REPORT

CENTRE FOR INTERNATIONAL ECONOMICS

Standards and the economy

Prepared for

Standards Australia

Centre for International Economics
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Summary

This report

- This report provides an analysis, and where possible quantification, of the impact of standards on the Australian economy.

There are many diverse standards in use …

- There are around 6 800 standards associated with Standards Australia currently in use in Australia.
  - These are extremely diverse, ranging from electrical and water industry technical standards, to information technology standards, to mechanical engineering standards, to health and safety standards, to management related standards.
  - The stock of standards is constantly changing; around 80 per cent of standards currently published were introduced or modified in the past 10 years.

… forming part of the economy's information infrastructure …

- Standards are part of a range of institutions that contribute to the diffusion of useful knowledge. They can be seen as an effective means of collecting, embodying and disseminating ideas about how to perform various activities.
  - Standards can distil knowledge, provide a common language for discussion, underpin markets and help solve some externality problems.

… with a broad range of potential economic effects.

- Standards potentially have a variety of economic effects including increasing the scope for gains from trade, underpinning innovation and knowledge dissemination, reducing costs of production and increasing productivity, helping provide safety outcomes and assisting with risk management.

Macroeconomic data suggests some important relationships

- Examining standards at an aggregate level, using a statistical approach that tries to explain changes in economywide productivity, indicates that there is a relationship between the stock of standards and productivity.
  - If standards are specified as a separate variable, a 1 per cent increase in the stock of standards is associated with a 0.17 per cent increase in economywide productivity.
  - If standards are specified as contributing to the stock of knowledge jointly with R&D expenditure, then a 1 per cent increase in this joint stock of knowledge leads to a 0.12 per cent increase in economywide productivity.
  - There are many caveats to this type of analysis. It does indicate, however, that there are good arguments for viewing standards as part of the growth and dissemination of knowledge in the economy.

Case studies further indicate the effects of standards

- Four standards or groups of standards were examined as case studies in this report including:
  - sample standards in the mining industry;
  - standards in water and electrical industries; and
  - the risk management standard.
- Sampling standards in the mining industry increase accuracy and precision in the knowledge of the true mineral content of shipments of ores and concentrates.
  - This type of standard enhances trade, and we conservatively estimate that this generates benefits of between $24 million and $100 million per year.
- The variety of standards associated with the water and electrical industries have two broad effects
  - they increase the effectiveness of the water and electricity providers in using various inputs to their operations — that is, they help in establishing the networks; and

   - they increase the effectiveness of the water and electricity users in accessing the networks.
   - These effects combined are estimated to generate economywide benefits of around $1.9 billion per year.
- There are, of course, many caveats around these estimates, particularly the difficulty in imagining or estimating what would happen in the absence of standards.

There is considerable scope for more information

- There is considerable scope for further data collection to provide a basis for ongoing evaluation of the impact of standards on the economy.

1 *Introduction*

The range of documents, processes, committees and publications that constitute the world of ‘standards’ is both broad and diverse. Standards cover most areas of economic activity and come in a variety of forms with a variety of effects.

Although economic impacts are not necessarily the drivers of all standards, the resources devoted to the production of standards, and the ways in which standards change the behaviour of those that use them, are subject to them, or would like to improve them, will inevitably have economic effects.

Because standards — whether home grown and developed by Standards Australia or international and implemented through organisations such as the ISO — lie behind so many activities, separating the role of standards and measuring their impact is extremely difficult. On the one hand, the diversity of standards makes it difficult to sensibly aggregate them into a single measure; while, on the other hand, the economywide rather than the specific effect of standards may be the most important.

This report provides an attempt to draw out some of the key characteristics of standards and to provide a broad indication of the ways in which standards influence the economy. Chapter 2 provides an overview of the role of standards in the economy, the core ideas of which are further tested through economywide statistical analysis in chapter 3, and through the examination of a number of case studies in chapter 4. Chapter 5 provides some broad conclusions.

2 Standards and the economy

The broad landscape

The database on standards available from SAI Global and Standards Australia allows standards to be aggregated by broad field, as well as by the committee that is responsible for producing the standard. Chart 2.1 shows the number of Australian standards by broad field. The field definitions are those used by Standards Australia and SAI Global in compiling data on standards published and sales of standards.

The largest number of standards is in the electrotechnical field. These include a wide variety of standards for electrical equipment, wiring rules and so on. Many of these standards are relatively recent, or have been recently amended, although some go back as far as 1981. Within this field, the largest number of sales of standards (and related publications, between 2001 and 2005) was associated with the committee concerned with the wiring rules.

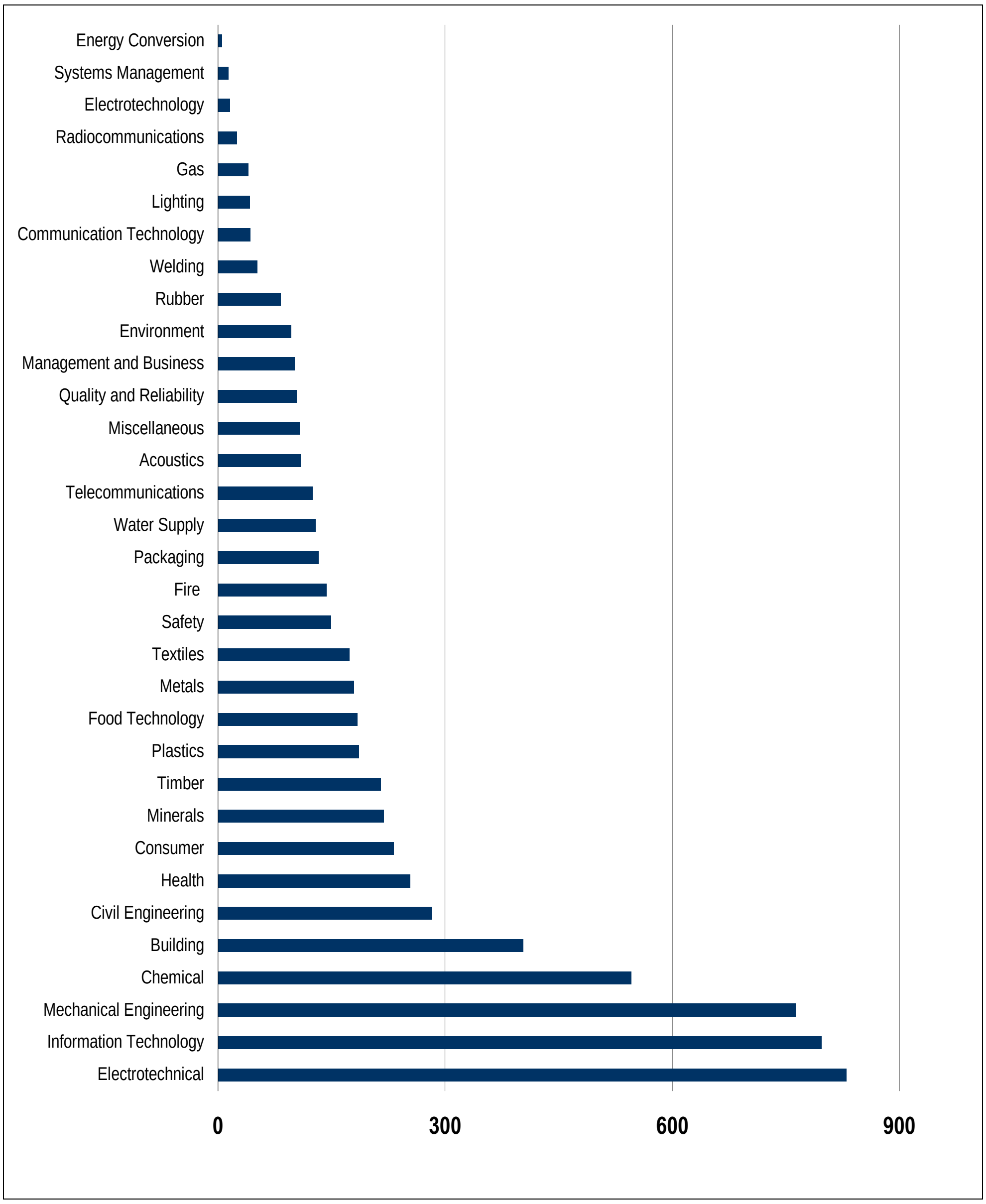
The next largest number of standards is in information technology. Again these standards are extraordinarily diverse and relate to a range of products within the IT industry. The age of these standards varies, although the majority have been published or modified within the past 10 years. Within this category, the largest number of standards (and related publications) is associated with the committee concerned with the interconnection of information systems.

The mechanical engineering standards (the third most numerous) are also extraordinarily diverse — ranging from screws and flanges to abrasives and gas cylinders. It also includes standards relating to silo designs and tractors. Within this category, the largest number of sales of standards (and related publications, between 2001 and 2005) are associated with committees concerned with ventilation and air conditioning and pressure equipment.

Health and consumer standards are the seventh and eighth most numerous and again cover a range of areas. Health standards include standards for dental and medical equipment, surgical materials, imaging, radiography and ultrasonics. Consumer standards cover helmets, filing cabinets, lawn mowers, exercise bikes and more.

Quite different to these product-based standards are the management and business standards, which include standards on engaging and contracting consultants, knowledge management, quality management and risk management. Within this category, the largest number of sales is associated with risk management.

2.1 **Standards by broad field**

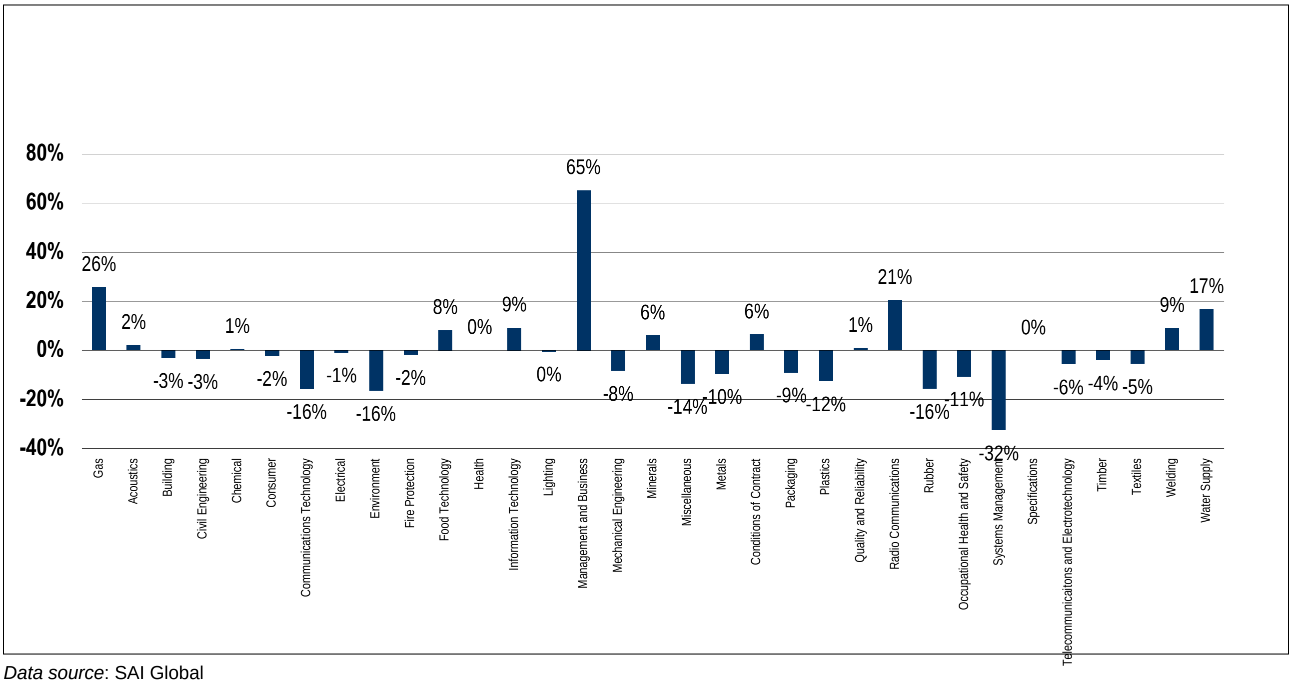


Data source: Standards Australia

Chart 2.2 provides a very broad indication of the changing ‘popularity’ of standards within various groups. It shows the change in the value of standards sales between 2001 and 2005. The strongest growth has been in the management and business standards, although there has also been strong growth in gas, radio communications and water supply standards.

Some care should be taken in interpreting these growth figures (for example, the growth in gas standards sales is partly the result of a transfer of standards from the Australian Gas Association to Standards Australia), but they serve to confirm the diverse nature of standards and their diverse patterns of use in Australia.

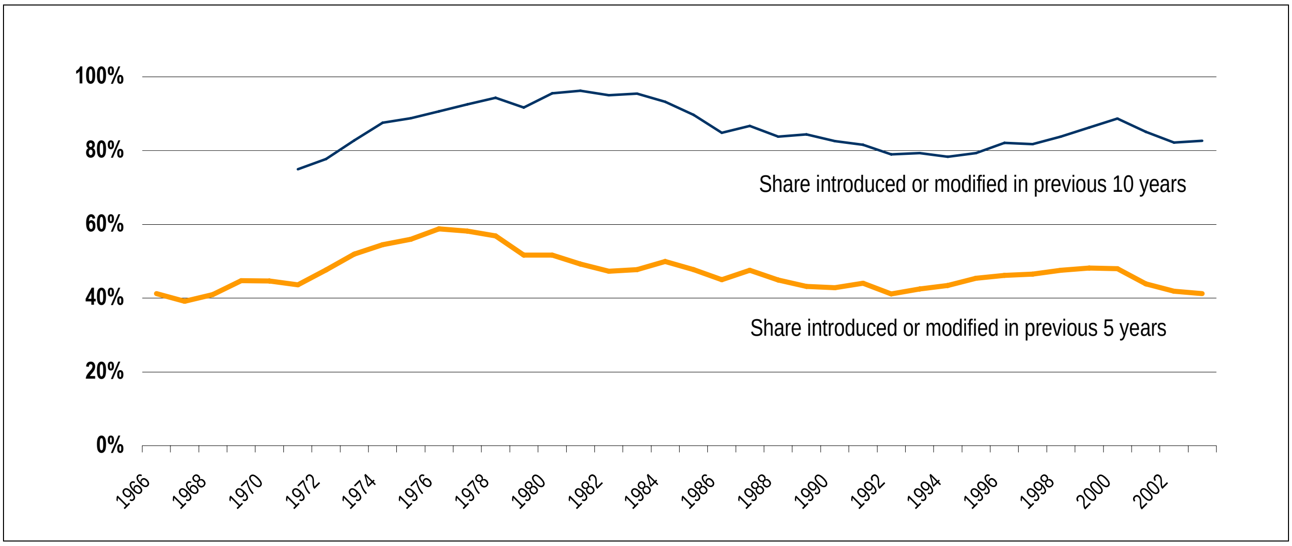
2.2 **Change in sales between 2001 and 2005**



Data source: SAI Global

Chart 2.3 illustrates the age profile of standards. It shows the proportion of the total stock of standards (at a given point in time) that were introduced or modified within the previous 5 or 10 years. The proportion introduced or modified in the previous 5 years has varied between 40 and 60 per cent, and is currently at 41 per cent. The proportion introduced or modified in the previous 10 years has varied between 75 and 96 per cent and is currently at 83 per cent. The entire stock of standards is turned over or modified roughly once every twelve years.

2.3 **Broad age profile of standards**



Data source: CIE estimates

What exactly is a standard?

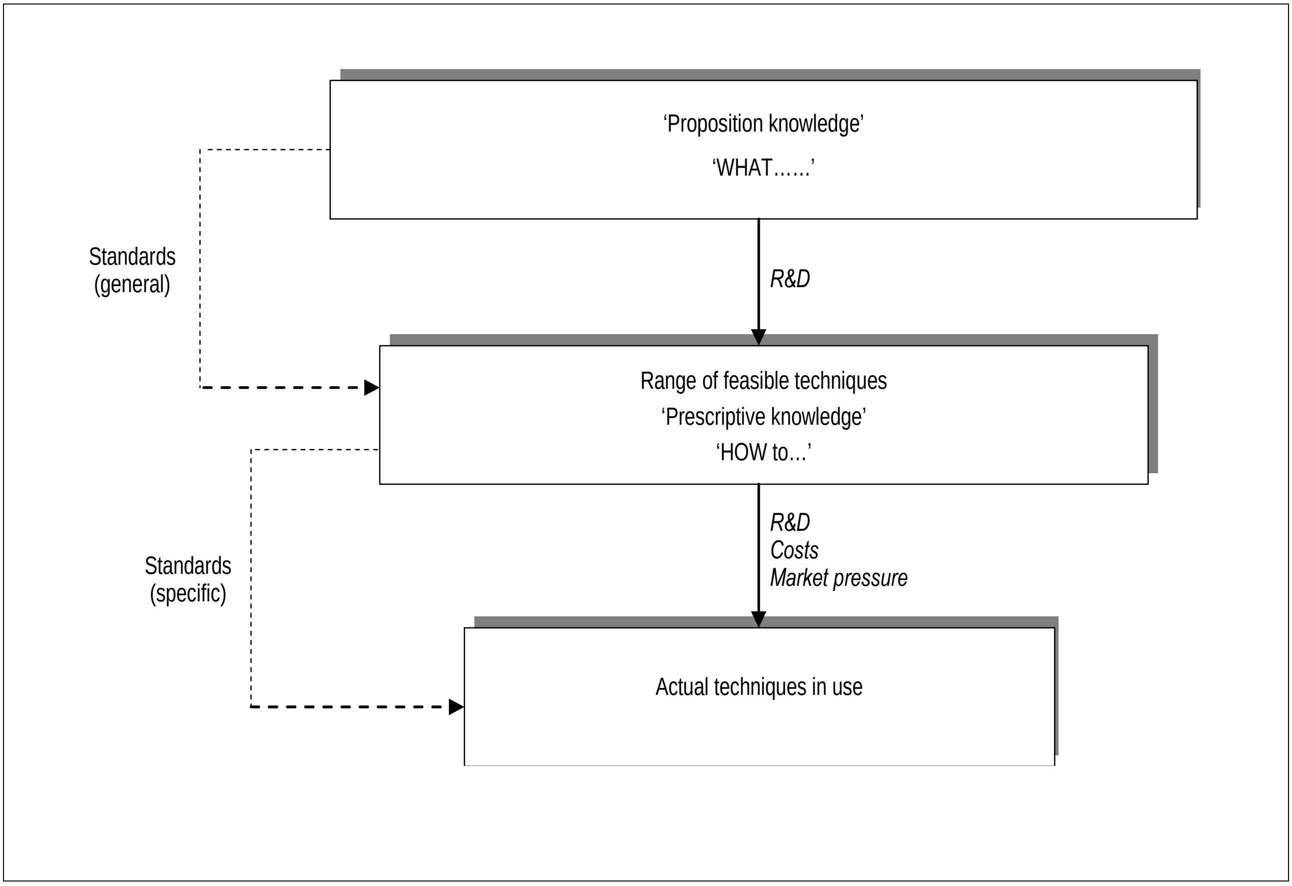
The definition of a standard used by Standards Australia is:

> … a published document which sets out specifications and procedures designed to ensure that a material, product, method or service is fit for its purpose and consistently performs in the way it was intended.

Within this definition, there is scope for a very wide range of content in the documents. Even a cursory examination of the 6 800 or so standards currently in place shows that they are extraordinarily diverse. Standards say many things to many different potential users. The users too are diverse — anywhere along the spectrum from consumers to producers.

A more general way of characterising a standard is to say that it is a statement of 'how to…'. What this means is illustrated in chart 2.1. Using the terminology of the historian Joel Mokyr (2002), knowledge can the thought of as two types: propositional knowledge (what) and prescriptive knowledge (how).

2.4 **Standards as prescriptive knowledge**



The full set of propositional knowledge (knowledge of the laws of physics, materials science, chemistry and so on) translates — through R&D, trial and error, experiment, practice and so on — into a set of feasible techniques, or knowledge *how to* do something. This feasible set of techniques in turn translates into the actual set of techniques in use, depending on a variety of factors such as market pressures, changing relative costs, consumer demands and so on.

Standards enter into the picture by being part of the transition from the 'what' to the 'how to…'. That is, a standard encodes within it knowledge about how to go about building things, or designing things for a purpose or how to behave in certain circumstances. For example:

- a product standard provides information on *how to* achieve a particular end with a product;
- a quality or design standard provides information on *how to* ensure that a product is adequate for a particular task;

- a compatibility standard provides information on *how to* ensure that components will fit together, or that users of different information can communicate;
- a safety standard provides information on *how to* ensure that a product (or process) really does reduce risk in the area intended or *how to* ensure that a product is associated with minimum risk if used as intended;
- a process or management standard provides information on *how to* go about particular activities such as *how to* calculate how profits are tracking (earned valued standard) or *how to* go about managing risks (the risk management standard); and
- a measurement or testing standard provides information on *how to* go about particular measuring activities in order to ensure that the results are meaningful and can be understood by the intended users.

The standard itself can convey knowledge in a 'prescriptive' way or in a more general and performance based way. In this context, 'prescriptive' standards are those that more tightly specify the actual technical details of the products or processes that are recommended. These types of standards convey a very specific form of 'how to' information, which is more like a 'must do' set of ideas. Prescriptive standards would tend to influence the actual techniques in use. Performance or more general standards provide information about what to look for when choosing a particular technique, and provide 'how to' guidelines that can be more flexibly applied in a variety of circumstances.

Distilling knowledge

The process of writing a standard — engaging committee members, preparing drafts, coming to consensus (in the approach that Standards Australia uses) is a process of distilling a variety of knowledge and practical experience into a document or set of documents that can be used and understood.

This process is a form of information diffusion and, given the resources involved developing standards, is likely to be a significant part of the many diffusion processes taking place within the economy.

The case study on mineral sampling standards presented in chapter 4 is an example of how standards can be used to diffuse sound scientific knowledge into particular areas of economic activity.

Standards as a language

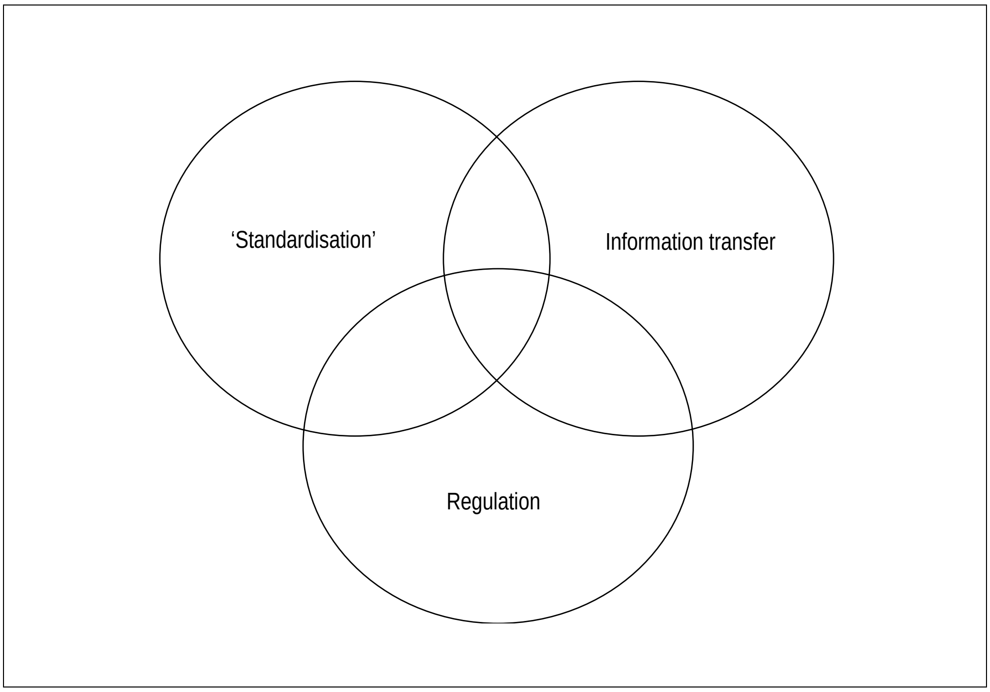
Communication, particularly the communication of complex ideas, requires a common terminology, or language. A language, once established, opens many possibilities for building on what is already known. Some standards — particularly management and measurement related standards — provide a common language to communicate key ideas.

The risk management standard examined in chapter 4 is an example of a standard that provides a common language — in this case a common language surrounding ideas of risk and how to manage that risk. In many markets — such as risk markets — the establishment of a common language can assist in allowing that market to expand and become more efficient.

Other dimensions of standards

Standards are not always viewed as primarily informational devices, particularly as standards are often associated with the process of 'standardisation' and regulation. Chart 2.5 illustrates that these other dimensions of standards may overlap with the information dimension, but they do not alone capture the full picture.

2.5 **Overlapping roles of standards**



While standards are often associated with 'standardisation', it is possible to have standards without standardisation emerging: it depends entirely on the nature of the standard. To the extent that standards focus on approaches or processes (that is, to the extent to which they are performance based) they will not necessarily lead to any standardisation at all. Indeed, by providing a common basis for some activities (such as in the case of the risk management standard), standards may in fact lead to increased diversity in outcomes.

Some standards, but not all, are imposed by regulation[1]. When a standard is made compulsory in this sense, its nature may change again. Whereas a voluntary standard may be changed at will, once placed in regulation a standard becomes considerably less flexible. In this case, the value of the standard depends on the integrity of the regulatory process and the ability of that process to adequately weigh the benefits and costs of the regulation.

Even the standardisation and regulation aspects of standards are ultimately based on the 'how to..' information provided by the standard itself.

The demand for standards

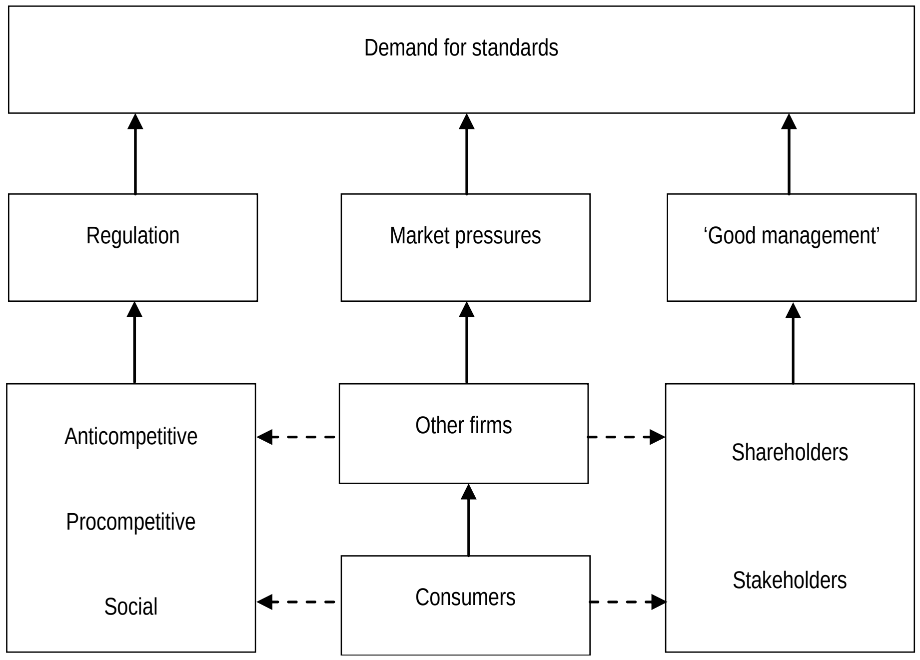
The demand for standards arises from a number of different sources as illustrated in chart 2.6.

As noted, some demand for standards arises as a result of regulation. Regulation itself comes in a variety of forms and standards may be regulated for a variety of reasons. Increasingly, the most common regulation of standards arises for social reasons, in particular safety and health related reasons. In the past, much Australian regulation has tended to be anticompetitive — that is providing an advantage to particular incumbents — however, regulation that affects competition is currently more likely to be procompetitive.

Demand for use of a particular standard (perhaps a product or design standard) may also arise as a result of market competition, or of processes that arise from various market pressures. Standards may also be a way of allowing markets to solve particular externality or public good problems.

1 Approximately one third of all Australian Standards have become mandatory under government legislation (Productivity Commission 2006, p.3).

2.6 The demand for standards



A common example of this is the 'network' externalities that arise when different devices (phones, faxes, DVDs etc) need to be able to communicate either with each other or with the media they are based on. In the absence of a standard, the scope for benefits from the products is considerably reduced (there is little point in 20 people having fax machines that can't communicate with each other). There is clearly a market imperative for such an externality to be resolved, as resolving it can increase the value that can be accessed by all producers. A standard can provide the means to resolve this. Whether the standard that does so must be regulated or imposed in some way is an important question, and there are mixed views on this issue.

Standards can be used to help resolve underlying uncertainties within markets that may limit the scope for gains from trade. For example, the mineral sampling standards (see chapter 4), by providing more precision regarding the mineral content of ores, have the effect of increasing confidence of both buyers and sellers.

Standards can also be used to underpin particular aspects of regulated markets. An efficient form of regulation for some issues may be to create a market to address the problem. For example, the greenhouse gas abatement scheme established in NSW is a mandatory emissions trading scheme. The trades established in this market are, at least partly, underpinned by *AS 4978.1 2002: Carbon accounting for greenhouse sinks — afforestation and reforestation*.

Demand for standards, in particular management standards, may arise through the need for good governance and management within an organisation, or within an industry grouping. This may ultimately come from competition or through the demands of various stakeholders (shareholders, customers).

The demand for standards may also arise through the demands of professionals (for example, engineers, designers and so on) working in particular organisations. Particular standards may make the work of these groups more cost effective (and rewarding) leading to a demand from them for standards in some areas.

The supply of standards

Worldwide, there are many standard setting organisations, ranging from the well known ISO, to the less well known ITU (International Telecommunications Union) and NIST (National Institute for Standards and Technology, US).

In Australia, the standards infrastructure arises through the interactions of a number of key organisations including Standards Australia, the National Associating of Testing Authorities (NATA), JAS-ANZ (the Joint Accreditation System of Australia and New Zealand), the National Measurement Institute, and various other standards writing and accreditation boards.

The process Standards Australia applies to the development of new standards is as follows:

- ***Request***. Standards Australia does not instigate the development of new standards but responds to requests from industry, consumers and government.
- ***Approval***. Standards Australia having received a request, the need and support for a new standard is reviewed. This review assesses whether the new standard will be of benefit to the community as a whole.
- ***Technical Committee***. When the new standard is approved for development a technical committee is formed. This committee is diverse in membership and consists of representatives from industry,

consumer groups, government, and so forth. The majority of members are unpaid and volunteer their time and resources. Aside from appointing a project manager to be the committee secretary, Standards Australia restricts its role to facilitating the development of the standard and does not actively take part in the decisions the committee makes.

- ***Draft***. This is the first stage in the actual writing of the standard. At this stage the committee must ensure that the standard is not a technical barrier to trade, does not stifle innovation or competition and generally complies with other laws and regulations already in place.[2] The committee works to achieve consensus in the group and, once a draft is ready, it is made available for public scrutiny and comment.
- ***Ballot***. Once all public comments have been considered and, if necessary, revisions incorporated, a ballot is held. Consensus is deemed to have been achieved if 67% of those eligible to vote have voted affirmatively and 80% of the total votes received are affirmative. There is also the requirement that no party with a major interest in the subject of the standard has voted in the negative.

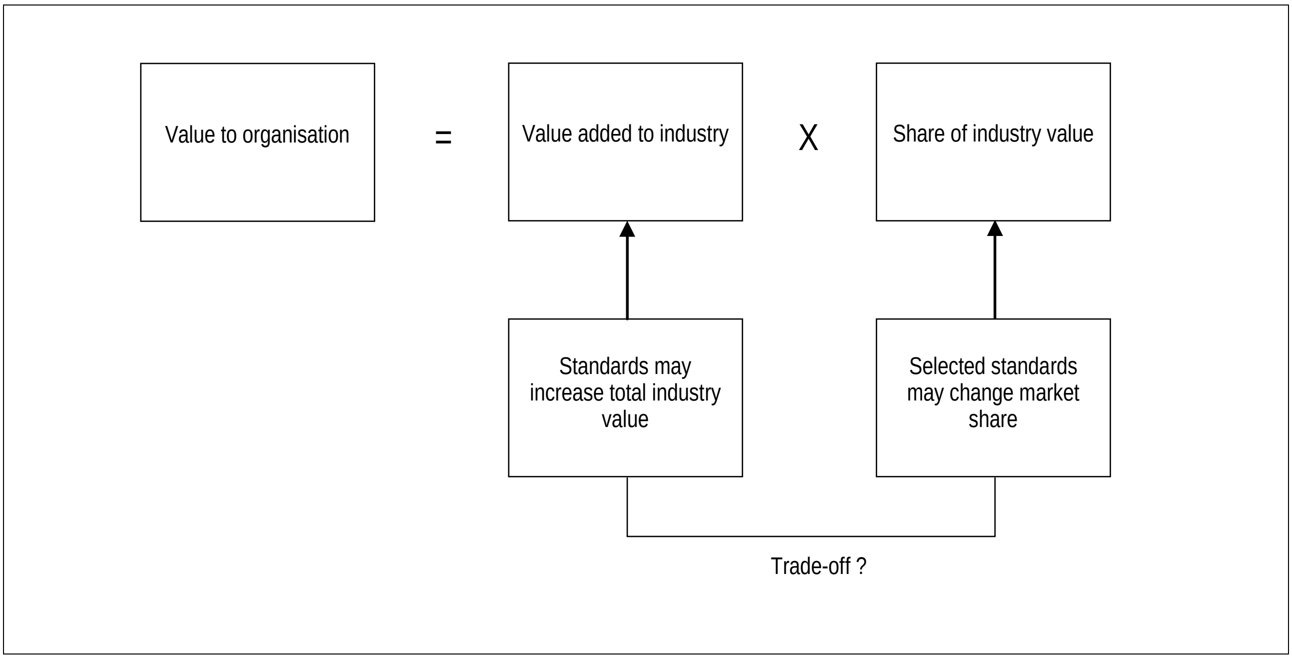
Two features in the writing of standards under this process are the facts that:

- the process draws on a wide range of expertise; and
- committee members volunteer their time (or are provided to the process by their employer).

Chart 2.7 illustrates some of the potential tradeoffs involved in organisations volunteering resources to standards development. The value to the organisation of the new standard will depend on the value that the standard adds to the whole industry and the share that that organisation has of that industry's value. Organisations will presumably be interested in maximising both of these, although there is a potential trade-off between the effort involved in increasing value to the industry, and effort put into increasing market share.

2 It is important to note that Standards Australia does not write standards specifically for law making purposes. However, it considers the use of standards in legislation and as such takes care to use terms which avoid ambiguity.

2.7 **The value of setting standards**



The benefits of standards

How does the 'how to…' knowledge encoded within a standard provide economic benefits? There are a range of possibilities, depending on the type of standard and the industry or activity that it is involved with.

Table 2.8 summarises some of the broad possibilities based on some of the typical classifications of standards. Particular aspects of these are examined in more detail below.

2.8 **Types of standards and their benefits**

Compatibility / Interface	***Minimum Quality / Safety***
Promotion of trade	Promotion of trade
Increased consumer confidence	Increased consumer confidence
Lowering of search costs	Lowering of search costs
Better knowledge dissemination	Better knowledge dissemination
Legislation	Legislation
Higher market place efficiency	
Network externalities	
Variety Reduction / Focussing Devices	***Information / Measurement***
Lowering of search costs	Promotion of trade
Higher market place efficiency	Increased consumer confidence
	Lowering of search costs
	Better knowledge dissemination
	Higher market place efficiency

Information diffusion and innovation

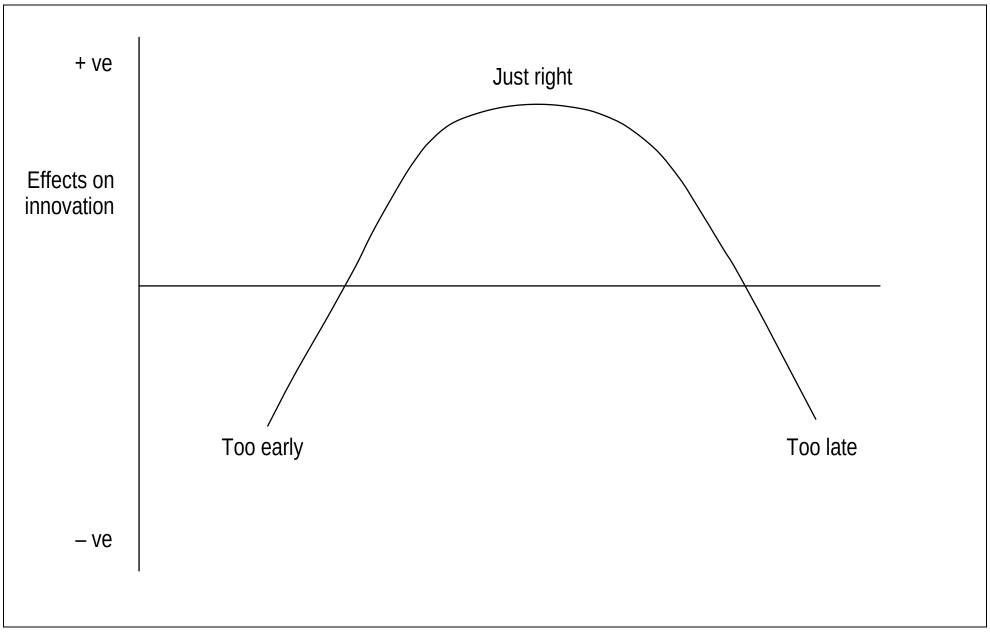
Research and development, an important component of any modern economy, is of little use if the ideas and discoveries that result are not diffused and used and if they can't provide a basis for future innovation.

Standards, if they are timely and appropriately based, can directly contribute to the diffusion of ideas, and can provide a means by which new ideas are embodied in products or processes. Chapter 3 below considers this aspect of standards in more detail.

As chart 2.9 illustrates, the effect of standards on innovation may depend on the timing of the standard. If a particular product or technical standard is imposed too early in the process of developing a new product, then the effect on innovation may be negative. On the other hand, a standard that comes along too late may result in unnecessary costs of duplication or 'lock in' to technologies that were not the most efficient, and potentially detrimental to innovation.

There is clearly a balancing act in the effect of standards on innovation, and where this balance emerges will depend on the particulars of the case. This balance will be significantly influenced by whether the standards are prescriptive or performance based. Narrow and prescriptive standards are much less likely to be conducive to innovation, particularly in markets with rapid technical change.

2.9 **Standards and innovation**



Standards may also help innovation by providing an essential platform on which new technologies, processes and so on can build. Recent work on innovation and economic growth by the economist William Baumol (2002) suggests that the significant rate of innovation in modern economies emerges from the ability of firms to 'routinize' innovation. Rather than random once-off innovations, modern economies are able to produce continual and routine innovations in doing things better and more efficiently[3].

Routinization may itself be, at least partly, the result of firms being able to build on existing standards in products and processes. In developing, for example, a design for a new product or process, it is likely to be extremely beneficial to be able to build on standard components in developing that design.

[3] This process of routine and continual development is captured by Petroski (1996), who shows the steady increments in design for some commonly used products.

Cost of production and productivity

The costs of production effects of standards are potentially significant. For processes that are routine, the use of a standard, predictable component may lower overall costs of production.

As an analogy, consider the current document, which was prepared using a template that defines the way in which fonts, paragraphs, charts and tables are prepared and enter into the document. Such a template significantly lowers the cost of preparing a document, as the elements are predefined and do not need to be developed time and time again.

This effect is evident in the water and electricity standards examined in chapter 4. These standards allow lower costs than would otherwise have been the case.

Standards can also lower production costs by providing an efficient means of communicating particular ideas within an organisation. For example, the various management standards (quality management, risk management, earned value and so on) can be seen as an efficient 'primer' on a particular subject and so can reduce the cost of spreading particular ideas within an organisation.

Safety outcomes and risk management

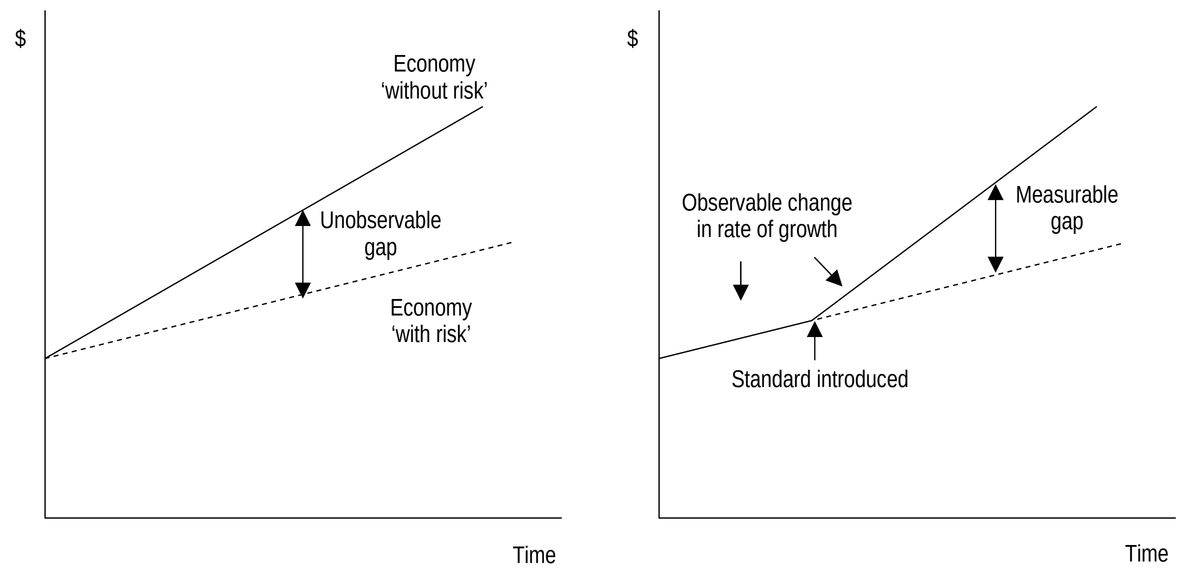
Many standards are designed not with specific economic outcomes in mind, but with increasing safety or managing risk. To the extent that accidents or risks lead to economic costs, these standards will have an economic impact, although this impact may be extremely hard to measure.

Chart 2.10 illustrates the measurement problem. The left panel shows two alternative states of the economy — with and without risk (or with and without accidents). The lines could represent the evolution of GDP or some other measure of economic activity. If the standard is successful in reducing risk, then the economy will move along the solid line, rather than the dotted line. It will have higher GDP than otherwise, but this difference will not be directly observable because the dotted line is something that *didn't actually happen*, and the fact that it didn't was a result of the standard[4].

[4] This is not meant to imply that the standard by itself can eliminate risk, but to illustrate the point.

An alternative situation is illustrated in the right panel of chart 2.10. The economy may be moving along a particular path, perhaps suffering from many safety issues, but after the introduction of the standard, there is a measurable increase in the growth rate of the economy[5]. In this case it may be possible to measure the gap between what would have continued to happen in the absence of the standard compared with what actually happened with the standard in place. This increased growth rate may be associated with higher productivity, which is examined further in chapter 3.

2.10 **Measuring safety and risk benefits of standards**



Network externalities

As noted above, the existence of network externalities may be a significant driver for the development of standards, and so may also be a major source of benefits. Interconnection standards of various kinds (whether physical or virtual) allow more people to join a particular network without threatening the integrity of the network, and therefore increase the value of the network to all users.

[5] Actually measuring such an increase poses a significant empirical problem, but the principle remains.

The nature of these externalities means that they need to be measured and evaluated at an aggregate level, as the gains to any individual user will not capture the full extent of the benefit.

At the economywide level, capturing network externalities may appear as an aggregate productivity increase. This is examined further in chapter 3. In some cases, such as water and electricity networks, these gains may be within the network but transmitted through the rest of the economy through costs savings. This is examined further in chapter 4.

The costs of standards

Standards, of course, do not come for free. Significant resources must be devoted to developing them and there may be significant tradeoffs in the ways in which standards lead to behavioural changes. While the time devoted to standards committees and so on is volunteered, it is still a cost to the economy as those individuals could have been doing something else.

Further, to the extent that standards are inappropriately regulated — perhaps by being too prescriptive — they may in fact impose costs on the economy. A lot of Australia’s microeconomic reform throughout the 1980s can in part be seen as a process of eliminating overly restrictive standards of various kinds.

There may also be unexpected tradeoffs that emerge from the behavioural effects of particular standards.

3 Macro evidence

Background — standards and growth theory

In recent analyses of the causes of economic growth, there is increasing recognition of the role of knowledge of various kinds as a major driver of productivity growth, which is in turn a major driver of economic growth.[6]

Given that in many ways standards can be seen as a form of knowledge, and in particular as a way of disseminating knowledge, it is natural to consider analysing the effect of standards within the framework of growth theory. Indeed, as noted above, many of the effects of standards may only be visible at an aggregate level and may ultimately emerge as improved economywide productivity.

Analysing standards within the framework of growth theory brings both benefits and significant challenges. On the benefits side, such analysis if successful would allow standards to be compared with other forms of knowledge growth (for example R&D) as well as providing an indication of the contribution that standards make to economic growth. This is the approach recently taken by DTI in their 2005 publication *The Empirical Economics of Standards*.

There are, however, significant challenges in undertaking such analysis. First, empirical applications of growth theory are very mixed in their results. The estimated effects of various drivers depend very much on the data sets used and on the specification of the models estimated. Recent work at the Productivity Commission (Shanks and Zheng, 2006) shows how extensive this challenge can be.

The major reason for this difficulty is statistical. The empirics of growth theory mean trying to discern causal relationships between variables that have a strong underlying trend. The always present risk is that various spurious correlations are likely to emerge, and while there are means of testing for these, the tests are not themselves particularly powerful.

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[6] A recent history of economic thinking in this area can be found in Warsh (2006).

This problem is further compounded by the fact that it is very difficult to obtain empirical measures that correspond to the theoretical notions of growth theory. Constructing a knowledge index, for example, poses many difficulties. This problem is particularly acute in the case of standards, where the main data available on a time series basis is simply the number of standards published at a particular point in time.

Nevertheless, this chapter reports the results of analysis that attempts to add standards into a typical growth theory framework.

The basic approach

Economic growth (the increase in GDP or GDP per person over time) depends upon both the use of various factors of production (land, labour, capital) and the efficiency with which these various factors are used.

Growth will increase if we use more labour, more land and more capital. But, within any economy, there is a limit to the extent to which these factors can be increased.

Growth will also increase if productivity, the efficiency with which the various factors of production are used, increases. Total factor productivity (TFP, sometimes called multifactor productivity or MFP) is a measure of how much is produced for a given level of total factor use. An increase in TFP means we get more for a given set of resources.

One aspect of growth theory involves considering the relative importance of the use of factors versus TFP changes in generating output increases. Studies generally find that TFP is a significant contributor to economic growth.

Another aspect of growth theory is to consider the importance of various factors that determine the rate of TFP growth itself. These factors include R&D, education, trade, foreign R&D and, potentially, standards.

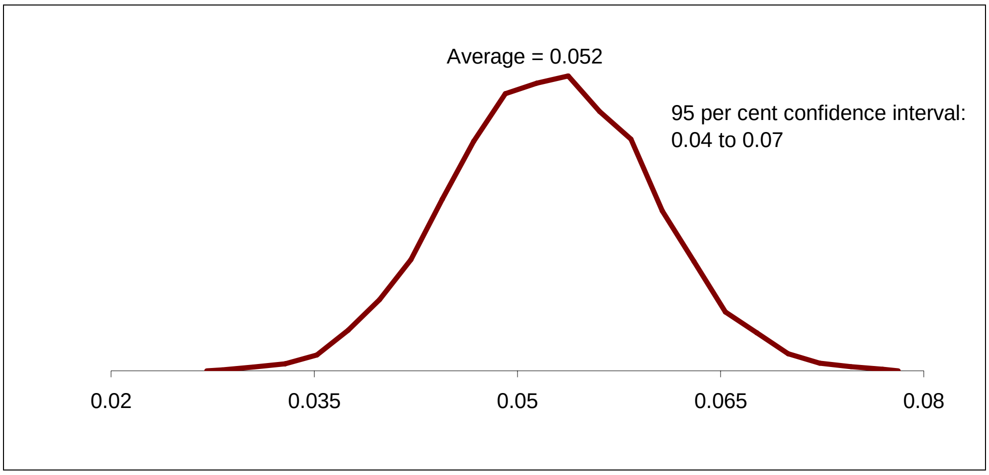
There are a number of ways in which the underlying equations of growth theory can be expressed and then empirically estimated. In the study undertaken by DTI, labour productivity was considered to be a function of the ratio of capital to labour and the stock of standards. DTI found significant positive results from this analysis. However, adopting this approach for Australia did not yield significant or positive results.

An alternative approach, reported here and used recently by the Productivity Commission, is to use TFP as the dependent variable and to attempt to explain it with a range of determining variables. The most common of these is R&D, or more correctly, the estimated stock of knowledge emerging from R&D spending.

Range of results for Australia

There is a broad range of estimates of the relationship between R&D stock and total factor productivity. Chart 3.1 illustrates the probability distribution of the estimates derived from recent work at the Productivity Commission.

3.1 **Impact of R&D knowledge stock on total factor productivity** [a] Elasticities



[a] This distribution is from a meta-analysis of various equations, the coefficients of which are given equal weight. The estimating equations underlying these results are of the form ln(TFP) = a + b.ln(R&D stock) + c.ln(other variables); where TFP is total factor productivity.

Data source: CIE estimates based on results in Shanks and Zheng (2006)

These results show, for example, that on average, a one per cent increase in the stock of R&D was found to lead to a 0.05 per cent increase in the economywide TFP. The estimates of this elasticity ranged from 0.04 to 0.07 depending on the model specification used.

As Shanks and Zheng (2006) point out, these results should be treated with some caution as there are many, many unresolved issues in estimating them. However, they do provide something of a benchmark against which to judge the results of our analysis of the effect of standards.

The standards data

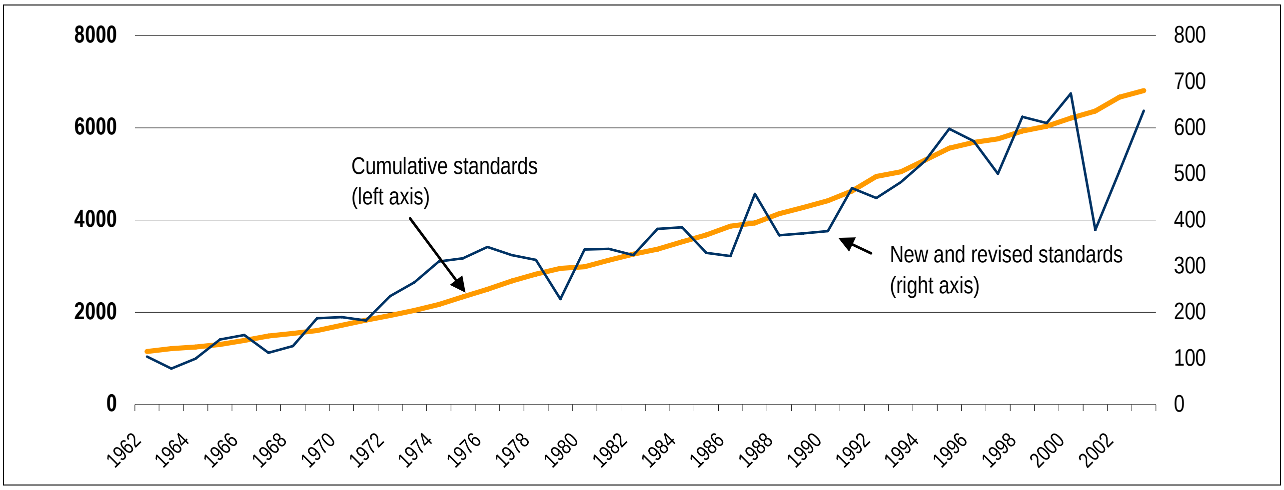
There are two historical data series available for Australian standards:

- the annual number of new and revised standards published each year; and
- the total stock of current standards.

The data used here are from 1962 to 2003. There are some gaps in the series in early years (particularly for the stock of standards), but it is possible to fill these gaps using some basic stock-flow accounting[7].

Chart 3.2 shows the cumulative stock of standards and the number of standards published in each year. Both of these have increased steadily, although there are some notable periods of acceleration and deceleration in the publication of new and revised standards.

3.2 **The number of standards**

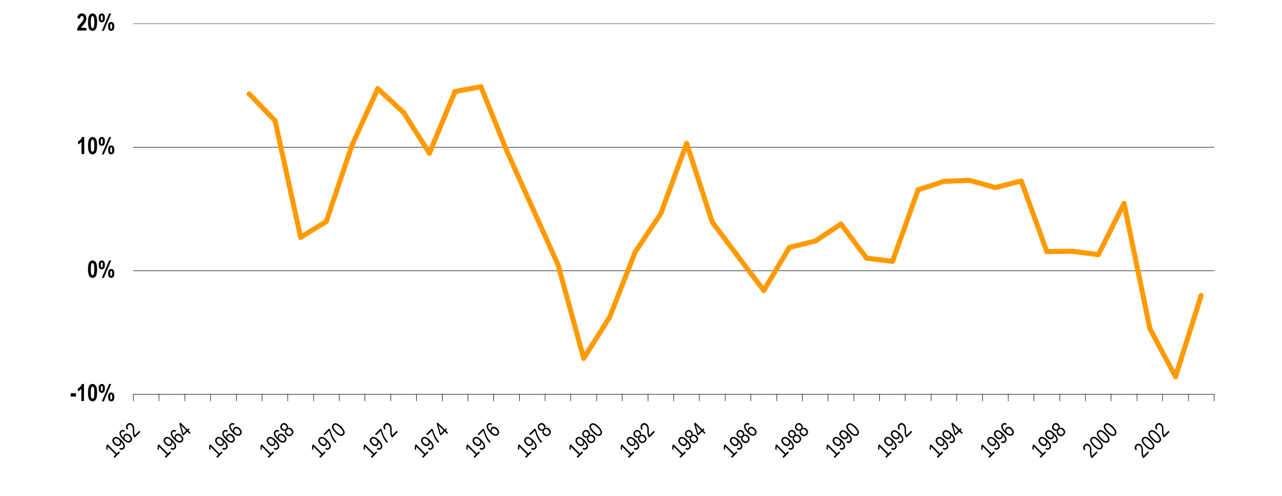


Data source: CIE estimates based on data from Standards Australia and SAI Global

Chart 3.3 shows the five year moving average of the change in the number of new or revised standards, and indicates that the late 1960s and early 1970s were times of high growth, as were the mid to late 1990s.

[7] For example, the current stock of standards is equal to last year's stock plus additions and minus removals. With some very mild assumptions we can use this relationship to fill in the gaps in the series.

3.3 **Five year moving average growth of new and modified standards**

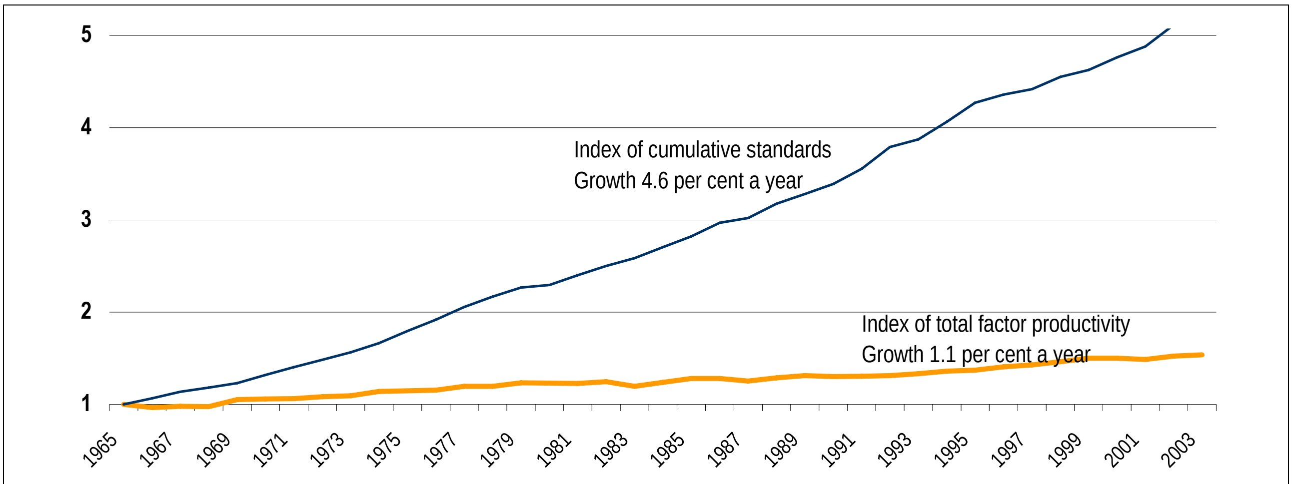


Data source: CIE estimates

Standards and productivity

Chart 3.4 shows an index of the stock of standards along with an index of total factor productivity for the economy. Both are clearly increasing, although the stock of standards is growing considerably faster than total factor productivity.

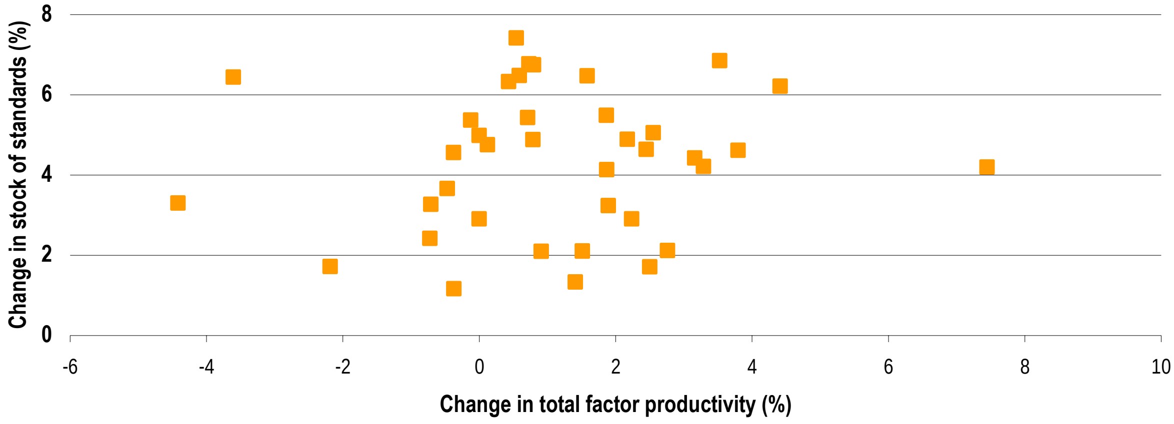
3.4 **Indexes of standards and productivity growth**



Data source: ABS, CIE estimates based on data from Standards Australia and SAI Global

Chart 3.5 shows the relationship between the annual change in standards and the annual change in total factor productivity. There is no direct relationship here, and statistical tests suggest that it is not sensible to relate these two variables alone.

3.5 Change in standards versus change in productivity



Data source: CIE estimates

Incorporating standards in the growth equations

There are two ways of incorporating standards into the typical growth equations. One is to treat standards as a separate stock of knowledge, and to incorporate this as a separate variable in the growth equations, alongside the stock of knowledge defined by R&D.

The second approach is to treat standards as a variable which helps define the stock of knowledge in the economy and interacts with other variables such as R&D. Under this approach, a new stock of knowledge determined by R&D growth and standards growth together is used in the estimating equations.

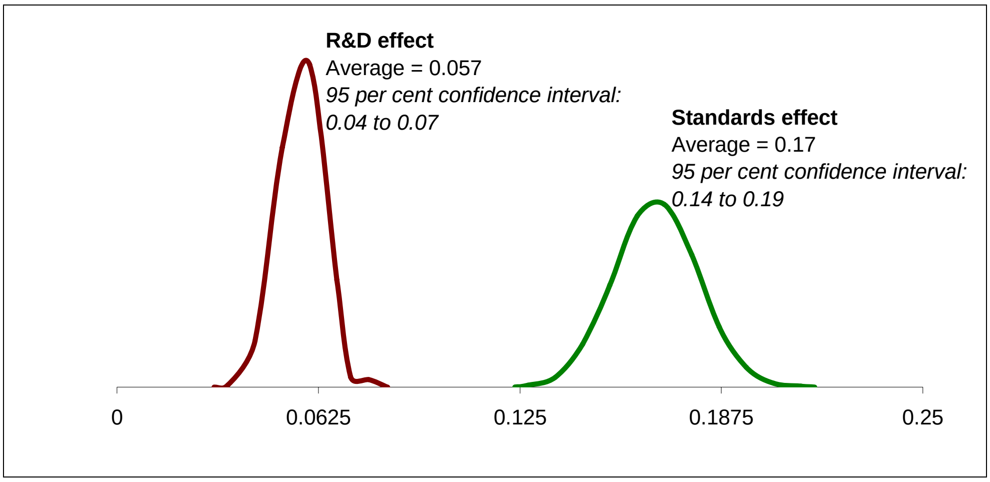
Putting standards alongside R&D

Chart 3.6 summarises the results of a number of estimating equations that relate TFP to the change in the stock of R&D, and various definitions of the stock of standards. The results indicate that:

- a one percent increase in the stock of R&D leads to, on average, a 0.057 per cent increase in TFP. This is very similar to the Shanks and Zheng (2006) results; and
- a one per cent increase in the stock of standards leads to a 0.17 per cent increase in the level of TFP. This estimate ranges from 0.14 to 0.19,

which does not intersect with the range for the R&D estimate, indicating that they are significantly different.

3.6 **R&D and standards effect on TFP:** Range of elasticity estimates [a]



[a] Summary based on four estimating equations: ln(TFP) = a + b.ln(R&D Stock) + c. ln(Standards stock). The equations have slight variations in the definition of the stock of standards and in the inclusion of foreign R&D variables. The R^2 for the estimating equations are 0.97, t statistics for the R&D variable range from 3 to 5.5 and t statistics for the standards variable range from 4.8 to 12.7. The variables appear to be cointegrated. See appendix for more details.

Data source: CIE estimates

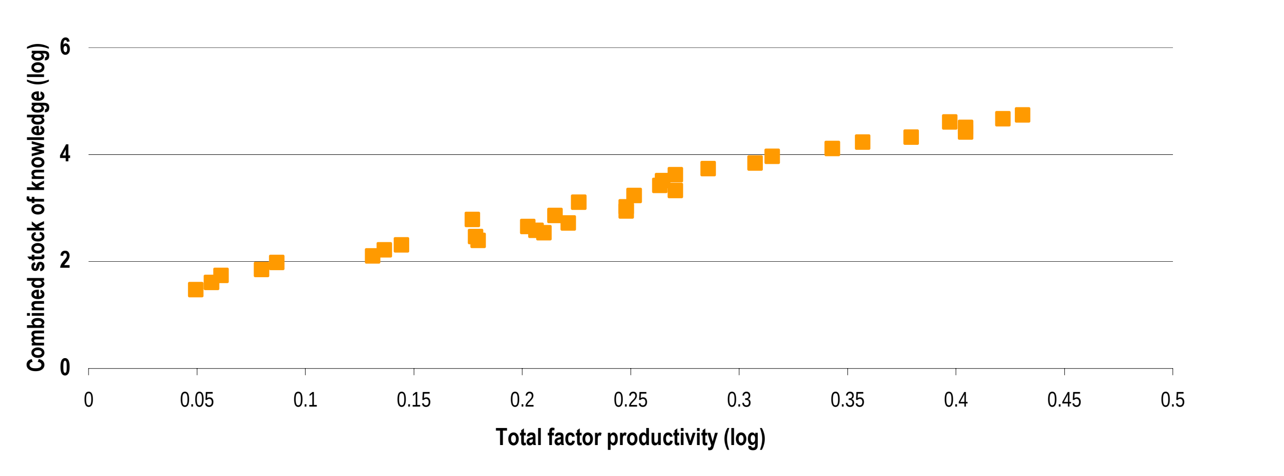
The statistical performance of these estimates appears acceptable, at least as acceptable as any other estimations of this kind. Nevertheless, there is still a risk that these estimates are spurious, which should be kept in mind in the interpretation discussion below.

Combining standards and R&D into a single knowledge stock

The second approach is to experiment with combining both R&D expenditure and the development of new or modified standards to form a single combined index of the stock of knowledge.

Chart 3.7 shows the relationship between this combined stock of knowledge and the index of total factor productivity (both expressed in logs). The chart indicates that there is a strong positive relationship.

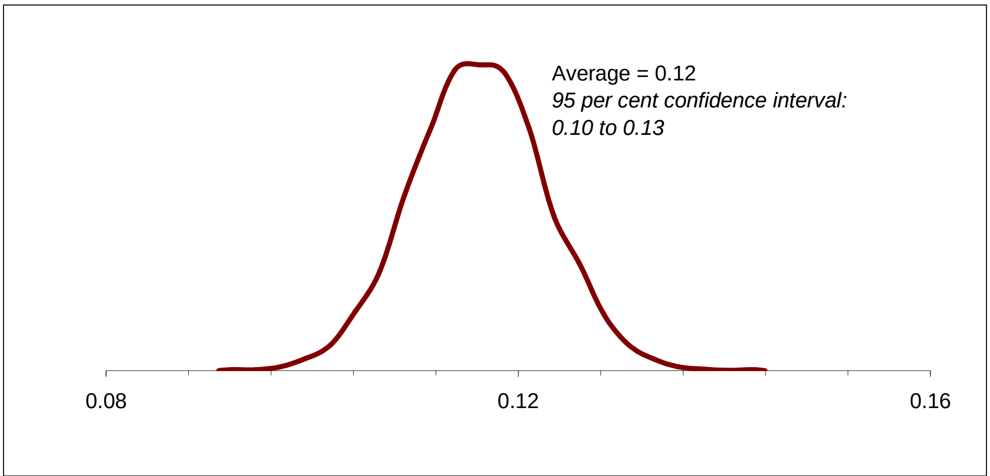
3.7 TFP and combined stock of knowledge



Data source: CIE estimates

Chart 3.8 summarises the results of estimating equations incorporating the combined stock of knowledge variable. The results show that, on average, a one per cent increase in the combined stock of knowledge (standards and R&D) leads to a 0.12 per cent increase in total factor productivity. The 95 per cent confidence interval is from 0.10 to 0.13, which indicates that this elasticity is fairly precisely estimated.

3.8 Combined R&D and standards knowledge stock effect on TFP [a]



[a] Summary based on six estimating equations ln(TPF) = a + b.ln(Combined stock). There are differences in the definition of the combined stock and the inclusion of foreign R&D between the equations. The R^2 for the equations are around 0.98. The t statistic for the stock variable ranges from 5.18 to 36.0. The variables appear to be cointegrated. See appendix for details.

Data source: CIE estimates

Implications and caveats

Several points emerge from the results presented here.

- There is apparently a positive relationship between economywide total factor productivity and the stock of standards, either when this is kept as a separate variable, or combined with a stock of R&D variable.
- This relationship is of an economically significant magnitude.
- These results are consistent with the idea that standards act as a means of diffusing or embodying knowledge.
- The various estimating equations perform relatively well at a statistical level, certainly as well as other similar equations in the growth literature.
- In the detailed estimates (reported in the appendix), there is an interesting interaction between the stock of standards and the stock of *foreign* R&D. These variables appear to play a similar role, or to be related to a similar but unobserved third variable.

At the same time these results should be treated with a great deal of caution.

- It is difficult to be completely confident in the statistical properties of the estimates generated here. It remains possible that the estimates are not in fact meaningful — although this conclusion would need to be applied to all estimates of this kind.
- Importantly, the standards variable used here is simply the cumulative stock of standards, or in some cases the total number of new or modified standards published in a given year. While this broad variable should be related to the knowledge content of standards, there is no guarantee that this is so. Even if it is, it is a crude measure as there are clear differences between particular individual standards and potentially large differences in their significance.

4 *Micro evidence*

This chapter presents case studies of four groups of standards in order to further illustrate the ways in which standards have economic effects and where possible to quantify the magnitude of the effects. Case studies provide an alternative to the broad macroeconomic analysis presented in the previous chapter as a way of examining the impact of standards. The challenge with case studies, however, is that because of the diversity of standards, it is very difficult to construct case studies that are representative of all standards.

The case studies presented here were chosen not in order to be representative, but in order to illustrate particular aspects of the economic effects of standards. These aspects can be summarised as follows.

- The standards around sample preparation procedures in mining illustrate the ways in which standards can be used to disseminate sound scientific knowledge and principles. These standards also illustrate the role that Australia can play in international standard setting in a way that increases the scope for gains from trade.
- The various standards in the water and electrical industries illustrate the ways in which standards can enhance the productivity of particular activities. Given the importance of both these industries in the economy, these cases also illustrate the ways in which the effects of standards can be transmitted throughout the economy.
- The risk management standard, one of the best selling Australian Standards, also illustrates the way in which standards can be used to collate and transmit valuable information.

At the level of individual standards, or groups of standards, a significant difficulty in estimating economic effects is in constructing estimates of what would happen without the standard. This 'counterfactual' can never be directly observed, and must be imputed — often subjectively — through general knowledge of the operations of a particular industry.

Sample preparation procedures in mining

Contracts for the sale of minerals, and in some cases metallurgical accounting and processing, are based on estimates of the mineral content of ores and concentrates. These estimates in turn depend on samples taken from the ore body (either at the extraction site, or on a conveyor belt or at some other point in the extraction and transport of the mineral).

The accuracy of the estimates depends crucially on how representative the sample is of the full body of ore. There are sound scientific principles of good sampling and the adoption of these principles can increase the accuracy of the mineral content estimates.

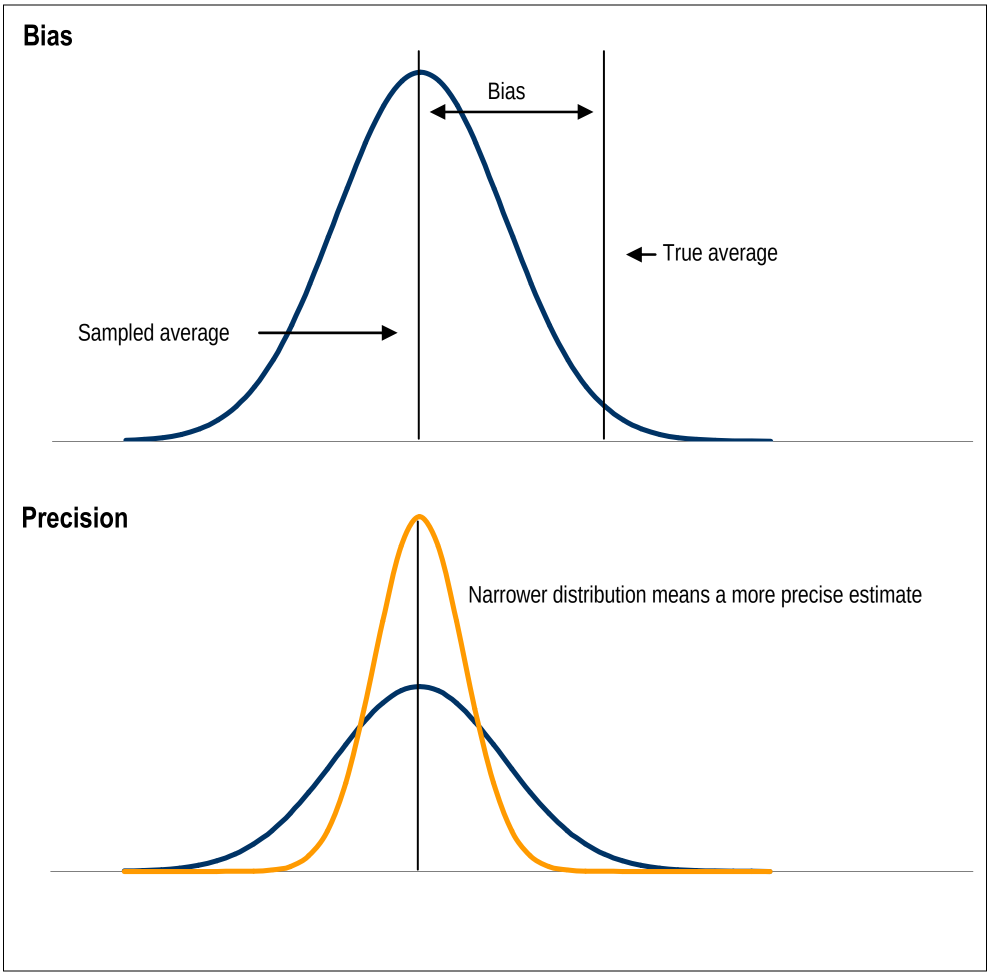
Bias and precision

There are two broad objectives when taking mineral samples – bias and precision. These are illustrated in chart 4.1. Any sample is an approximation of the true content of the ore, and any sample has a distribution associated with it. The narrower the distribution, the more precise is the sampling procedure (bottom panel of chart 4.1). The objective of good sampling is to provide a narrow distribution of estimates.

It is possible, however, for the physical basis of the sampling method to produce biased estimates. This occurs when the sampled estimates are centred not around the true average of the ore body, but on another value, as illustrated in the top panel of chart 4.1. [8]

[8] For a discussion of these sampling issues, and how they are embodied in standards, see Holmes (2004) Holmes and Robinson (2004).

4.1 **Bias and precision in sampling**



The standards

Scientific principles of good sampling have been embodied in a number of Australian and international standards. The ongoing development of international standards in this area has, to a large degree, been driven by Australian research, and Australians are well represented on the international committees in this area.

Examples of some of the standards in this area include:

- *AS 2862-1 1999 Copper lead and zinc sulphide concentrates: sampling procedures for determination of metal and moisture content*. This is identical to ISO 12743.
- *ISO 3082: 2000 Iron ores — sampling and sample preparation procedures.*
- *AS 4264.1 – 1995 Coal and coke – Sampling, Part 1: Higher rank coal – Sampling procedures.*

There are many other similar standards dealing with sampling and analytical techniques.

Economic effects

The bias and precision of mineral samples affect both the buyer and seller of commodities. The seller in particular needs to ensure that the contract price properly reflects the content of the ores. A downward bias, for example, in sampling may result in a lower price for the commodity based on a false perception of the mineral content of the commodity. More accurate sampling would allow the seller to negotiate a higher price than otherwise. The net effect of this on the amount traded depends on how responsive the buyer is to price changes – while the seller is getting more, the buyer must now pay more, which may lead to a subsequent reduction in demand.

The buyer also needs to have confidence in the true content of the ores as processing operations may depend on this knowledge. If the buyer is uncertain about the product, the uncertainty may be reflected in lower demand than otherwise, which would result in less trade and hence losses to both the buyer and the seller.

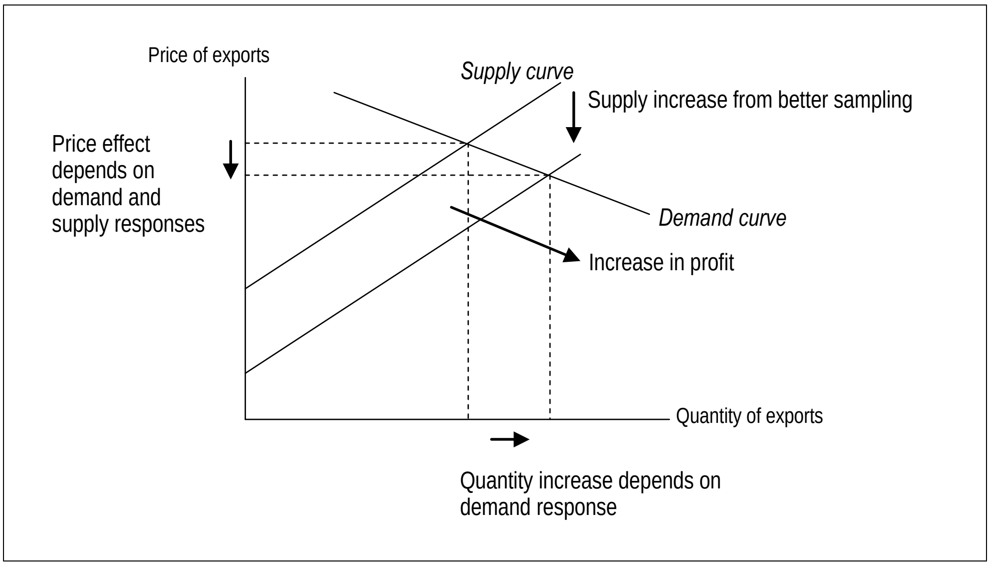
More precise sample estimates also allow the seller to more confidently deliver products to a particular specification (for example, based on the iron content of the ore). Uncertain sample estimates may result in delivering an actual quality higher than necessary, with some product not being sold at all. More certain sample estimates provides the confidence to deliver on specification, which effectively allows an increase in supply.

Quantitative estimates

We can estimate a conservative order of magnitude of these effects by measuring the implications of an effective increase in minerals supplied as a result of the better content estimates allowed by using the sampling standards. Our assumption is that without the adoption of the standard, there would be greater uncertainty, and potential bias in the estimates of the mineral content of the ores.

In technical terms, we are concerned with measuring the effect on industry profits of a small vertical shift in the industry supply curve. This is illustrated in chart 4.2. The use of the sampling standards allows a small shift in the supply curve as a result of more precise estimates of the content of the ore. Depending on how responsive demand is to price, this will lead to an increase in demand and potentially some lowering of price compared to what it would otherwise have been. From the perspective of the seller, which in this case is Australia, the gain is the increase in profits, which can be measured as the area between the two supply curves but below the new price.

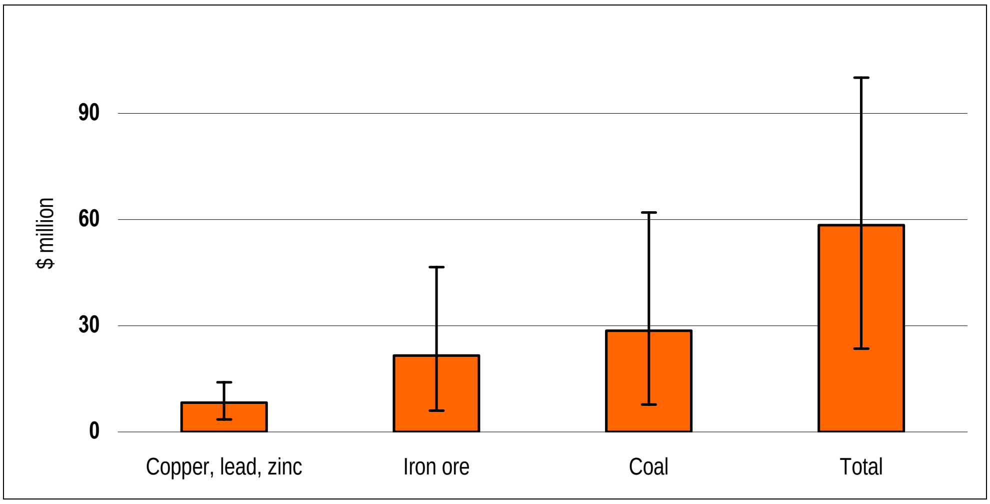
4.2 **Illustration of benefits of sample standards**



To estimate the value of this effect, we use base data for copper, lead and zinc, iron ore and coal. We use average 2004-05 prices and quantities, which is a conservative assumption given recent rapid increases in mineral prices and commodities. We assume a range of estimates of supply and demand responsiveness (the slopes of the demand and supply curves in chart 4.2). Importantly, we assume that the sampling standard leads to a very small shift in the supply curve, between 0.1 and 0.5 per cent of the original price of the commodity. That is, we assume that the bias and precision improvements as a result of the standard lead to an effective increase in price of between 0.1 and 0.5 per cent. This estimate, or course, cannot be exactly known, but industry discussions indicate that this is a reasonable conservative value.

The estimates of the benefits generated in this way are presented in chart 4.3. The chart shows that total average annual benefits are $58 million per year (with a range from $24 million to $100 million per year). The largest components of this are in the iron ore ($22 million per year) and coal ($29 million per year) industries, but with significant benefits also from copper, lead and zinc ($8 million per year).

4.3 **Value of sampling standards by commodity** [a] Average annual benefits



[a] Underlying data for estimates are taken from ABARE (2006). For the ranges, prices and quantities area varied by 20 per cent above and below base values. Supply elasticities range from 1 to 2 and demand elasticities range from -2 to -8.

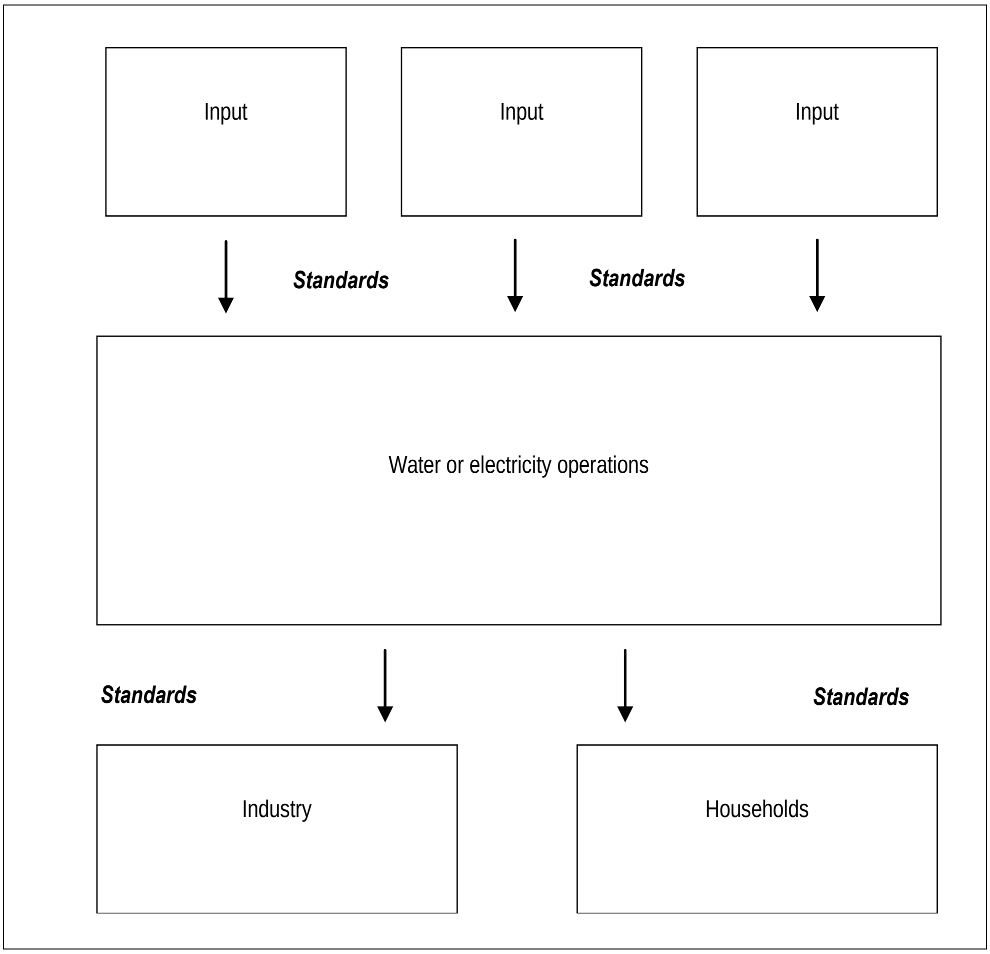
Data source: CIE estimates

Standards in electrical and water industries

There are a large number of standards in both the water and electrical industries. While these standards are highly diverse, they tend to have a similar economic effect on both industries. This effect is illustrated in chart 4.4. The electrical and water industries both involve using a variety of inputs to produce a product which is then distributed to a variety of users. The standards in place in these industries affect both the inputs that they purchase and the way in which their final product is distributed to users.

In the water industry, the inputs include pipes, pumps, digging of trenches and tunnels and so on. All of these products and processes have standards associated with them. The output of the water industry is, of course, water provided to households and industries. The way in which these final users access the water for their own purposes involves a range of products and processes which are also covered by a variety of plumbing and drainage standards.

4.4 **Standards, inputs and outputs**



In the water industry, many of the standards seek to ensure public safety and to maintain system integrity. For example, products incorrectly connected to the water supply system could generate backflow and contaminate potable water supply. This would affect other users of the system, potentially increasing their costs and lowering the value of the product. Incorrect connections may also damage water supply infrastructure, leading to higher costs for both suppliers and users.

There is a similar basic pattern in the process of generating and distributing electricity to households. There is a broad range of inputs, covered by a variety of standards as well as distribution to households and business users, again covered by a variety of standards (the best known of these being the wiring rules).

These various standards contain information that, if used, will result in two efficiency gains:

- First, an improvement in the efficiency with which the utility (water or electricity) uses the various products and services as inputs to its own activities.
- Second, an improvement in the efficiency with which the users are able to access the supply networks and the products and services of the water or electric utility. In this case, efficiency is defined fairly broadly and includes, for example, avoiding costs imposed by threats to system integrity that might occur in the absence of standards.

Water and electricity are both fundamental activities within the economy, and any improvement in the efficiency of either production or use is likely to have significant economic benefits that are transmitted throughout the economy. To capture this effect, we use an economywide model of the Australian economy to simulate the two sorts of productivity improvements identified above.

To do this, we need to estimate the extent of the productivity improvement, or cost reduction, that is allowed by the standard. It is extremely difficult to separate the effect of the standard from the effect of the other managerial and technical elements that contribute to the cost of operations. However, industry discussions indicate the following broad orders of magnitude.

- In the water industry, standards are estimated to have resulted in input cost reduction for large utilities of between 1 and 5 per cent, and for small utilities of between 5 and 10 per cent. Similar orders of magnitude are expected for the users of water.
- In the electrical industry, standards are estimated to have resulted in input cost reductions of between 1 and 5 per cent, both for the generators and distributors as well as for the users.

Using an economywide model to simulate this gives the results summarised in chart 4.5.

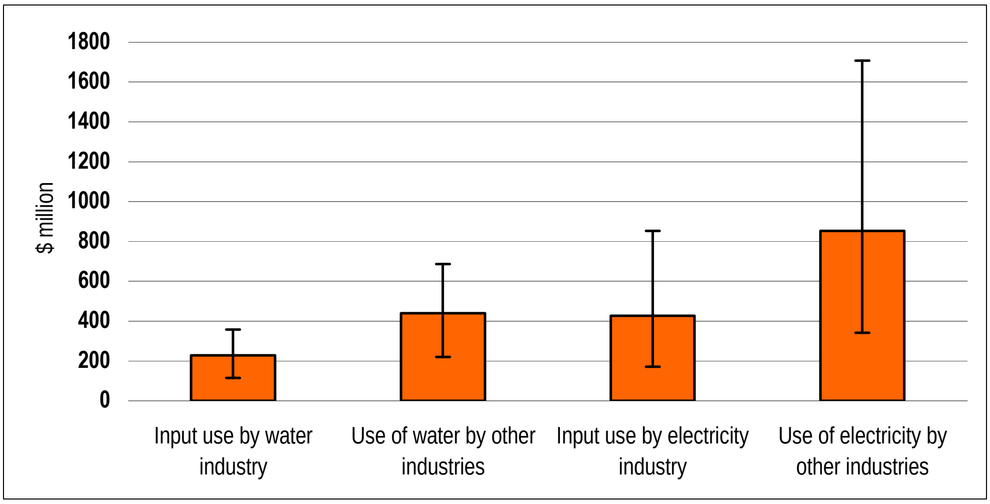
The chart shows that:

- improvements in input efficiency by the water industry itself are projected to result in an increase in GDP of $230 million per year, with a range from $114 million to $360 million;
- improvements in the efficiency of the use of water by other industries are projected to result in an increase in GDP of $440 million per year, with a range from $220 million to $690 million;
- improvements in input efficiency by the electrical industry itself are projected to result in an increase in GDP of $430 million per year, with a range from $170 million to $850 million; and

- improvements in the efficiency of electricity use by other industries are projected to result in an increase in GDP of $850 million a year, with a range from $340 million to $1.7 billion.

In total, these estimates sum to an average annual increase in GDP — relative to where it would have been without standards — of $1.9 billion dollars, with a range from $850 million to $3.6 billion.

4.5 **Change in GDP from water and electricity related standards** Average annual



Data source: CIE estimates

The risk management standard

Australian standard *AS/NZS 4360:2004 Risk Management* is a unique product. It doesn't really fit the traditional definition of a standard, but it does show very clearly how a standard can be used to convey and disseminate important information.

The standard *AS/NZS 4360* (and its associated handbook) is more like a 'primer' or a 'made simple' guide than it is like a standard that sets out particular specifications. The purpose of *AS/NZS 4360* (and the associated handbook) is to set out the principles of good risk management and to explain a broad process by which risk management can effectively be undertaken within an organisation.

Cost savings from a standard

Risk management is, of course, an important decision activity that is undertaken by firms and organisations in all fields of activity. There is no doubt that risk management could take place without the standard. There are, however, several advantages from having a standard that forms a foundation for risk management activities.

- Using an existing framework significantly reduces the initial set up costs of risk management systems for individual firms. *AS/NZS 4360* is general, and can be applied to a wide range of activities, and the framework it provides is likely to allow firms to get risk management operating at lower cost than would otherwise be the case. Part of this cost saving will result from lower costs of training staff.
- Related to this is the idea that using an existing framework lowers the risk involved in setting up a new system. The standard should help firms avoid 'dry holes' in designing new systems.
- *AS/NZS 4360* provides a language or terminology which allows users to communicate risk management issues. For example, the standard defines risk as (likelihood of an event) x (consequence of the event). This definition immediately makes it very clear what is meant by 'risk' and so provides a common way of communicating ideas.
- If firms choose to outsource some risk management activities, or are looking to buy software products related to risk management, then the existence of the standard will help identify both appropriate contactors and software products.

AS/NZS 4360 feeds into many other standards

The ideas in *AS/NZS 4360* form an important base for a large number of other standards. For example, within Standards Australia, *AS/NZS 4360* is referenced by at least 90 other standards or handbooks. These referencing standards are in diverse areas, ranging from occupational health and safety to structural steel welding to safety in laboratories.

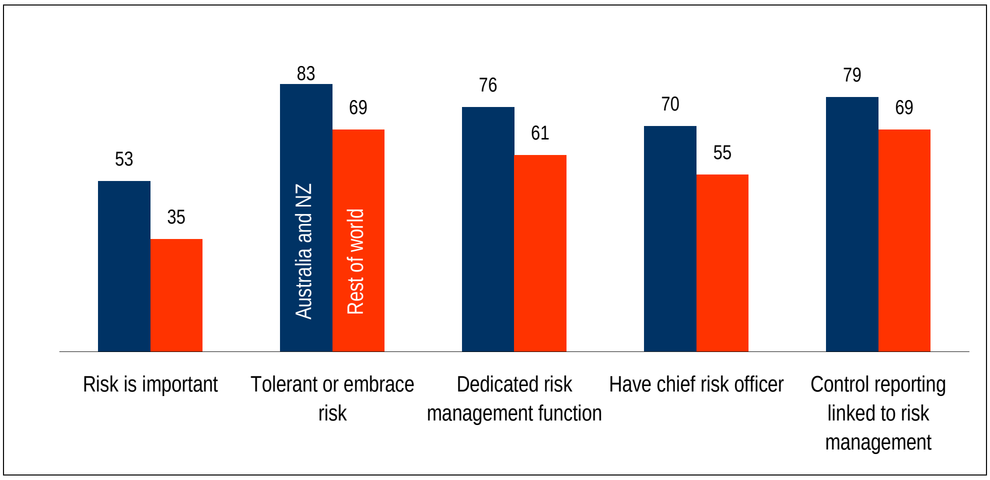
In addition, *AS/NZS 4360* has fed into a number of risk related handbooks and activities outside Standards Australia. For example, the recent guide *Climate Change Impacts and Risk Management* published by the Australian Government is essentially an application of *AS/NZS 4360* to a specific field.

Indirect evidence of the contribution of the standard

A recent survey of risk management attitudes by Ernst and Young found that Australian and New Zealand firms had a more 'mature' attitude to risk than did firms from other countries. Chart 4.6 summarises the responses to a number of key questions. It shows, for example, that 53 per cent of

Australian firms felt that risk was important, whereas only 35 per cent of firms in the rest of the world thought so.

4.6 **Attitudes to risk** Percentage of responses [a]



[a] From the published data, we are unable to test whether these differences are statistically significant, or whether the original sample was representative.

Data source: Ernst and Young (2006)

These differences are telling, and Ernst and Young partly attribute them to the existence of the risk management standard noting that:

> [Australian and New Zealand] business communities have been highly risk aware since 1995 when the Australian/New Zealand Standard, AS/NZS:4360-Risk Management, was one of the first risk standards to be published anywhere in the world. (Ernst and Young 2006, Supplement p. iii).

The benefits of risk management

Risk management allows better decision making through the anticipation of and adaptation to future expected risks. If a particular risk is prepared for, then its effects can be mitigated or even eliminated. Even where risk cannot be avoided, risk management allows for risks to be more effectively traded.

The value of risk management depends entirely on the context and is very hard to evaluate in general. Straightforward calculations can indicate, however, that the benefits of risk management are potentially very large.

For example, a major risk facing Australia is climate change, and in particular the ways in which this might affect Australian agriculture. Looking at the history of Australian agriculture indicates that there is a severe drought roughly every 7 years, and when one occurs, there is a 15 per cent productivity loss in agriculture (relative to the trend growth in productivity). This is equivalent to an expected annual productivity loss of 2 per cent. If, under climate change, the frequency of severe droughts were to double, this would be equivalent to an additional annual productivity loss (relative to what would otherwise have been the case) of 2 per cent. This would in turn lead to a loss in national income of $1.7 billion. Risk management that allows adaptation to this change could therefore prevent a significant loss. Examples like this multiply across the entire economy.

The full benefits of risk management cannot, of course, be attributed to the risk management standard. Rather, the benefits of risk management arise through an interaction between management – which may be based on the standard – technology, and various forms of trade in risk.

5 Conclusion

There are three challenges to providing a comprehensive assessment of the role of standards in the economy:

- the diversity of standards;
- the difficulty in estimating what would happen if standards were not in place, particularly at an economywide level; and
- some fundamental data limitations.

This report has taken a two pronged approach to these difficulties. First, we have undertaken a broad macroeconomic analysis of the effect of standards on economywide productivity using a broad range of data from a variety of sources. The results of this analysis indicate good reason to believe that there is some form of interaction between standards and economic growth, especially when standards are considered jointly with other factors such as R&D. The results of this analysis are not definitive, however, and there is considerable scope to further refine it as more data becomes available.

Second, we studied four case studies of particular standards (or groups of standards) to get an indication of the order of magnitude of effects of those standards. Here we have aimed to illustrate various aspects of standards and to not claim that these standards are necessarily fully representative. A large proportion of these case studies inevitably involve subjective judgements, particularly about what would have happened in the absence of standards. The case studies illustrate that there is some evidence to suggest that these standards could have important economic effects.

A major piece of data that is currently lacking is a detailed picture of how standards affect firm operations at an individual firm level. (Standards Australia is collecting anecdotal material.) Collecting this data would require a detailed survey of a large number of firms, but could easily be undertaken in conjunction with existing firm level surveys, undertaken, for example, by the Australian Bureau of Statistics.

A Estimation details

Tables A.1 and A.2 report the regression estimates underlying the summaries presented in charts 3.6 and 3.8.

A.1 Regression results with standards and R&D as separate variables [a]

	E1	E2	E3	E4
Variable definitions	*R&D stock, current* *Foreign R&D stock, current* *Standard stock (PIM)*	*R&D stock, lagged 1* *Foreign R&D stock, lagged 1* *Standard stock (PIM)*	*R&D stock, current* *Standard stock (PIM)*	*R&D stock, lagged 1* *Standard stock (PIM)*
Equation results				
R&D coefficient	0.0499** (0.0165)	0.0571** (0.0151)	0.0594** (0.01134)	0.0626** (0.1140)
Foreign R&D coefficent	0.0248 (0.0312)	0.01722 (0.0306)	- -	- -
Standards coefficient	0.1538** (0.0321)	0.16014** (0.0350)	0.1768** (0.01368)	0.1782** (0.0140)
R^2	0.974	0.975	0.973	0.975
ADF test	no cointegration rejected (5%)	no cointegration rejected (5%)	no cointegration rejected (5%)	no cointegration rejected (5%)

[a] All variables are in logs. Standard errors in parentheses. ** indicates significant at 95% level. ADF is the augmented Dickey-Fuller test.

Data source: CIE estimates

A.2 Regression results with standards and R&D combined into a single knowledge stock [a]

	K1	K2	K3	K4	K5	K6
Variable definitions	*SK1, lagged 1* *Foreign R&D stock, current*	*SK3, current* *Foreign R&D stock, current*	*SK3, lagged 1* *Foreign R&D stock, current*	*SK1, lagged 1*	*SK3, current*	*SK3, lagged 1*
Equation results						
Combined knowledge	0.1129** (0.0229)	0.1129** (0.0218)	0.1211** (0.0211)	0.1251*** (0.0037)	0.1227*** (0.00315)	0.1124*** (0.00305)
Foreign R&D coefficent	0.0172 (0.0319)	-0.0004 (0.0342)	-0.0138 (0.0328)	- -	- -	- -
R^2	0.974	0.975	0.977	0.973	0.975	0.977
ADF test	no cointegration rejected (5%)	no cointegration rejected (5%)	no cointegration rejected (5%)	no cointegration rejected (5%)	no cointegration rejected (5%)	no cointegration rejected (5%)

[a] All variables are in logs. Standard errors in parentheses. ** indicates significant at 95% level. *** indicates significant at 99% level. ADF is the augmented Dickey-Fuller test.

Data source: CIE estimates

For the equations in table A.1, the stock of standards variable was constructed from series of annual new or modified standards (as reported in table 3.2) using the perpetual inventory method.

For the equations in table A.2:

- SK1 refers to a combined stock of knowledge variable constructed by multiplying the contemporaneous annual R&D expenditure and number of new and revised standards, and then using the perpetual inventory method to construct a knowledge stock variable.
- SK3 refers to a combined stock of knowledge variable constructed by multiplying annual R&D expenditure and number of new and revised standards lagged by one year, and then using the perpetual inventory method to construct a knowledge stock variable.

As is typical for an exercise of this type, we tried a number of alternative model specifications with alternative ways of constructing the knowledge index. The results reported here have the best overall properties.

It is interesting to note that the inclusion of a standards variable, either separately or jointly with R&D expenditure, improves the properties of the overall regressions used to explain TFP.

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