products from elsewhere. Differing elasticities amongst the commodities reflect, in part, aggregation as well as non-market barriers to the expansion of export sales. In general, New Zealand exporters of primary commodities such as dairy and meat face steeper demand curves than manufacturers and service exporters.

⁶⁴ Constant Ratio of Elasticity of Substitution Homothetic.

⁶⁵ Linear Expenditure System.

All work is done, and services rendered at the request of, and for the purposes of the client only. Neither BERL nor any of its employees accepts any responsibility on any grounds whatsoever, including negligence, to any other person.

While every effort is made by BERL to ensure that the information, opinions and forecasts provided to the client are accurate and reliable, BERL shall not be liable for any adverse consequences of the client's decisions made in reliance of any report provided by BERL, nor shall BERL be held to have given or implied any warranty as to whether any report provided by BERL will assist in the performance of the client's functions.