STANDARDS Australia

Research Paper:
The Economic Benefits of Standardisation

1. Introduction

The imperative for sustainable economic growth has attracted an impressive body of economic research to better understand its determinants. Driving much of this research has been the neoclassical view of outputs as a function of physical and human capital as well as productivity[1]. The relationships between capital, labour and economic growth are typified by diminishing marginal returns, meaning that as the stocks of capital increase, the return from the deployment of that capital decreases. To counter this effect, productivity is identified as a third central contributor to economic growth. Productivity measures the technological progress of the economy and represents the efficiency with which resources are utilised. Factors such as economies of scale, exposure to competition and the diffusion of technological knowledge have been demonstrated to increase this progress[2] and standards play a decisive role in each.

At the macroeconomic level, the role of standards is four-fold and directly related to productivity. Specifically, standards protect the safety of the community; facilitate international trade; enhance the interoperability of technologies and processes; and facilitate technological change and economic development by reducing information asymmetry. However, it is also true that the inappropriate use of standards can hinder productivity through reducing choice, reducing competition and creating technical barriers to trade[3]. It is therefore important that the contribution of Standards to the national economy is monitored, not only to provide greater insights into the drivers of growth itself, but to provide an internationally comparable metric which estimates the influence that Standards development activities have on national economies.

This analysis seeks to empirically demonstrate the value of Australian Standards to the Australian economy. By Australian standards, this report is referring to all Australian only Standards, all Australian/New Zealand joint Standards, and all international adoptions[4]. These standards cover 12 key sectors of the Australian economy[5] and are developed by balanced committees of technical experts for the net benefit of the Australian community.

While it is not possible to capture all of the impacts of Australian standards in this analysis, particularly those impacts associated with safety, the modelling will provide valuable insights into the relationship between Australian standards and economic growth in a way which is comparable to the research undertaken in other countries.

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1 OECD (2001). The Driving Forces of Economic Growth: Panel Data Evidence for the OECD Countries. *OECD Economic Studies*, 33.

2 Mclean, I.W. (2004). Australian Economic Growth in Historical Perspective. *The Economic Record*, 80, 250, 330-345.

3 Hesser, W., Feilzer, A., de Vries, H. (2006). Standardisation in Companies and Markets. *Helmut Schmidt University*, Hamburg.

4 For the purposes of this report, international standards are those developed by the International Organisation for Standardisation (ISO) or the International Electrotechnical Commission (IEC).

5 Sectors: Agriculture, Forestry, Fishing and Food; Mining; Manufacturing and Processing; Building and Construction; Electrotechnology and Energy; Water and waste Services; Transport and Logistics; Health and Community Services; Consumer Products and Safety; Education and Training Services; Communications, IT and e-commerce; Public Safety, Public Administration and Business Management.

2. Background Literature

The relationship between standards and national economic performance has become an increasingly well researched topic over the past decade. The studies undertaken by Germany, United Kingdom, Canada, France and Australia have drawn on classical growth theory to empirically delineate a consistently positive and strong association between standards and sustainable economic growth using standards to represent the diffusion of technological knowledge throughout the economy. The following sections provide a brief summary of each study.

2.1. Germany

The DIN (2011)[6] study sought to update and improve upon the initial investigation into The Economic Benefits of Standardisation (DIN, 2000)[7]. This research estimated the value of labour, capital, standards, patents and licences to output as measured by Gross Value Added (GVA). The results indicate that Standards have a significant and positive association with economic output, however, the magnitude of this relationship changed over time due to economic shocks experienced by the German economy. Taking these into account, the study shows that a 1% change in the stock of standards is positively associated with a 0.7% to 0.8% change in economic growth following German reunification.

2.2. United Kingdom

The DTI Economics (2005)[8] report investigates the empirical economics of standards on labour productivity. The results demonstrate that standards and the capital to labour ratio are positively associated with labour productivity. Specifically, the analysis revealed that 1% change in the stock of standards was indirectly associated with a 0.054% change in labour productivity. These results are comparable to the later study conducted by New Zealand (BERL, 2011).

2.3. Canada

The Conference Board of Canada (2007)[9] measured the influence of standards and the capital-to-labour ratio on Canadian labour productivity from 1981 to 2004. Their results indicate that standards have a direct, significant and positive association with labour productivity such that a 1% change in the stock of standards is associated with a 0.356% change in labour productivity.

2.4. France

AFNOR (2009)[10] conducted a macroeconomic investigation into the impact of Standards on economic growth as measured by Total Factor Productivity (TFP). Their results indicate that, on average since 1950, the impact of standards on economic growth has been significant and positive such that a 1% change in the stock of Standards is positively associated with a 0.12% change in total factor productivity.

2.5. New Zealand

New Zealand (2011)[11] conducted a two stage estimation procedure to determine the relationship between standards, patents, and TFP; and finally the capital-labour ratio and TFP on labour productivity. The results show a significant and positive relationship between standards and TFP such that a 1% change in the stock of Standards is associated with a 0.10% increase in TFP and therefore a 0.054% increase in labour productivity.

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6 DIN. (2011). The Economic Benefits of Standardisation: An update of the study carried out by DIN in 2000, *DIN German Institute of Standardisation*, Berlin.

7 DIN. (2000). The Economic Benefits of Standardisation. *DIN German Institute of Standardisation*, Berlin.

8 DTI. (2005). The Empirical Economics of Standards, *DTI Economics Paper No 12*, London.

9 Standards Council of Canada. (2007). Economic Value of Standardization. *The Conference Board of Canada*, Ottawa.

10 AFNOR. (2009). The Economic Impact of Standardization – Technological Change, Standards and Long-Term Growth in France. *AFNOR*, Paris.

11 BERL. (2011). The Economic Benefits of Standards to New Zealand, *Standards Council of New Zealand and BRANZ* Wellington.

2.6. Australia

The 2006 Centre for International Economics (CIE)[12] report adopted a somewhat different approach to the aforementioned studies. The CIE tested two separate models. The first analysed the effects of R&D and Standards on TFP, demonstrating that a 1% increase in the stock of Standards is associated with a 0.17% increase in TFP. The second phase of the study combined R&D and Standards to create an index of the knowledge stock within the Australian economy. The results suggest that a 1% increase in this knowledge is associated with a 0.12% increase in TFP.

2.7. Summary of Findings

The findings of the abovementioned research should be interpreted with some degree of caution. This is because standards are used as a proxy for the dissemination of knowledge within the economy and should therefore be regarded as an important indicator of a broader infrastructure supporting that process. The results also do not capture all the benefits of Standards resulting from improved safety, community welfare and trade. However, these pose interesting questions for future research.

3. New Empirical Analysis

The present analysis seeks to update the CIE (2006) results and provide a basis for comparison with the research identified in section 2 of this report. This model therefore necessarily departs from that previously specified by the CIE (2006). Instead, this investigation will replicate, as far as data allows, that conducted by DIN (2011). The work conducted by DTI (2005) and BERL (2011) have also been replicated for the purpose of comparison. No significant results were obtained by replicating the DTI (2005) study so these results are not reported here. The replication of the BERL study did reveal significant results. Furthermore, the model presented in this report makes the assumption that Standards and patents are important for MFP. These results are therefore reported in the appendix.

3.1. Overview of data

At the macroeconomic level, the production of output has traditionally been a function of the inputs of labour, capital and land. However, the importance of human knowledge for more efficiently utilising these inputs is also fundamental to economic growth and improved standards of living[13]. This productivity is traditionally measured by Total Factor Productivity (TFP) or Multifactor Productivity (MFP) in Australia. Modelling TFP or MFP directly is challenging due to the multifaceted nature of the variable[14] (see: Appendix for a replication of the BERL (2011) study using MFP and two-stage ordinary least squares regression). As an alternative, the production function can be specified directly using data which approximates productivity. In this case, this productivity is estimated by modelling innovative technological knowledge generation as well as dissemination throughout the Australian economy.

In the current analysis the publication of Standards and the registration of patents will be used as indicators of productivity. Specifically, as with DIN (2011), this model will estimate the stock of innovative, technical knowledge within Australia using the annual number of patent registrations. Unfortunately there is no requirement for technology licences to be registered within Australia and therefore no reliable indicator of knowledge imports could be estimated. Patent data is available from IP Australia from 1978, however, as shown in figure 1 the data is somewhat unreliable until 1982. It is possible that the significant increase in the number of registered patents in this time may represent a reporting anomaly rather than a significant increase in technological knowledge. Therefore data used for this analysis will cover the 28 years from 1982 until 2010.

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12 Centre for International Economics. (2006). Standards and the Economy, *Standards Australia*, Sydney.

13 Mclean, I.W. (2004). Australian Economic Growth in Historical Perspective. The Economic Record, 80, 250, 330-345.

14 BERL. (2011). The Economic Benefits of Standards to New Zealand, *Standards Council of New Zealand and BRANZ* Wellington.

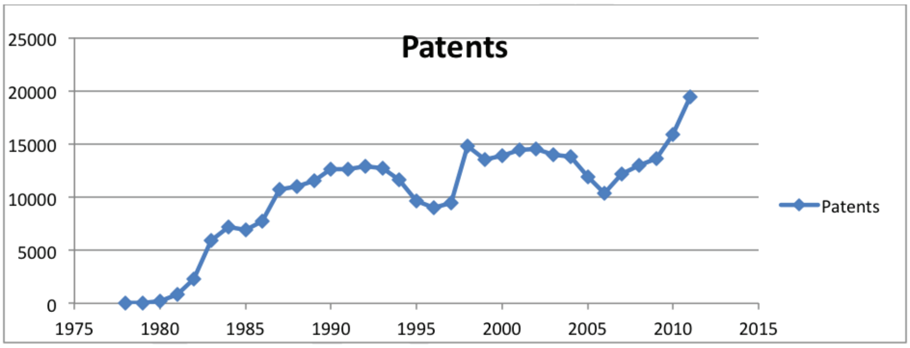

Figure 1. Patent Registrations 1978-2012

The diffusion of knowledge, critical for economic growth, is to be estimated by the annual production of Standards. The production rate as opposed to the stock of Standards has been selected primarily due to reliability issues with the stock of standards data. Furthermore the production rate is arguably more reflective of the productivity of Standards Australia as an organisation and its ability to meet the evolving needs of the Australian economy. This data is reliably available from 1964 – 2010 though due to the limitations of the patent data, the period 1982 – 2010 will be used for the analysis. Standards represent the codification of technical knowledge made available to individuals and companies throughout the world at a relatively low cost and are therefore an excellent measure of knowledge dissemination throughout the economy[15].

The traditional inputs of labour and capital are estimated in the analysis by the number of employed persons within Australia and Gross Fixed Capital Formation measured in chain volumes (GFCF) respectively. GFCF measures gross additions to national wealth from the following three sources[16]:

1. Producer acquisitions less disposals of fixed assets;
2. Changes in inventories to enterprise;
3. Acquisitions less disposals of valuables.

For the purpose of this analysis the intellectual property component is removed from GFCF as it is expected to possibly enhance colinearity issues with standards and patents in the model. A comparison of the two measures was conducted and found not to significantly affect the results, however, the modified measure was retained.

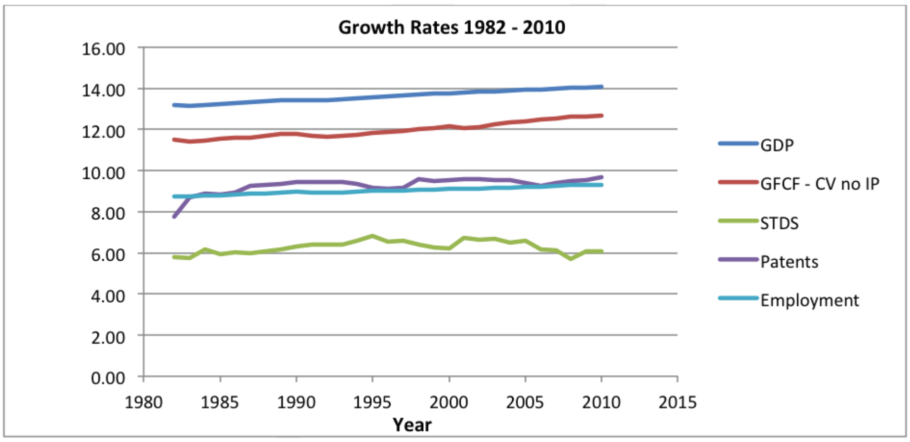

Figure 2. Transformed volumes 1982 – 2010

15 Patents and Standards are shown to be significantly and positively related to MFP in model 1 of Appendix A.

16 ABS. (2012). Australian System of National Accounts: Concepts, Sources and Measures Edn 1, *Australian Bureau of Statistics*, Canberra.

3.2. Model Specification

The Cobb-Douglas production function empirically describes the relationship between economic output and the input factors of capital, labour and technological progress.

$$Y_{(t)} = A_{(t)} [F(K_{(t)}, L_{(t)})] \quad (1)$$

Here, $Y_{(t)}$ is total GDP produced in the specified time period (t), which for the purposes of this analysis is annual. $K_{(t)}$ represents yearly GFCF and $L_{(t)}$ is the number of employed persons. $A_{(t)}$ represents the productivity with which capital and labour resources are used and is included to acknowledge the impact of diminishing marginal returns from the addition of resources to the economy. It is therefore a measure of the qualitative use of these resources and can be represented by the stock of innovative technological knowledge within an economy (patents) and its dissemination throughout (standards)[17].

The next stage is to transform the production function into a linear equation by taking the logarithm of each side so that a simple regression can be conducted on the data. This allows us to estimate the elasticities of the variables and their significance for total economic output. The new equation is:

$$y_{(t)} = a + \alpha k_{(t)} + \beta l_{(t)} + \gamma s_{(t)} + \delta p_{(t)} + \eta t + \varepsilon \quad (2)$$

In this equation, $y_{(t)}$ or GDP is explained by the following:

$\alpha k_{(t)}$: GFCF

$\beta l_{(t)}$: the number of employed persons

$\gamma s_{(t)}$: the number of standards published

$\delta p_{(t)}$: the number of patent registrations

ηt: the time trend

ε: error

The variable ηt has been included to account for the impact of the previous year's GDP on current GDP. The error component of the model captures all the influences on GDP which are not reflected in the model specified.

4. Results

The analysis reveals a strong and positive relationship between standards and economic performance. A slightly different model to that specified in equation 2 was estimated due to the high colinearity between capital and labour (*r=0.94*), labour was subsequently removed from the analysis and model 2 was estimated. A comparison of the two models can be seen in table 1. The model fit (R^2), Durbin-Watson and the impact of Standards on GDP remains reasonably stable across models 1 and 2. Notable changes can be seen in the partial elasticity of patents and capital.

The second model is considered superior due to the high multicolinearity in the first model. This inflates the standard errors associated with the elasticities of capital, labour and patents, threatening the validity of the estimates. This is reflected in the high variance inflation factors (VIF) for capital and labour, VIF=96.23 VIF=111.503 and VIF=3.1 respectively. The VIF indicates that the colinearity is significantly inflating the estimated elasticities of these variables resulting in a higher chance of Type I errors[18,19].

Note that the Durbin-Watson statistic in non-significant for both models. This is a measure of autocorrelation in the data. Autocorrelation occurs when the dependent

17 DIN. (2011). The Economic Benefits of Standardisation: An update of the study carried out by DIN in 2000, *DIN German Institute of Standardisation*, Berlin.

18 As a general rule, a VIF > 2 with a tolerance < .4 is considered problematic. This is the case with all references to colinearity issues throughout this report. Reference: Allison, P. D. (1999). Logistic regression using the SAS system: Theory and application. *SAS Institute*, North Carolina.

19 Note the improvements to the standard error of the estimates for each iteration of the estimated production function.

variable (GDP_t) is a function of itself in the previous time period (GDP_{t-1}). To account for this, the first differenced lagged correlation (time) was included in the analysis. Time is non-significant in both models implying that GDP_{t-1} is not a significant predictor of GDP_t. This result is congruent with the insignificant Durbin-Watson observed which indicates that little to no first order autocorrelation is present.

Table 1. Results

Statistic	Model 1	Model 2
R^2	.990***	.989***
Durbin-Watson	1.020	1.309
Constant	1.067 (1.268)	3.839*** (.249)
Capital	.496** (.146)	.934*** (.021)
Labour	.476** (.368)	-
Standards	.100*** (.031)	.151*** (.024)
Patents	.020 (.040)	.068** (.035)
Time	-.012 (.588)	-.379 (.368)

***99% confidence interval; **95% confidence interval; *90% confidence interval. Durbin-Watson confidence interval for N=26, K=3 is 0.928< DW >1.410; N=26, K=4 is 0.885<DW>1.517. A non-significant Durbin Watson implies that there is no issue of autocorrelation. Standards errors are reported in brackets next to the partial elasticities.

While removing labour from the analysis improves the stability of the model, the effect is that the partial elasticity of capital is unreasonably inflated. To manage this, a biased estimate of labour can be introduced into the regression equation. By doing this, an empirically valid portion of the variance in GDP can be assigned to labour based on the result of the first model and the effects of labour in other OECD countries with the result of presenting a more complete and stable model.

Based on figures observed in Knut and Jungmittag (2008) a conservative partial elasticity of 0.40 can be predetermined for labour and the restricted regression can be estimated. The effect of this was a slight reduction in the partial elasticities to provide an arguably more valid model of economic growth and estimates of the partial effect of each variable of interest. The new elasticities and standard errors can be seen in table 2.

Table 2. Restricted Regression Elasticities[20]

Variable	Model 3 Elasticities
Capital	.533*** (.013)
Labour	.400
Standards	.123*** (.017)
Patents	.032** (.013)
Time	-.279 (.308)

The revised elasticities indicate that a 1 per cent change in capital, labour, standards or patents will have a 0.533; 0.400; 0.123; and 0.032 per cent change in GDP respectively. These percentages can also be converted to a monetary value. For example, the 1.5% increase in the production of Standards in 2009 translates into approximately $2.33 billion in GDP[21].

The findings from this research are positive and are in line with those from previous research. Despite this, it is important to highlight that Standards are used here as a proxy for knowledge dissemination throughout the economy. While Standards are central to this process, they form part of a broader architecture and it is therefore necessary that the findings are treated as upper bound estimates.

20 This analysis was conducted using a maximum likelihood estimation procedure in AMOS. The constant is assumed to be zero.

21 Australian GDP was $1263.934 billion in 2009. Source: ABS System of National Accounts, 2012. *www.abs.gov.au.*

Summary

Economic growth is dependent upon not only the abundance of traditional inputs such as capital and labour, but also upon the productivity with which these inputs are applied to the creation of valuable outputs. A key component of this productivity is not only the development of innovative technological knowledge but the diffusion of these technological innovations through the economy. It is in the latter that standards play a central role in many economies throughout the world.

Standards are essentially a public good in that they are available at a low cost to all producers and consumers[22]. The information contained within is the technological benchmark for innovation, safety, interoperability and trade and is developed by balanced committees of technical experts for the betterment of national and international practices. It is in this way that Standards are a key mechanism for the diffusion of technological knowledge and therefore a key component of productivity.

This research has tested an econometric model of Australian economic growth which is useful for understanding the unique contributions of its key drivers. In this case, as with previous research, economic growth has been empirically explained by capital, patents and standards. Labour, though a theoretically valid predictor was removed from the model only due to the statistical issues caused by its high correlation with capital. What the results have shown is that those factors contributing to productivity, innovative technical knowledge generation and diffusion, and estimated by patent registrations and standards, support economic growth in Australia. Specifically, standards have been shown to exhibit a positive relationship with GDP such that a 1% increase in the production of standards is associated with a 0.17% increase in GDP, which translates to approximately $2.78 billion in 2009.

These results are positive and align with those found in other countries, however, are merely indicative of the role of Standards within the economy. On the one hand, standards in this analysis are an estimate of the diffusion of technical knowledge within the economy, an infrastructure of which Standards are one aspect. On the other, the multifaceted impacts of Standards cannot be captured in this sort of macro analysis. Having said this, the strong and positive relationship between standards and GDP demonstrated here, provides compelling empirical evidence of the importance of standards to the national economy.

22 Blind, K., Jungmittag, A. (2008). The impact of patents and standards on macroeconomic growth: a panel approach to covering four countries and 12 sectors. *Journal of Productivity Analysis*, 29, 51-60

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OECD (2001). The Driving Forces of Economic Growth: Panel Data Evidence for the OECD Countries. *OECD Economic Studies*, 33.

Standards Council of Canada. (2007). Economic Value of Standardization. *The Conference Board of Canada*, Ottawa.

Appendix 1. 2OLS Regression

Below are the results of the two-stage ordinary least square regression undertaken to replicate the New Zealand study. The statistical performance of this model is inferior to the production function estimated in section 3. Both of the models estimated for this analysis demonstrate significant autocorrelation which is not affected by the inclusion of the lagged time variable. The second model suffers from colinearity of the independent variables as evidenced by the high VIF (VIF=3.081). For these reasons the results may be spurious and should be interpreted with caution.

In this analysis, the Cobb-Douglass production function is estimated as:

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

Such that:

$$A_t = c + \beta Standards_t + \beta Patents_t + \beta Royalties_t + \sum f_i x_i + \varepsilon_i \quad (2)$$

In these equations, Y is production, K is capital, L is labour, A is MFP and 1-a represents profits and wages in the value added market. BERL (2011) suggests that economic output is induced when the factors that affect labour productivity increase. Therefore, the Cobb-Douglas production function in its logarithmic form is:

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

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

In this analysis Standards and patents are used to represent technological progress and to measure their impact of the on MFP. The second stage of the analysis is then used to deduce the indirect impact of Standards on labour productivity. The productivity data is calculated until 2007 and therefore this analysis covers the period 1982 until 2007. The results of the analysis can be seen in table A1.

Table A1. Two-Stage Ordinary Least Squares

Statistic	Stage 1 – MFP	Stage 2 – Labour Productivity
R2	.772***	.99***
Durbin-Watson	.225**	.693**
Constant	2.195***	-1.77**
Time	-.176	-.001
Standards	.390*	-
Patents	.385*	-
Capital to labour ratio	-	.443*
MFP	-	.546**

***99% confidence interval; **95% confidence interval; *90% confidence interval. Durbin-Watson confidence interval for N=24, K=3 is 0.881< DW >1.407.

Table A1 shows that standards and patents have a positive association with MFP such that a 1% change in the production of Standards is positively related to a 0.390% change in MFP and patents are similarly associated with 0.385% change in MFP. The second stage of the analysis reveals that MFP and the capital to labour ratio are positively related to labour productivity, such that a 1% change in MFP or the capital-to-labour ratio are associated with a 0.546% and 0.443% change in labour productivity respectively. From this we can infer that standards contribute to economic growth through their impact in labour productivity such that a 1% change in the production of Standards is associated with a 0.213% increase in labour productivity.

By way of comparison, this figure is high compared to the 0.054% increase in labour productivity associated with Standards in New Zealand, however is lower than the impact observed in the Canadian study.