Electricity Industry Reform in Australia: Rationale, Impacts, Challenges

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CERTIFICATE FOR AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Mənə səbri, qənaəti öyrədən Anama,
və
qətiyyət, müstəqilliyi öyrədən Atama həsr edirəm

To my parents

تقدیم به پدر و مادرم

ABSTRACT

The Australian electricity industry has undergone significant reform in the past decade. The industry has been functionally unbundled into competitive and monopoly segments, several segments of the industry have been privatised and new regulatory arrangements have been developed. The outcome of this reform has been mixed. Overall, there appears to be a gap between expectations from reform and its actual outcomes. The discussion about the reasons behind this gap and how to narrow it, and indeed every aspect of reform (e.g., its rationale, 'model' of reform, methodologies for assessing impact of reform) has been carried out exclusively in the economic domain. This research has demonstrated that this (economic only) approach is rather limited. It has contributed to painting a rather positive picture of reform and has resulted in the adoption of policy measures that are unlikely to provide satisfactory redress for the challenges faced by the electricity industry. Such redress, this thesis has argued, could instead be provided by taking an institutional perspective on reform. This perspective views electricity reform as an institutional phenomenon, shaped by ever-changing cultural, social, and political belief systems. These belief systems, this research has shown, emerge from the interaction between humans, organisations, and institutions. The dynamics of this interaction has been analysed in this research in a problem-solving framework that employs a political economy approach. It was shown how humans, guided by motivation and cognition, created various electricity organisations that, through a chain of two-stage process of 'tentative-solution-and-error-elimination' (or 'trial-and-error'), set into motion an organisational learning process that determined the final contours of the Australian electricity reform. This research also suggested how political economy approach could be effectively employed to re-define future directions for the Australian electricity reform program.

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2. Fathollahzadeh, R. and D. Sharma, (2004), "Rationale Behind Electricity Industry Reform in the ASEAN: A Review" , *Journal of Eghtesad-e-Energy, Energy Economics*, IRAEE, April&May No. 58/59, pp. 27-32., [also presented at *The 25th Annual IAEE International Conference, University of Aberdeen*, 26-29 June 2002, Scotland, (see below)].
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1 INTRODUCTION

1.1 Background

Electricity is an essential ingredient for economic growth. Therefore, the development of electricity industry – throughout more than twelve decades of its existence[1] – has traditionally been accorded a high priority by most countries in the world. This importance is likely to grow in the years to come as our daily lives become more reliant on electricity. According to the International Energy Agency, it is expected that 'global electricity-sector investment over the next three decades will amount to $10 trillion. This is 60% of total energy investment and nearly three times higher in real terms than investment in the electricity sector during the past thirty years' (IEA 2003, p. 339).

In Australia too, electricity industry has been accorded a high priority by the country's policy makers and planners. For example, over the period 1955–2002, more than $410 billions of investments (in nominal terms) have been made in the electricity industry (ESAA various). Over this period, the electricity industry has grown significantly in terms of size and organisational structure. For example, the generation capacity increased at an average annual rate of 5.4%, and generation by 5.7%, over the period 1955–2002. Coal has been the mainstay of electricity generation in Australia, accounting for more than 70% of total installed capacity and 85% of generation. Coal based electricity generation is also responsible for more than half of the CO_2 emissions produced by Australia. Currently, state-owned electricity companies in Australia have assets of above $50 billions with annual turnover of more than $18 billions[2] (ESAA

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[1] In the 19th century, modern applications of electric power resulted in emergence of several new industries. Some of these industries such as telegraph (invented in 1844) emerged a few decades earlier than electricity industry itself. This was because they were battery operating. The first modern battery was invented as early as 1800 (Volta's *dry pile*). Electricity industry was however not founded until the 1880s, when mass *electrification* became possible due to commercialisation of early generations of dynamos and incandescent lamps that, in turn, only emerged in the late 1870s (see Chapter 2).

[2] Comparable financial statements are only available for government-owned electricity companies. This includes most of the companies in New South Wales, Queensland, Western Australia, and Tasmania. Northern Territory figures are not included as figures for the electricity business could not be split from

2005). Further, the industry employs more than 35 thousands people (excluding in mining, and various outsourced activities). Table 1.1 provides a snapshot of the key features of the Australian electricity industry for the period 1955–2002 (further state-based information is presented in Chapter 4).

The above noted physical evolution of the industry was accompanied, indeed facilitated, by intensive evolution in the industry's *organisations* (that is, corporate players or collective units) and *institutions* (that is, the rules of the game; see Appendix 1.1 for more detailed definitions of organisations and institutions). These organisations and institutions have served Australia well and have ensured the provision of safe, adequate, reliable and affordable electricity to all that has contributed to the emergence of the nation as an advanced economy.

Electricity is constitutionally a state matter in Australia. Each state has therefore developed its electricity industry in accordance with its own priority. Notwithstanding these differences, the electricity industry in each state, in the early 1990s, was typified by a vertically integrated monopoly with generation, transmission, distribution, and supply under one (or two) government owned entities. These entities practised centralised operational philosophy, and their mandates included a variety of Community Service Obligations (CSOs).

In the mid 1980s, in response to emerging concerns about the inefficiency in the electricity industry, some reforms were undertaken by the respective state governments. The focus of these reforms was to strengthen the management and control arrangements for the electricity industry. This resulted in significant productivity gains (BIE 1994; Short et al. 2001; Fathollahzadeh and Sharma 2004).

Notwithstanding these gains, the Australian electricity industry came under enormous pressures, in the early 1990s, to undertake more radical reform. These pressures essentially arose from the emerging neo-liberal ideology in the mainstream Australian polity. This emergence is attributed by some to the fundamental global pressures in the

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the water utility. Further, there are no government-owned electricity companies in Victoria or South Australia.

Table 1.1 Electricity Industry in Australia: A Snapshot

		1955	%	1970	%	1980	%	1990	%	2002	%	Average annual growth 1955-02 (%)
Generation	**Installed Capacity (MW)**	**3526**	***100***	**14003**	***100***	**24142**	***100***	**34449**	***100***	**44742**	***100***	***5.4***
	Hydro	555	*15.7*	3796	*27.1*	6103	*25.3*	7261	*21.1*	7384	*16.5*	*5.5*
	Steam	2791	*79.2*	9864	*70.4*	16789	*69.5*	25042	*72.7*	31336	*70.0*	*5.1*
	Internal Combustion	180	*5.1*	188	*1.3*	286	*1.2*	377	*1.1*	268	*0.6*	*0.8*
	Gas Turbine	0	*0.0*	155	*1.1*	963	*4.0*	1674	*4.9*	4313	*9.6*	-
	Combined Cycle Gas Turbine	0	*0.0*	0	*0.0*	0	*0.0*	95	*0.3*	1441	*3.2*	-
	Generated Electricity (GWh)	**13853**	***100***	**49572**	***100***	**88147**	***100***	**143322**	***100***	**201141**	***100***	***5.7***
	Hydro	1935	*14.0*	9125	*18.4*	13721	*15.6*	14643	*10.2*	15363	*7.6*	*4.4*
	Steam	11562	*83.5*	40081	*80.9*	72663	*82.4*	125922	*87.9*	174511	*86.8*	*5.8*
	Internal Combustion	356	*2.6*	356	*0.7*	528	*0.6*	501	*0.3*	501	*0.2*	*0.7*
	Gas Turbine	0	*0.0*	10	*0.0*	1234	*1.4*	1638	*1.1*	3442	*1.7*	-
	Combined Cycle Gas Turbine	0	*0.0*	0	*0.0*	0	*0.0*	618	*0.4*	7324	*3.6*	-
T&D	**Network Length (km)**	**na**		**496325**		**603569**		**790331**		**861407**		**1.7***
	Network Capacity (MVA)	**na**		**74289**		**124913**		**175181**		**223072**		**3.4***
Consumption	**Final Electricity Consumption (GWh)**	**11248**	***100***	**41662**	***100***	**74306**	***100***	**123957**	***100***	**176279**	***100***	***5.9***
	Residential	4190	*37.2*	15293	*36.7*	29026	*39.1*	38685	*31.2*	51012	*28.9*	*5.3*
	Commercial and Industrial	6033	*53.6*	25387	*60.9*	44012	*59.2*	81532	*65.8*	121748	*69.1*	*6.4*
	Others	1026	*9.1*	982	*2.4*	1268	*1.7*	3740	*3.0*	3519	*2.0*	*2.6*
	Number of Customers ('000)	**2496**	***100***	**4272**	***100***	**5625**	***100***	**7118**	***100***	**8969**	***100***	***2.7***
	Residential	2118	*84.9*	3682	*86.2*	4911	*87.3*	6198	*87.1*	7749	*86.4*	*2.8*
	Commercial and Industrial	335	*13.4*	587	*13.8*	710	*12.6*	899	*12.6*	951	*10.6*	*2.2*
	Others	43	*1.7*	2	*0.0*	4	*0.1*	20	*0.3*	269	*3.0*	*3.9*
Other Features	**Electricity Price (c/kWh - 1990 prices)**	**16.2**		**11.0**		**8.5**		**8.4**		**7.5**		**-1.6**
	Electricity Cost (c/kWh - 1990 prices)	**15.5**		**10.9**		**9.1**		**8.5**		**na**		**na**
	Cost/Price Ration	1.0		1.0		1.1		1.0		na		na
	Employment ('000)	**51**		**69**		**74**		**66**		**34**		**-0.9**
	Share of total labour force (%)	*na*		*na*		*1.19*		*0.84*		*0.36*		*-5.4***
	CO2 emissions (Mt)	**18.5**		**44.6**		**78.2**		**117.1**		**177.0**		**4.8**
	Share of total CO2 emission (%)	*na*		*31.5*		*37.7*		*45.1*		*51.1*		*1.5**
	Investment (m$, 2001 prices)	**na**		**412.9**		**352.8**		**541.6**		**na**		**na**
	Share of total investment (%)	*na*		*0.77*		*0.53*		*0.53*		*na*		*na*
	Share of real GDP (%)	*na*		*0.16*		*0.10*		*0.11*		*na*		*na*

Sources: ABS (2004a; 2004b; 2004c); ESAA (various); IEA (2005).
Notes: T&D – Transmission and Distribution; and na – 'not available'; * and ** refer to period 1970-02 and 1980-02, respectively.

early 1990s, created by the collapse of the Soviet Union, the end of the Cold War, and the US- and UK-led globalisation movements.

The Australian response to these pressures was to introduce of a series of economy-wide reform measures, under the broad title of *microeconomic reform*. The reform of the electricity industry, hence, became an integral element of this reform program (Sharma et al. 1999). Consequently, in the early 1990s, several agreements were reached between various governments in Australia to reform their electricity industries (as well as some other infrastructure industries). The main emphasis of this reform was to provide a market orientation to the electricity industry, by introducing 'competition' in electricity supply and providing 'choice' to costumers to select their electricity service providers (ICOIICPIA 1993). This reform is called *market reform*, in the context of this research.

This reform transformed the electricity industry into a kind of *stock exchange market* in which prices are determined through bidding process between numerous sellers and buyers. This necessitated substantial changes in almost every organisational and institutional facets of the industry. The main organisational changes included: unbundling of the vertically integrated industry into generation, transmission, distribution, and retail functions; horizontal separation of generation and retail functions; and re-organisation of transmission and distribution functions. The institutional changes included: formation of a new regulatory framework; establishment of the National Electricity Code (NEC); replacement of the traditional order-of-merit dispatch with a mandatory bid-based dispatch system; provision of more choice for consumers; introduction of third-party access to monopoly networks; and privatisation. With the exception of full privatisation most of these changes have been implemented.

Several challenges emerged during the course of implementation of market reform, and the actual impacts of reform have differed from expectations. This has raised concerns amongst the electricity policy makers and planners, and the industry at large. Some of these concerns relate to issues arising from: excessive market power enjoyed by some market players; high degree of price volatility; inadequate dynamic investment; regulatory complexity; re-emergence of market power through industry reconsolidation (mergers and acquisitions); increase in CO_2 emissions and energy intensities; and job losses and inequity.

Debate on the nature of the challenges and the ways to address them intensified in the early 2000s. Some commentators have argued that these challenges are a natural outcome of reform of such magnitude. Others argue that these are due to the inappropriateness of the market model for the electricity industry. Electricity is non-storable commodity and electricity system is an interconnected system, requiring intricate physical demand-supply balance at all time. These features render the market model inappropriate for the electricity industry, argue these commentators. Significant impetus to the debate was provided by the findings of the Council of Australian Governments (COAG) Review (COAG 2002) that classified main challenges into the following categories:

(i) governance and regulation (issues related to complexity, overlap, unaccountability, ambiguity and inconsistency of regulatory framework);
(ii) market mechanism (issues related to market power and price spikes) and structure (issues related to horizontal and vertical integration such as mergers and acquisitions);
(iii) transmission (natural monopoly and its related regulatory and ownership issues);
(iv) investments and financial market (inadequate investments and lack of incentives for new investments);
(v) retail contestability and demand side management; and
(vi) environmental issues.

COAG Review correspondingly provided the following recommendations for addressing these challenges:

(i) establishing a national regulatory framework to encompass federal, state and territory regulatory frameworks;
(ii) allowing the current mandatory bid-based pool market to perform as intended;

(iii) giving the system operator (that is, national electricity market management company (NEMMCO)) some responsibility to identify transmission capacity needs and introducing some explicit incentives that penalise/reward transmission entities according to their performance and the NEM's requirements;

(iv) moving towards removal of price control (that is, abolishing the electricity tariff equalisation fund and benchmarking pricing agreement) and enhancing NEMMCO's role to facilitate financial contracts;

(v) mandating the roll-out of interval meters, removing the retail price cap, introducing 'pay-as-bid' mechanism into NEMMCO's dispatch and market systems for demand reduction; and

(vi) introducing an environment-related institutional framework in co-ordination with the market reform (for example, introducing an economy-wide emission trading institution).

The Ministerial Council on Energy (MCE), in recognition of these recommendations, released its own review in December 2003. This was endorsed by the COAG and led into a new formal agreement between the Australian governments. This agreement sought to create a truly national and efficient electricity market working under the discipline of a new regulatory and governance arrangements (Sharma 2005). Consequently, a new set of policy initiatives was launched by the Australian governments (MCE 2003; DPMC 2004).

A review of these policy initiatives suggests that their main focus is economic. This focus is similar to the focus of the reform in the early 1990s that collapsed all aspects of reform into two aspects, namely, 'competition' and 'choice'. This focus views reform essentially as an economic issue, and human as economic beings (*Homo oeconomicus*). This conception, in neoclassical economics, is often immediately translated in terms of 'optimisation' and 'rationality' of human behaviour (utility/profit maximisation) for individual and social decision-makings. This is why one can clearly note that in the conventional approach, profitability and financial viability of electricity industry play dominant role in the process of decision making. Social obligations and responsibilities are less acknowledged in such approach.

A review of the COAG Report also reveals that it has assumed an uncompromising view of the direction and shape of the reform program. The discussion on the nature of various challenges (and the ways to address them) is therefore influenced by such view. This appears to have imparted a narrow perspective on challenges and ways to address them.

The conventional approach, this thesis contends, is short-sighted and inadequate for addressing emerging challenges, because it ignores institutional dimensions of reform. It does not explain how organisations and institutions are formed in first place and how they evolve over time. This explanation would require an examination of the 'human behaviour', that is, how humans – through *motivation* and *cognition* – constantly form and reform organisations and institutions. It is in this examination resides a fuller understanding of:

- Why has electricity reform taken place in Australia?
- Why it has a particular shape and size?
- Why have new challenges emerged?
- Why there is disparity between expectations from reform and its actual outcomes?
- What could be done to progress the current reform program and improve its efficacy?

1.2 Research Objectives

Against the above background, the overall objective of this thesis is to provide a comprehensive understanding about various aspects of electricity reform in Australia – its rationale, approach, experience, impacts, and challenges. Three specific objectives are set for this research, namely:

Objective (1) Providing a comprehensive description of the evolution of the Australian electricity industry including in its organisations and institutions, with a view to analyse the nature of this evolution and to identifying the underlying reasons behind it;

Objective (2) Assessing the impacts of electricity reform on the performance of the electricity industry and the wider economy, with a view to identify if there has been significant disparity between expectations from electricity reform and its actual outcomes, and to develop an understanding about the reasons for such disparity;

Objective (3) Demonstrating how insights gained from *Objectives 1* and *2* could be useful to develop policy guidance for improving the efficacy of electricity reform program.

1.3 Methodological Frameworks

Clearly, addressing these objectives is a multidisciplinary task, requiring recourse to concepts and methodologies belonging to several disciplines such as economics, sociology, philosophy, politics, psychology and engineering. A combination of methodologies is therefore applied in this research to address these objectives. Salient points of these methodologies are explained in this section, fuller details will be provided in corresponding chapters.

1.3.1 Rationale for Reform

The methodology of this objective consists of two sub-methodologies, namely 'historical review' and 'problem-solving framework'. The 'historical review' would examine whether electricity reform is *institutional phenomenon*. The 'problem-solving framework' would analyse the influence of human behaviour on the shaping of institutional phenomenon.

a) Historical Review

The following steps are developed for the 'historical review' in this research:

1) Providing an overall chronological review of major events and key changes in electricity industry's underlying institutions in terms of culture, social beliefs, and economic ideologies – in state, national, and global contexts.
2) Developing a time profile of key changes in the industry's organisation in terms of its technological, structural, ownership, and other socio-economic features.

3) Juxtaposing organisational and institutional features of the industry and identifying cause and effect relationships between them.

Several studies have reviewed the history of the Australian electricity industry, for example, ESAA (1973), McColl (1976), Rosenthal and Russ (1988), Linn (1996), Sharma and Bartel (1997), Booth (2003), and Spoehr (2003). Each study has described how the electricity industry has changed over time. Some of these studies have also provided useful explanations for the reasons behind changes in the industry's organisations, for example Sharma and Bartel (1997) and Booth (2003). The analysis in this research contributes to this literature by providing a more comprehensive description of the evolution of the industry in terms of its organisational and institutional features. In this historical review, various technical, economic, social, environmental, and political dimensions of reform are taken into consideration. Therefore, this methodology would provide an insightful explanation about the true nature of electricity reforms and the underlying reasons behind these reforms.

b) Problem-solving Framework

The analysis of 'historical review' – while useful for examining electricity reform as an *institutional phenomenon* – is inadequate. It is inadequate because it does not explain how organisations and institutions are formed in the first place, and how they evolve over time. This explanation – this research contends – would require an examination of 'human behaviour', that is, how humans – through *motivation* and *cognition* – constantly form and reform institutions and organisations. It is in this examination therefore resides a fuller understanding of why electricity reform has taken place in Australia.

Individuals, organisations and institutions – being three main constituents of electricity industry, as a sub-system of national economy – are studied in this research to capture human behaviour in society (see Appendix 1.1). In social and human science, especially sociology and economics, examination of institutional phenomenon in terms of the underlying human behaviour often starts with the analysis of individual behaviour. This methodology is called *methodological individualism*. The most important point about methodological individualism is that it consistently distinguishes between changes in organisations and institutions (Schumpeter 1909). While organisational changes are described in terms of changes in collective *ends* of organisations (for example, changes in the structure of an organisation), the institutional changes are captured by changes which take place in the social *means* of the individuals and organisations (for example, changes in culture, social norms, rules and regulations).

In order to incorporate the premises of methodological individualism, there is a need for an analytical framework. In social and human sciences, there are two main analytical frameworks – often used in economics and sociology – guided by two different conceptions of human beings and particularly of human behaviour. One such framework considers a human as *Homo oeconomicus* and the other, *Homo sociologicus*. Homo oeconomicus is about the calculus of human choices. In neoclassical economics, this conception is immediately translated in terms of “optimisation” and “rationality” of human behaviour (hypothesised as utility/profit maximisers). Homo sociologicus, on the other hand, is about the quasi-inertial forces or institutional coercion behind human behaviour that leave no choice as such for human actions.

This research adopts an alternative analytical framework – a *problem-solving framework* – in order to examine human behaviour. The problem-solving framework has been developed by Mantzavinos (2001). The selection of this framework will be justified in Chapter 3 on the ground of its: (i) consistency with the premises of the methodological individualism; (ii) more realistic conception of human behaviour (as compared with Homo oeconomicus and Homo sociologicus) that captures an adequate account of the *motivational* and *cognitive* aspects of the human behaviour; (iii) usefulness for analysing the institutional phenomena by calling for a *political economy* approach that fills the institutional vacuum of neoclassical economics; and (iv) philosophical underpinnings – inspired by *cognitive psychology* and *evolutionary epistemology* – which provides a useful synthesis of two main analytical frameworks (that is, Homo oeconomicus and Homo sociologicus). This methodology together with the above-discussed ‘historical review’ – this research contends – would constitute an *institutional* approach to understand electricity reform.

1.3.2 Impacts of Reform

The methodology of this research for assessing impacts of electricity reform (*Objective 2*) essentially consists of 'inferential statistics' ('hypothesis testing'), which has been used together with two distinct sub-methodologies, namely 'productivity analysis' (for assessing the impacts of electricity reform on the performance of the Australian electricity industry) and 'econometrics' (for assessing the impacts of this reform on the wider economy).

There are two main points about this methodology that should be discussed here. The first point is that, in this methodology, this research explicitly distinguishes between two classes of methodological frameworks: (i) framework for measuring economic performances; and (ii) framework for assessing the extent and significance of the impacts of reform on the performance of the Australian electricity industry and the wider economy. These frameworks, in the context of this thesis, are called *measurement-frameworks* and *assessment-frameworks*, respectively. Therefore, 'productivity analysis' and 'econometrics' are used as measurement-frameworks, and 'inferential statistics' as an assessment-framework.

This distinction has not been made explicit in existing studies (see Appendix 4.1 for the list of these studies), perhaps because these frameworks are often tightly intertwined with each other. Some analysts may argue that such a distinction is unnecessary and that measurement-frameworks are assessment-frameworks as well. Such argument, to some extent, may be true, because the concept of performance is a relative concept and the measurement of 'performance' always carries some kind of assessment as well. This can be seen in simple comparisons over time (time serries analyses) or across the same counterparts (cross section analyses). However, this thesis contends that this distinction is useful because it allows a more comprehensive approach for assessing industry performance, and for ascertaining the impact of electricity reform on industry performance and the wider economy (see also, Fathollahzadeh 2005; Fathollahzadeh & Sharma 2004).

The second point about this methodology is that analyses of impacts are classified into two broad groups. The first group includes analyses of the impacts of electricity reform on the performance of the electricity industry. These analyses typically employ 'productivity analyses'. These analyses, in the context of this thesis, are called *micro-impact analyses*. The impacts measured on the bases of these analyses are, in turn, called *micro-impacts*. The second group of analyses – relying largely on the results of the first group of analyses – focus on assessing the impacts of electricity reform on the wider economy (expressed in terms of overall economic growth). These analyses, in the context of this thesis, are called *macro-impact analyses* and the corresponding impacts, *macro-impacts*. This classification is also observed in several reviewed studies (listed in Appendix 4.1).

The following discussion presents the salient points of each of these three methodologies, namely, 'inferential statistics', 'productivity analysis' and 'econometrics'. A brief justification for their selection in this research is also provided. A fuller discussion on each is provided in Chapter 4.

c) Inferential Statistics (Hypothesis Testing)

'Inferential statistics' has been used by various studies as a relevant assessment-framework. Atkinson and Halvorsen (1986), Pollitt (1995) and Hattori and Tsutsui (2004) have employed 'inferential statistical' – together with some measurement-frameworks – as their principal assessment-framework. However, this methodology, so far, has not been employed in the context of Australia.

In this research, Analysis of Variance (ANOVA) is used together with productivity analysis (as measurement-framework, see below) in order to test various hypotheses regarding the significance of the impacts of electricity reform on the productivity of the electricity industry. Similarly, various statistical tests (t, F, and so on), as embedded constituents of econometric analysis (as another measurement-framework, see below), are conducted in this research in order to test various hypotheses regarding the significance of the impacts of electricity reform on the wider economy.

Various dummy variables are introduced to capture institutional changes that have taken place as a result of Australian electricity reform. These dummy variables essentially capture changes in the structure and ownership arrangements of the Australian electricity industry (see Section 4.3.1 in Chapter 4 for further details).

This methodology is well accepted in social sciences and economics and is fully consistent with ‘problem-solving framework’ developed in this research. Further, as this methodology has not so far been employed in the context of the Australia electricity reform, its application in this research can therefore be considered as a methodological contribution to literature.

d) Productivity Analysis

‘Productivity analysis’ is an appropriate methodology for micro-impact analysis. Several studies have employed this methodology to measure the productivity of the Australian electricity industry. These studies include: IC (1991; 1995); Lawrence et. al. (1990; 1991); BIE (1992; 1994); Swan Consultants (1991; 1992); London Economics (1993); Coelli (1998); Whiteman (1999); and Short et. al. (2001).

A review of these studies however reveals that these studies portray humans as ‘economic’ beings, motivated solely by their economic interests, namely cost minimisation and profit maximisation (that is, human beings as *Homo oeconomicus*). Further, a society, in such studies, is portrayed solely in terms of its ‘economic’ dimension, for example, gross domestic product and price levels. Such portrayals of humans and human society are also reflected in the selection of various methodologies for measuring (and assessing) industry performance. The measurement/assessment of industry performance based on these methodologies, this research contends, reflects a limited (that is, economic only) aspect of industry performance; it ignores the institutional aspects of performance. Consequently, they provide rather limited insights for developing policy measures that could be taken to improve industry performance. This also explains why there is significant disparity between expectations from electricity reform and its actual outcomes.

Some modifications are made in this research to the traditional ‘productivity analysis’. The insights gained from the application of ‘problem-solving framework’ constitute the basis for such modification. The most important modification is to eliminate any behavioural assumption about the decision-making behaviour of human beings. This involves relaxing conventional behavioural assumptions as employed in neoclassical economics (namely, cost minimisation, profit maximisation). This modification is consistent with the nature of organisations in the electricity industry with a mandates to fulfil CSOs, in addition to generating profits (see also, Coelli (1998)). In Chapter 4, the conceptual aspects of this methodology are discussed in detail.

e) Econometrics

Analysis of macro-impacts – in the existing literature – is often made using a variant of Computable General Equilibrium (CGE) model. For example, IC (1995; 1999), Quiggin (1997), Whiteman (1999) and short et. al. (2001) have all applied a particular type CGE model for measuring the macro-impacts of electricity reform. Macro-impact analysis is generally more complex than micro-impact analysis because of the need to capture inter-relationships between various macro-economic variables, and between the micro- and macro-impacts. This is complex also because it is difficult to decompose the impacts of electricity reform from the impacts of all other simultaneously occurring reforms (for example, gas and water) on overall performance of the economy.

While the dominant focus in this research is on estimating micro-impacts, a specific (*ad hoc*) econometric model[3] (as an alternative to CGE models) has been employed in this research in order to develop broad estimation of macro-impacts of electricity reform. This approach, although somewhat limited in scope, is still appropriate because it: i) enables one to analyse the causality between micro- and macro-impacts; ii) allows for hypothesis testing of the estimated economic gains from reform on the basis of ex-post analysis of the historical data; and iii) is free from large number of judgmental assumptions in counterfactuals and data-smoothing (which are typical problems confronted in CGE modelling).

1.3.3 Efficacy of Electricity Reform

f) Political Economy Approach

The recommendations for improving the efficacy of reform (*Objective 3*) are based on the application of a 'political economy' approach, informed by the premises of 'problem-solving framework' developed in this research and the insights gained from the analyses of *Objectives 1* and *2*. This approach comprises the following: i) analysing

[3] Due to time and resource limitation, it was not possible to develop CGE models for analysing the macro-impact of reform in this research.

the nature of contemporary challenges that emerged during the course of implementing market reforms; ii) reviewing the appropriateness of the conventional approach for addressing these challenges; and iii) describing how a 'political economy' approach would overcome the limitations of conventional approach.

This approach, it is contended, would help to develop a more balanced view towards political and economic processes that underpin every organisational action and the emergence of institutions.

1.4 Scope of this research

This research considers electricity reform in all Australian State/Territory electricity industries. Australia is a confederation of six States and two Territories, namely New South Wales (NSW), Victoria (VIC), Queensland (QLD), South Australia (SA), Western Australia (WA), Tasmania (TAS), Australian Capital Territories (ACT) and the Northern Territory (NT). NSW, VIC, QLD, SA, ACT and TAS are parties to the Australian national electricity market (NEM).

The time-scale for analysis in this research however varies for each specific objective. For example, historical evolution of the electricity industry is carried out from the time of the inception of the industry (1880s) to the present time. The econometric analysis focuses on the period 1955–2002. Some specific analysis are however limited to shorter time periods. The decision about time period for analyses was based on the availability of data and other related considerations.

1.5 Data and Software Considerations

This research is extremely data intensive. Data collection and organisation in formats appropriate for analyses constituted a major challenge for this research. The data were collected from various publicly available sources, and through personal communications with energy officials. The time series of the Australian energy balance for the period of 1960–2000 was obtained from the International Energy Agency (IEA) online database, SourceOECD (IEA various). An econometric model was developed in this thesis to estimate some components of the Australian State-base energy balances. The State-based energy balances of the Australian electricity industries are based on

Electricity Supply Association of Australia (ESAA) publications. The inputs and outputs of various segments of the Australian State electricity industries (for example, labour, capital, fuel, expenditures) were also obtained from various ESAA publications. The inputs and outputs of the Snowy Mountain Scheme were estimated on the basis of pro-rata shares of NSW and Victoria. The Australian Capital Territory is merged with New South Wales. Therefore, the cross-section of the panel data consists of seven States including: NSW, VIC, QLD, SA, WA, TAS, and NT.

Most of the macroeconomic data was collected from the Australian Bureau of Statistics (ABS). These data include Gross State Products (GSP), labour force, capital formation, capital stock, population and the consumer price index.

CO_2 emissions are estimated on the basis of emission factors for fuels consumed in electricity generation, as provided by the National Greenhouse Gas Inventory Committee (1994).

Additional information has been obtained from web-sites of various organisations (for example, the Productivity Commission). Qualitative data have been obtained from libraries, internet search, and personal communications. Further details about data is provided in the corresponding chapters of this thesis.

With regard to software packages, all computations for micro-impact analyses are performed using Microsoft Excel. The mathematical models (Linear Programming (LP)) are solved using the built-in solver facility of Excel and a macro-program developed for this research (see Appendix 4.3). The model results have been double-checked using the DEAP program developed by Coelli (1996). Further, for econometric modelling Eviews 4.1 software package has been used (Lilien et al. 2002).

1.6 Significance of this Research

This research provides a deeper understanding of the historical, organisational and institutional aspects of electricity reform in Australia. It also makes useful conceptual and methodological contributions for conducting multidisciplinary research. The combination of methodologies used in this research provides a sound analytical framework for analysing policy issues not only on the topic of electricity reform, but also on infrastructure reforms (for example, gas, water, and energy) more generally.

This research provides useful inputs for electricity policy analysis, planning and management. It shows how knowledge residing in multiple disciplines (for example, philosophy, politics, economics, sociology, psychology, and engineering) could be coherently employed to inform an important policy topic.

This research makes useful suggestions about how to enhance the capability of conventional modelling tools, by including interdisciplinary content under different sets of assumptions. For example, how to analyse the impact in a situation where there is a relaxation in conventional behavioural assumptions of cost minimisation and profit maximisation. Such analysis could particularly be useful for productivity analysis – a major topic in infrastructure reform. The nature of inter-relationship between ex-post and ex-ante analysis, as determined on the basis of the application of problem-solving framework, could be useful for policy analysis.

Australian state and federal governments might find the results of this research interesting as they demonstrate the criticality of institutional issues in determining reform outcomes. A satisfactory redress of institutional issues is widely recognised by many commentators, as the key to furthering the reform program.

Further, academic researcher might find the political economy approach as an useful approach for understanding the subtleties of infrastructure reform.

1.7 Organisation of this thesis

This thesis comprises six chapters. Chapter 2 provides a comprehensive description of the evolution of the Australian electricity industry. Chapter 3 analyses the influence of human behaviour on shaping electricity reform, as an institutional phenomenon. Chapter 4 assesses the impacts electricity reform on the performance of the electricity industry and the wider economy. Chapter 5 demonstrates how insights gained from analyses in Chapters 2, 3, and 4 could be used to improve the efficacy of electricity reform. Chapter 6 provides conclusions.

Chapters 1, 2 and 4 have appendices for supporting the arguments in these chapters. Appendices are numbered corresponding to their respective chapters. Appendix 1.1 provides definitions for three fundamental concepts used in this research, namely, individuals, organisations and institutions. Appendix 1.2 gives details about the peculiarities of electricity. Appendix 2.1 lists some of the first recorded applications of electricity in Australia. Chapter 4 has six appendices. Appendix 4.1 provides a list of existing studies on impacts of electricity reform. Appendix 4.2 describes mathematical specifications of micro-impact models, used in this research. Appendix 4.3 shows Excel macro-program of this research for a typical micro-impact model. Appendix 4.4 describes the mathematical specification of the macro-impact. Appendix 4.5 presents the outputs of Eviews program for the macro-impact model. Finally, Appendix 4.6 contains comprehensive results of micro-impact models.

2 EVOLUTION OF THE ELECTRICITY INDUSTRY IN AUSTRALIA

2.1 Introduction

As noted in the previous chapter, the Australian electricity industry has undergone continuous organisational and institutional changes since its inception in the late 1880s. Several studies have reviewed the history of the Australian electricity industry, for example, ESAA (1973), McColl (1976), Rosenthal and Russ (1988), Linn (1996), Sharma and Bartel (1997), Booth (2003), and Spoehr (2003). Each study describes how the electricity industry has changed over time. Some of these studies also provide useful explanation for the reasons behind the changes in the industry's organisations, for example Sharma and Bartel (1997), Booth (2003), and Spoehr (2003). The objective of this chapter (and the following chapter) is to provide a more comprehensive description of the evolution of the Australian electricity industry, with a view to analysing the nature of the changes and, more specifically, the underlying reasons behind these changes. This analysis would demonstrate that electricity reform is an institutional phenomenon and that the contours of this institutional phenomenon are shaped by human behaviour. This chapter addresses the first element of this claim, namely that electricity is an institutional phenomenon. Chapter 3 addresses the second element of the claim (the role of human behaviour).

For this analysis, the history of the Australian electricity industry is partitioned into six periods, each marked by significant changes in the industry's organisation. The organisation is described here in terms of its technological, structural, ownership, and other socio-economic features. Further, with this argument – as the main research hypothesis of this chapter – that organisational changes are influenced by the underlying institutions (for example, culture, social beliefs, and economic ideologies), a description is provided for each time period about the changes in such institutions. The methodology for the analysis in this chapter is shown in Figure 2.1.

This chapter is organised as follows. Section 2.2 provides a brief description of the underlying institutions in Australia prior to the emergence of the industry (before 1888). This provides an appropriate institutional backdrop for the Australian electricity industry at the time of its inception.

Sections 2.3 to 2.7 provide descriptions of the changes in the organisations and institutions of the industry for subsequent periods. These periods include: the early years (1988–1913); the War and Depression Years (1914–1944); industry consolidation (1945–1985); internal reforms (1986–1993); and market reform (1994–present). In each section, there is a dual focus. The first focus is the institutional environment of the Australian economy, and particularly the Australian electricity industry. This analysis deals with global, national, and state contexts. The second is the electricity industry's organisations. Section 2.8 provides a summary of the major findings of this chapter.

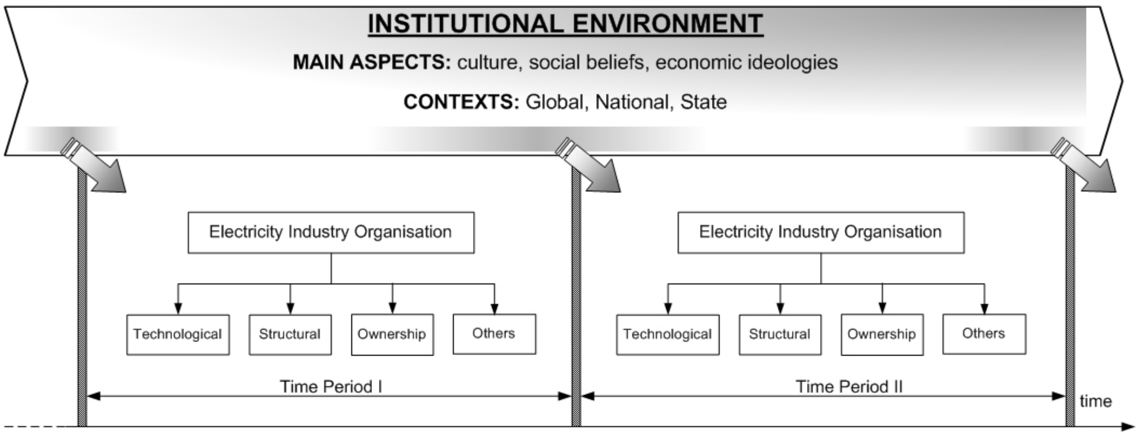

Figure 2.1 Methodology of Analysis: Evolution of the Australian Electricity Industry

2.2 Pre-electrification History (before 1888)

2.2.1 Evolution of Human Understanding of Electricity

Knowledge of electricity has existed for much longer than its modern usage. Primitive humans were familiar with various features of electrical power in nature, such as lightning in the sky and the special abilities of certain kinds of animals, such as the electric eel in the sea. There is also historical evidence suggesting that several applications of electricity and magnetism[4] were known from ancient times. For

[4] There is a close relationship between electricity and magnetism, which was scientifically explained in 1820 by Hans Christian Oersted (about.com 2004b).

example, there is emerging consensus that the term *electricity* was used for the first time in around 600 B.C., when Thales – Greek philosopher and mathematician – referred to amber's special characteristic in attracting light objects such as pieces of straw or feather.[5] It is also widely accepted that the natural characteristics of lodestones and their application in early compasses were known to the Chinese by as early as 200 B.C. (about.com 2004a). Further, it is generally acknowledged that the Parthians[6] were aware of *electroplating* and had invented the first battery – the *Parthian Battery*[7], sometime between 250 B.C. and 250 A.D. (Science Daily 2004a). Even the etymological origin of the term *electricity*, namely, its connection with the Greek term *elektron*, meaning amber (Habashi 2003, p. 1), suggests that human knowledge about electricity is indeed ancient.

Therefore, human knowledge about electricity has been accumulated gradually over a long period of time. Many ideas and mental models have contributed to this process since ancient times. As an energy form that is not visible, except in violent discharges, it has long held the attention of individual philosophers, scientists or adventurers. Ideas, concepts and mental models were then shared with other individuals and organisations and it influenced social cultures. This process resembles a continuous dialectical change in human knowledge, which forms the institutions (that is, culture, social belief, morals, conventions, norms, laws, or, in general, every shared mental model).

In Australia, as elsewhere, the electricity industry was not founded until key principles and understanding of electromagnetic (connection between electricity and magnetism) were discovered. Michael Faraday's (1791–1867) contribution to this understanding was crucial that led to the invention of early electromagnetic generators and dynamos. However, it was not until the invention of early commercial generators (known as Gramme dynamos named after Zénobe Gramme (1826–1901)) in 1870s, and commercial incandescent lamps (invented, simultaneously, by Joseph Swan (1828–1914) and Thomas Edison (1847–1931)) in 1879 that mass electrification became

[5] What Thales noticed is now called static electricity. Scientific discovery of the *electron* as a subatomic particle with constant negative charge was made by Joseph John Thompson in 1897.
[6] An ancient Iranian dynasty that ruled a territory bigger than current-day Iran including Mesopotamia, between 190 B.C. and 224 A.D.
[7] The *Parthian Battery* – also known as the *Baghdad battery* – was discovered in 1938 by a German archaeologist, Wilhelm König, near Baghdad. It has a structure similar to that of a modern battery (see Iran Chamber Society 2004; Science Daily 2004a, 2004b).

possible. Mass electrification required electricity industry. According to many historical surveys, the 1880s, therefore, mark the beginning of the electricity industry. For example, the establishment of a company in Newcastle in 1883 to produce Joseph Swan's newly-patented electric lamp is regarded as the starting point of the electricity industry in Britain (Simpson 2004). Thomas Edison's Pearl Street steam-electric plant, which was built in 1882, is considered to be the beginning of the electricity industry in the United States of America (Casazza & Delea 2003, p. 1). In Australia, the starting point of the industry is referred to as the year 1888, when Tamworth became the first town in New South Wales to have its streets lit by electricity (EANSW 1986, p. 1).

2.2.2 Australian History Prior to Electrification

One can divide Australia's history into the histories of Aboriginal Australia and modern Australia. This section focuses on the main aspects of the institutional environment of Australia after the arrival of the Europeans, assuming that the history of Aboriginal Australia has no impact on development of the electricity industry in this country.

Global context

Europeans first arrived in Australia as settlers in the late 18th century. Amongst the Dutch, Spanish, French and British explorers, it was the British who took the lead and colonised Australia. Captain James Cook took possession in 1770 in the name of Great Britain, but the formal declaration from the British Government was made in 1788 at the time of the first British settlement (Clarke 2002, p. 24). This opened a new chapter in the history of Australia – modern Australia. Six colonies were eventually established, and in 1901 they came together under a federated constitution to form an independent nation state within the British Empire.

The colonisation of Australia in the late 18th century occurred while significant changes were taking place in the mindsets of the world's leading nations (that is, Europe and America) as a result of the Industrial Revolution of the late 18th to early 19th centuries. Among the leading nations, England – Australia's motherland – is often recognised as the first industrialised country (Keris 2001). Influenced by Francis Bacon's (1561–

1626) writings and the emergence of Protestantism[8], social belief and ideologies in the western societies as well as the political power systems (in particular, the Catholic Church and governments) were seriously challenged by natural philosophy and science during the Industrial Revolution. Science and technology were in the process of significant and continuous improvement. The Industrial Revolution drastically improved the productive capacity of Great Britain – as well as Europe and America. The Industrial Revolution, according to Karl Marx, was regarded a transition from Feudalism to Capitalism[9] in terms of the mode of production of the western societies. Further, it was during this period that the mercantilist doctrine was replaced by Adam Smith's *laissez-faire* and free-trade doctrine. While the mercantilism focused on government intervention in trade and business, the classical *laissez-faire* doctrine emphasised minimum government intervention in economic activities and freedom of capital mobility.

These institutional changes had both positive and negative sides. On the positive side, symbols of tyranny, fanaticism, superstition, oppression and despotism (which, often, were associated with governments of the time) were swept away by the masses, and replaced with liberty and democracy. French revolution (1789–1799) is a typical example of such change. A more related example to the context of this section (that is, Australian history) is the American independence movement (1784–1790). This movement seems to have been very influential in British Government's decision to think of a replacement for its colony (that is, implicitly replacing America by Australia) – not knowing that soon Australia would also stand for its independence for the same institutional reasons (that is, to gain liberty and democracy).

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[8] The Industrial Revolution was deeply influenced by profound social and cultural changes triggered by the post-medieval Renaissance (that is, the intellectual and ideological changes that occurred in Europe from the 14th to 17th centuries). The social and cultural dimensions of the Renaissance were not just limited to technological changes in the society. Technological changes became the outcome of the more profound changes in theological and philosophical beliefs of the society. For example, the controversial debates of Martin Luther (1483–1546) against the Roman Catholic Church could be mentioned here as one of the most pivotal steps in the process of the Renaissance. It was the influence of Renaissance that eventually led to Industrial Revolution of the late 18th century and early 19th century.

[9] The term capitalism – due to its heavy political burden – later, especially in the 1950s and 1960s, has been used reluctantly and the term 'industrial societies', firstly used by F. A. Hayak, became widespread (Bottomore 1985, p. 46). However, this term, in the context of this thesis, simply refers to a mode of production or 'a system in which private capital or wealth is used in the production or distribution of goods' (LC 1998) – the essence of economic institutions in the west.

On the negative side, the improved productive capacity occurred at the expanse of the working-class (according to Karl Marx, the proletariat). This resulted in mass unemployment, increasing gap between rich and poor, unequal ground between nations in international trade, inter-individual and inter-national aggressions[10]. 'Man no longer treated men as men, but as commodity which could be bought and sold on open market' (Keris 2001). It was because of such "commodification" of man in the western society that Karl Marx constructed his criticism against capitalism and the *laissez-faire*.

All these events and institutional changes were not only influential in the colonisation of Australia, but also influenced the path of development of Australia.

National Context

The extent of historical changes in Australia from 1788 to 1888 (that is, from the beginning of colonisation to the beginning of electrification) is vast. Some of the key historical factors that have been influential in the process of economic development and electrification of Australia are discussed here.

First of all, the rapid growth of population mostly due to the waves of migration in the 1830s and afterwards played a triggering role for economic development in Australia. These migrants were people with high expectations, ambitions and hopes. The gold-rush in the 1850s had brought a new momentum for the economic development of Australia. The development of the mining industry in those years brought about a new flow of resources for the colonial economies. Further, the era of bourgeois liberalism in the 1860s and 1870s also played a key role in Australia's socio-economic development. It was during those years that the land laws of the colonies were changed. This changed squatterdom in Australia and the bourgeois in the cities made their stand on the principle of equality of opportunity, democracy and liberty[11] (Clark 1986). Furthermore, increase in the proportion of native-born Australians[12] and the rise of a nationalist

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[10] In fact, these problems were later counted by many experts as the main reasons behind the Great Depression and the emergence of Nazism and Bolshevism in the early to mid 20th century (see, for example, BBC Persian 2004).

[11] The uprise of Ned Kelly (1854–1880) against injustice also occurred during this period. One should however note that these events in Australia did not end the power of squattocracy, and eventually created a new bourgeois elite in the cities.

[12] In 1861 over 50% of population had been born in the United Kingdom. This ratio, by 1871, 1891, and 1901 had increased to 60, 75, and 82%, respectively (Clark 1986, p. 164).

movement during the 1880s, which peaked later during the 1890s, in accord with all other factors, shaped the Australian pattern of development (Clark 1986; Clarke 2002).

From an historical point of view, over the first 100 years of the development of modern Australia (1788–1888), the social beliefs of Australians were closely in harmony with the social beliefs of Britain. Many development programs in Australia were planned or commanded by the British during that period.

Booth (2003) provides a picture of a typical Australian of those days: 'who is an Australian?' For example, it is quoted from Dutton (1980) that Australians are '… the greatest democrats in the world … good mates, good fighters, good drinkers … chronically under-confident in their country and in themselves …' (Booth 2003, p. 158). Further, it is ascribed to Manning Clark that:

> … how … he (Clark) demolished some of the fashionable clichés as a cultural desert ("populated by well-fed barbarians, the descendants of convicts of social injustice, basking in a radicalised tradition"). Clark dropped what he called "these comforters of the past" and showed just how diverse and full of dramatic conflict Australia's past had been. He quoted D. H. Lawrence's irate comment that Australia was "the most democratic place I have ever been in. And the more I see democracy, the more I dislike it" (Booth 2003, p. 2).

Moreover, it is quoted from Dutton again that for many years Australians were '… people who … gave their deepest loyalty to Britain, calling Britain home' (Dutton & Peccinotti 1980, p. 10). For a typical Australian, being loyal to Britain has been very important. Perhaps it is because of such history that, as Booth mentions, there have always been strong ties to Britain. No matter how appropriate such a tie has been, this culture has been retained up to the present time. Although this culture was relatively demoted in the post-World War Two period and significantly replaced with a relationship with the USA (culturally, economically, and militarily), one can still observe that this culture and the extent of its strength has remained as one of the most important institutions in Australia. Perhaps the victory of the monarchist league in opposition to the republican movement that occurred in a referendum in the 1999 is an example in this regard. Australia has had a permanent alliance with Britain (also with the USA) in most of the worldwide military actions. It will be seen in this chapter that this institution has also played a major role in the formation of the electricity industry in Australia and its reforms through history (see also Booth 2003, p. 2).

Reviewing the history of the first 100 years of modern Australia reveals that social, cultural and political affinity with Britain and to its democratic values has been a major social institution in Australia. During this period and through such institutional affinity, the main social beliefs and economic thoughts in Australia included the principles of representative democracy, liberty, free market and capitalism. These institutions not only shaped the electricity industry in the early years, but also played major roles throughout other periods, which will be analysed in the next sections of this chapter. Knowing about these institutional facts makes it easier to understand why Australia adopted the British reform model in the electricity reform of the 1990s.

2.3 Early Years of the Electricity Industry (1888–1913)

The electricity industry in Australia – as noted earlier in this Chapter – started in 1888. Some applications of electricity, such as the telegraph and telephone, had however already been introduced prior to that year. Even electric lighting had been introduced prior to 1888 by arch lamps. However, the inception of the electricity industry is linked to the commercially successful electrification (especially lighting) of the Australian towns. This essentially happened in around 1888.

In the early years, electricity was relatively more expensive than other sources of energy and was considered as a luxury. In Australia – like elsewhere in the world – most of the early usages of electricity were luxurious too. For example, the first recorded usage of electricity in Australia was a battery-operated electric arc light, which was installed at the Sydney Observatory in 1863 as part of the celebrations of the Prince of Wales' marriage (EANSW 1986, p.1). Some more examples of the first recorded uses of electricity in Australian states are provided in Appendix 2.1.

The following analysis reviews the most important aspects of the institutional environment of the Australian electricity industry during 1888–1913 period (that is, prior to the beginning of World War One), in global and national contexts. The analysis is then followed by a description of the organisation of the electricity industry in terms of its technological, structural, and ownership aspects.

Global Context

During this period, the institutional environment of the electricity industry in the global context remained almost unchanged from the pre-electrification period. The principles of representative democracy, liberty, free trade and capitalism remained the main guiding rules for economic development and social well-being in the western world. One should however also note that protectionism has been (not often explicitly stated) one of the main principles of the western powers, since the 18th century. In other words, while free-trade and capitalism were officially propagated by the west as one essential principle for economic development at international level, protectionism was largely in place for internal administration of the western countries. Hence, *laissez-faire* and protectionism – though, conceptually, being in contradiction with each other – has worked very well for the benefit of the west. The Australian pattern of development was significantly influenced by these principles.

National Context

During this period, the electricity industry in every Australian state was limited to state capitals and rural towns. By the end of the nineteenth century, most of the Australian cities were reputed as among the world's most modern cities (Booth 2003). Such modernity was the outcome of institutional changes which took place during the pre-electrification period – as discussed in the previous section. The use of modern appliances of those days, such as the telegraph[13] and telephone[14] reflected part of such modernity. The extensive railway and tramway systems in the main cities – mostly electrified by the 1900s – were also symbols of modernity in Australia of those days. Further, the electrification of Australian towns and cities started as early as in most of the modern cities in the world. Therefore, the electrification of Australia was simultaneously a feature of development and a means for that development.

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[13] Invented by Samuel Morse in 1844 (about.com 2004e). In Australia: the first inter-city links in 1858, between Melbourne and Adelaide, and in the same year between Melbourne and Sydney (Clark 1986, p. 163)

[14] Invented by Alexander G. Bell in 1876 (about.com 2004d). In Australia, the first telephone exchanges were installed in: Melbourne in 1878, Brisbane in 1880, Sydney in 1881, Adelaide and Hobart in 1883 (Clark 1986, p. 164).

The declaration of independence from the British in 1901 was one of the most important institutional changes during this period. Although the process of this change, as a national social movement, started at the beginning of the electrification process, it had no significant impact on the process of electrification at the national level. This was essentially because there were no perceived economic benefits of developing a national electricity industry. Due to large distances between the residential and industrial centres, the process of electrification naturally remained outside the domain of national interests (ESAA 1973, p. 8). This feature of the industry resonates with what Blainey (1983) called the 'tyranny of distance' (see also ESAA 1973). Consequently, in the newly established confederation, the electricity industry remained as a state matter in the Australian constitution.

Another factor which contributed to the emergence of state-based electricity systems was states' desires to preserve their territorial sovereignty. The preservation of such sovereignty was, in fact, one of their main reasons behind states' willingness to join the confederation. Electricity, therefore, became a means for the states' to strengthen their territorial sovereignty. Such sovereignty, in turn, prompted further distinctiveness in the development of electricity industry. This, clearly, made any future national approach more difficult to be implemented. For example, during the 1950s and 1960s, despite the realisation of the economic benefits of a national approach to electricity, such approach was never adopted by the states. Booth (2003) metaphorizes the Australian states as 'warring tribes', who had a strong resistance against any national approach. Sharma (2003b) argues that 'fierce inter-state rivalries and a penchant for sovereignty, as epitomised by the "Australian rail gauge syndrome"' prevented the development of a 'national' industry in Australia.

The following sub-sections discuss the electricity industry's organisations in terms of technical, structural, and ownership dimensions.

2.3.1 Technology: Lack of Standards, No Transmission, British Origin

During this period, there were no common standards for electricity systems, either at intra- or inter-state levels. This, however, was not limited to Australia and was a world-wide issue. Being in its infancy, most of the electricity technology was not yet standardised. For example, a controversial debate was taking place regarding the advantages/disadvantages of Direct Current (DC) versus Alternating Current (AC) electricity. Since the early 1800s, when Alessandro Volta invented the first dry pile (about.com 2004c), electricity was introduced through DC, such as electricity produced by the first generation of batteries (for example, Volta's dry pile) and dynamos. In 1888, Nikola Tesla introduced AC electricity, and suggested that this would be a more efficient and effective way of providing electrical power. In 1893, George Westinghouse displayed the AC system at the Chicago World Fair (Hyman & Public Utilities Reports Inc. 1983).

Thomas Edison opposed AC in favour of DC, due to the heavy investment he had already made on the basis of DC electricity. But finally AC electricity proved its advantages – especially regarding its longer transmissibility and larger applications – and won out.[15] This victory affected the US electricity industry as immediately as the 1890s, because of the Niagara Power Project in which there was a need for transmission lines.

In Australia, DC electricity was largely in use in several towns up to 1920 (Scholz Electrical Company 2004). One of the first applications of AC electricity in Australia was the power plant in Charters Towers, about 140 km south-west of Townsville in North Queensland, which became the second town in Queensland outside Brisbane to have electricity. This plant obtained its order-in-council in 1897. It was a single-phase 110 volts generated at 95 Hz. This frequency for AC electricity seems very odd according to today's standards (ibid). However, during those days there were no specific standards for voltage and frequency, or for the type of DC or AC electricity.

Another technological feature of the electricity industry during this period was that generators were often located close to consumers and there were no transmission lines as such. Technically, no interconnection between two sources of generation was possible in those days.

In this period, most of the technology (that is, power plant and equipment) were imported from Britain by companies which were British-owned (privately) or were

[15] It is interesting to note that recently, High Voltage Direct Current (HVDC) has been applied for very efficient long-distance transmissions.

dependent to some extent on British finance and technical assistance (ESAA 1973, p. 23). Although, in the initial stages, there were British interests in this matter, as mentioned earlier, due to strong cultural ties between Australia and Britain, this tradition, to a large extent, has been retained until later periods.[16]

2.3.2 Structure: Fragmented, Fierce Competition

During this period, due to the technical features discussed above, the industry's organisation was fragmented and included a large number of companies. This situation could be observed in Australia as well as in other developed countries such as the USA and UK. For example, between 1887 and 1893, there were 24 companies within Chicago alone in the USA (Stoft 2002, p. 6). In the early 1920s, there were about 600 separate companies including 400 generating stations in England (Anonymous). In Australia also, the number of electricity companies was rapidly increasing before World War One (Scholz Electrical Company 2004). There was competition among numerous electricity companies. The competition was fierce and very costly. For example, companies had to invest substantial capital costs in order to attract a few more customers from their rivals to make more profits. Bankruptcies were widespread.

In 1898, the president of the National Electric Light Association in America, Samuel Insull solved this problem by acquiring a monopoly over all central-station production in Chicago. Insull stated that not only was the electricity business a 'natural monopoly' it should also be regulated and this regulation should be at the state level, not the local level (Stoft 2002, p. 6). By 1912, Insull monopolised the industry in the entire Chicago area. In Britain, arrangements about 'increasing returns to scale' were often discussed in the early 1990s (Anonymous). In Australia, the fiercely competitive situation continued until about the mid-1910s, when gradually state governments and major municipalities took some serious actions towards the electricity industries. Each state government, depending on its own socio-political conditions and priorities, acted differently though.

[16] Other countries that gradually started making their contribution, especially after World War Two, include the USA, Switzerland, Germany, and Sweden. In recent decades Japan has also played a major role and Canada has been added to the list of contributors. Further, after World War II there has been a rapid growth of local manufacturing, but some operating under licence to British firms (ESAA 1973, p. 23).

2.3.3 Ownership: Predominantly Private

The industry – the world over – was predominantly privately-owned during this period. In Australia, until the end of the nineteenth century, the industry was almost entirely under private ownership. The speed of public participation in the Australian electricity industry was different in each state. In New South Wales (NSW), one of the first pieces of legislation to open the road for public ownership in the industry was the Municipal Council of Sydney's *Electric Lighting Act, 1896*. On the basis of this Act a right was given to the Council to generate and supply electricity within the city area and also to places outside the city limits. The Council's electricity undertaking began its operation in 1904, when the first Pyrmont Power Station was officially opened (EANSW 1986). However, a mixture of private and public ownership existed across the Australian states during this period, with a larger proportion being held by the private sector.

Concerted steps towards government ownership and control in some of the Australian state electricity industries, such as in NSW and Victoria, took place after the 1920s. However, some of the states, such as South Australia and Western Australia, did not consider public ownership to be necessary until the end of World War Two.

2.4 The War and Depression Years (1914–1944)

During this period, electricity demand started to slowly increase, and electricity started to be viewed as less of a luxury and more a necessity. The Australian state governments also began to realise the development potential and political appeal of electricity (Sharma 2003b). The institutional environment of the Australian electricity industry during this period is discussed below in the global and national contexts.

Global Context

During this period, the world was faced with considerable turmoils. The institutional environment of the industry in terms of the world's mainstream culture, social beliefs and economic ideologies consequently was profoundly influenced by the events of this period and was subject to significant instability and chaos. Some of the most important events during this period included: World War One, the revival of Marxism[17], the

[17] The Marxian school of thought emerged soon after the death of Karl Marx (1818–1883), under the leadership of Marx's inner circle of companions and co-writers, especially Friedrich Engels (1820–1895).

Bolshevik Revolution in Russia of 1917, the Great Depression of the early 1930s, the emergence of the National Socialist Party in Germany, and World War Two.

National Context

The Australian polity and economy were also influenced by these global issues. As mentioned earlier, due to the strong ties with the British, Australia was not to leave Britain alone in the battle-fields and this was also formally institutionalised in the Australian Constitution. 'Australia had no right to declare war or even to choose neutrality. As an automatic result of Britain's declaration of war … Australia was also at war' (Clarke 2002, p. 104). 'To our last man and our last shilling'; this was a slogan heard during those days to support the British in the War. These facts do not mean that there was no opposition to the War, but this, according to Clark (1986), was politically very weak. In addition, there were still many first-generation – British-born – migrants. Moreover, everybody had the impression that the War 'would be over' by the Christmas of 1915 (BBC 2004). Thus, when recruitment for the Australian Imperial Forces started, 50,000 had enlisted (Clark 1986). It was only after the ANZAC's high casualties that public opposition to the War started to be reconsidered more seriously.

During this period, there were other institutional similarities between Australia's socio-political approach towards worldwide issues with those of Britain's (and also the USA's). Among these similarities was the position of Marxism in the Australian political system and intellectual thoughts during the late nineteenth and early twentieth centuries. Marxism traditionally remained at the margin of the political forces in Australia ever since the early stages of the labour movement. As Joseph Schumpeter said, in America (true for Australia too), until the 1920s 'What Marxism there was always had been superficial, insignificant and without standing' (1950, p. 3). Nevertheless, a revival of Marxism in the intellectual thoughts in Australia and other English-speaking countries was significant during this period. After World War One, new political parties were formed in Australia, including the Communist Party of

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However, the Marxian school was soon entangled with "Revisionist" debates. For example, in 1899 Eduard Bernstein (1850–1932) challenged the Marxian notion of inevitability of the economic breakdown of capitalism and argued that if socialism is to exist, it must be a conscious choice, channelled through the political and educational system, instead of an "inevitable" revolution. A similar position was taken by Sidney Webb (1859–1947) and the Fabian Socialists in Great Britain and Jean Jaurès (1859–1914) in France (New School University 2004).

Australia in 1920. However, this party - likewise its sister in the UK and USA – 'did not become a significant political force' (Clarke 2002, p. 115). The reason was mainly due to strong political desire among the main political parties in Australia (that is, the Conservative and Labour) to marginalise Marxism and lessen its public appeal. Similar institutional environment existed regarding communism in the UK and USA.[18]

The revival of Marxism in Australia and other English-speaking countries, right in the midst of World War One and in the 1920s was regarded (by the main political parties) as a serious threat for socio-political institutions in the western world. It was not merely because of the Bolshevik phenomenon, but essentially because of Marx's criticism of capitalism, which were always serious and undeniable. However, what Marxists believed was that the only way of resolving the inherent socio-political problems of capitalism would be through a proletarian revolution. During this period, the Great Depression of the 1930s was already interpreted as a proof of Marx's predictions for the collapse of capitalism. Such belief (whether based on a right prediction or not) fuelled serious political tensions between the west and the Soviet Union (later, together with its allied nations, named as the Marxist or Eastern bloc or, briefly, the east), where Marx approach (that is, proletarian revolution) was already employed. These political tensions formed the nucleus of an ideological war between the west and east, later known as the Cold War.

In the post World War Two period, the Cold War was further fuelled by political tensions arising from the emergence of Stalinist model of Marxism in the Soviet Union, which later proved to be absolutely totalitarian. These socio-political tensions between the west-east eventually led to the embrace of Keynesianism throughout the western world – as a non-Marxian solution for Marx's criticism of capitalism.

It is interesting to note that in the Marxist bloc, the electricity industry had been given a special place. In 1920s, Lenin, the leader of the Bolshevik Revolution in Russia, stressed the role of electricity in his famous phrase: 'Communism is Soviet power plus electrification of the whole country' (cited in Booth 2003, p. 8).

[18] The Conservative and Labour parties in the UK and the Republican and Democratic Parties in the USA, respectively, played the same roles in marginalising the Communist parties in these countries.

During this period, the development of the electricity industry was slow. The main reason contributing to this slowness was the special conditions during the Wars and the Great Depression. In spite of such slow development, the electricity industry's organisation made some progress in terms of its structure and technology. Some of the main features of the industry's organisation are analysed below.

2.4.1 Technology: Standardisation

In spite of the slow growth in demand, technological improvements and the process of standardisation in the electricity industry were considerable in this period. Some of the technological achievements ironically are indebted to the Wars. In this period radio, refrigerator, television, gas turbines, jet engines, jet flight, sodium lights, large thermal plants, the possibility for longer transmissions (from 11 kV for about 35 km in 1893, increased to more than 290 kV for above 430 km in 1936 (Hyman & Public Utilities Reports inc. 1983)), and atomic fission (and eventually the atomic bomb) were among the most significant technological achievements.

As mentioned in the previous section, the AC electricity has already proven its advantages and took over from DC electricity. In Australia, it was during this period that DC electricity was broadly replaced by AC electricity. This replacement soon caused a lot of voltage and frequency issues within and across states. The process of standardisation of voltage and frequency, especially at the state level, was accelerated. The progress of this process at the national was however slow due to the 'tyranny of distance' and inter-state rivalry.

For example, in Victoria, the frequency of 25 Hz was adopted for railway traction and 50 Hz for lighting and other general usages. These were British standards (Booth 2003, p. 30). In Western Australia (WA), whose electricity industry was, and is still, totally isolated from the rest of the country, the situation was more complicated than in other states. The development of the electricity industry in WA was strongly influenced by the discovery of gold. Most of the mining machinery and associated equipments were imported from the USA and were designed for a frequency of 40 Hz. Although in the USA 60 Hz was used for other purposes than traction, the Western Australian system was initially set on only 40 Hz (Booth 2003, pp. 121-41). Later, as demand grew in residential areas, some power stations were also installed based on 50 Hz. Thus, both 40

Hz and 50 Hz standards were in use. During this period, a series of controversial debates took place for standardising the frequency system in Western Australia between 25 Hz vs 40 Hz for traction purposes, and 50 Hz vs 40 Hz for general purposes. Finally, the decision was made to adopt 40 Hz for traction purposes (different from the other States). Further, in 1944, the Commonwealth agreed to pay half of the conversion costs, up to maximum of £300,000 for standardising to 50 Hz for general purposes state-wide (Western Power 2004). The project was completed in the 1970s. Another issue was that electricity voltage in this state has remained different from other States (see Booth 2003, p. 124).

The main feature of AC electricity is its advantage in longer transmissibility. During this period transmission lines became a part of the electricity industry. The interconnection between various sources of electricity supplies was another important development during this period. For example, in New South Wales, electricity industry was interconnected between the main electricity authorities. The path for such development was prepared under the 1935 Act (mentioned above). World War Two made such interconnections an emergency measure. Thus, by 1940, the first interconnection of 132 kV was built by the Southern Electricity Supply between Port Kembla and Burrinjuck power stations. At the beginning of World War Two, four electricity authorities were supplying about 95% of the electricity consumed in New South Wales. These included the Sydney County Council, Electric Light and Power Supply Corporation Ltd. (Balmain), the Department of Railways, and Southern Electricity Supply (EANSW 1986, p. 2). The interconnections between these electricity authorities, although with limited capacities, later proved their value during the years between 1946 and 1953, when electricity shortages occurred (ibid).

In Victoria too, similar interconnections were embarked upon by the establishment of the State Electricity Commission of Victoria (SECV). According to Booth (2003), the term ‘linking-up’ was used for the concept of interconnection by Sir John Monash, the first Chairman of SECV.

One should remember that during this period any power transmission required full co-ordination beforehand between two sources of supply. Otherwise, it could have caused instability in the power system. There was no automated load frequency controller.

Technological improvements in this regard were later achieved in the late 1970s, when third-party accesses to the grid became possible (IEA 1999, p. 22).

2.4.2 Structure: Divergent Legislations, Heterogeneous Statutory Authorities

During this period, the Australian state governments started to pass a series of laws to regulate the industry. These legislative actions were not coordinated across states and were merely based on individual states' interests. Consequently, states' approaches toward the electricity industry were considerably different from each other in terms of their organisational structure.

In New South Wales, the Municipal Council of Sydney *Electric Lighting Act 1896* provided the Council with the right to generate and sell electricity in the city area and also to places outside the city limits. By 1904, when the Pyrmont Power Station was opened, existing private companies and the Redfern Municipal Council's electricity undertaking (public), which were supplying electricity in the city area, were all acquired by Municipal Council of Sydney. Further legislation was passed in 1904, 1906 and 1919, granting further franchises to local government bodies. The *Local Government Act 1919* became the principal Act, which gave various rights and responsibilities to local government bodies in the establishment and operation of electricity trading undertakings (ESAA 1973, p. 31). Soon, electricity trade in New South Wales that was initially developed as a minor service of councils grew and became, in many cases, the main function of councils (EANSW 1986, p.1).

A more serious step in the co-ordination of development plans among electricity authorities was made by the enactment of the *Gas and Electricity Act 1935*. This Act established the Sydney County Council, which was responsible for distribution of electricity in a large part of Sydney's metropolitan area. The Act further amended the *Local Government Act 1919* in certain respects. In spite of these developments, it was not until the end of World War Two that centralisation empowered the industry authority in New South Wales (McColl 1976, p. 6).

In Victoria, during this period, the State started to adopt a new organisational structure for the electricity industry that was later followed by other states. In 1918, the Victorian Government decided to exploit the State's Latrobe Valley brown coal resources in order to avoid any possible supply shortages and reliance on imported coal from New South Wales. Feasibility studies for the use of these resources dated back to the nineteenth century. The development of these resources, however, began after the establishment of the panel of Electricity Commissioners in 1918 (Booth 2003, p. 30; McColl 1976, p. 6). This was partly in response to a strike on the New South Wales coal fields, which caused serious coal shortages in Victoria (McColl 1976, p. 97). This ultimately led to the establishment of the SECV in 1921, taking over from the temporary panel of Electricity Commissioners (Booth 2003, p. 30). The SECV was a statutory authority. It is worthwhile to spend a few lines in describing the Statutory Authority, its historical origins and institutional underpinnings.

Put simply, a Statutory Authority – in the context of Westminster-style Parliamentary democracies – 'is (generally) a public sector organisation established by a specific Act of Parliament' (Johnson & Rix 1991, p. 92). Thus, it is clearly different from a Ministerial Department in that its existence is free from any Act of parliament or 'legislation' (ibid 1991, p. 93). Statutory Authority is responsible for managing assets and/or other functions of the government (for example, regulation), in a manner commensurate with the government policy objectives and priorities (Sharma 2004b). It is interesting to note that a Statutory Authority has a longer history than the Ministerial Department (Johnson & Rix 1991, pp. 93–4). According to Sharma (2004b):

> The main rationale behind the creation of statutory authorities in Australia was to enable them to perform their assigned roles in a professionally autonomous manner, under the guidance of a professionally-oriented board, removed from day-to-day operational interference by the relevant minister. This is in contrast to a government department, which is directly accountable to the minister on a day-to-day basis, and the minister, in turn, is personally responsible to the parliament for the conduct of the department. According to Quiggin (2001), 'Statutory Authorities were … an organisational innovation arising from the recognition that the structure of a government department was not appropriate for an organisation primarily involved in the production of marketed goods and services'. The statutory authorities – by virtue of their status as public entities - had access to capital at much lower rates as compared with the private sector.

> This … ensured that adequate and timely investments were made by the utilities. The system security risks were therefore non-existent.

Further, regarding the electricity industry in Victoria, it is interesting to note that according to Kellow (1996, p. 130):

> (SECV) was established as an independent statutory commission, not just because of the need to ensure that technical rather than political rationality infused the organisation but also because Victoria had pioneered this form of institutional arrangement after a series of scandals in the nineteenth century involving political decisions over routing rail lines to the advantage of particular land developers.

The formation of a central Statutory Authority in Victoria was a radical structural reform in the Victorian electricity industry, which led to an amalgamation of all private/public electricity undertakings in this State. The reform created a vertical integration in the industry from coal mines to supply of electricity. This organisational structure of the electricity industry remained in Victoria for a long period of time until the State initiated another radical reform in the 1990s, which will be discussed in Section 2.7.

Queensland was the first state to follow the Victorian Model. The *State Electricity Commission Acts 1937/1965* constituted the State Electricity Commission of Queensland (SECQ) and set out its powers and duties (ESAA 1973, p. 36). The SECQ was responsible for overseeing the development plans for the electricity industry and advising the Government. Like Victoria, it was responsible to a single Commissioner, rather than a Board of Commissioners – as was the case in New South Wales (Booth 2003, p. 91).

In South Australia and Western Australia, the organisational structure of their electricity industries were largely changed into franchised monopolies (under private ownership). The bulk of the electricity in specific areas was produced by monopolies that were granted franchises from State Governments. For example, in South Australia, with the passing of the *South Australian Electric Light and Motive Power Act 1897*, the South

Australian Electric Light and Motive Power Company Limited (SAELMP) was granted a franchise to supply electricity. The SAELMP was already established in 1895, but under the new legislation became the largest electricity provider (a private monopoly). The Act 1897 empowered the SAELMP to ‘generate, accumulate, and supply electricity for motive power and lighting purposes, and by means of electricity, to light cities, towns, streets, docks, markets, public and private buildings and places’ (Spoehr 2003, p. 10). The *Electricity Act 1943* ‘established an Electricity Commission with certain investigating powers in relation to the generation, supply and price of electricity in the State’ (ESAA 1973, p. 38). This commission was later substituted by a Trust in 1946 (see next section).

In Western Australia, perhaps one of the most important pieces of legislation during this period was the older version[19] of the *Electricity Act 1937*, which led to the formation of the Electricity Advisory Committee. The establishment of the South West Power Scheme – as a public body – was proposed by this committee. A Royal Commission rejected this proposal, after completing its investigations into it in 1940 (Western Power 2004).

In Tasmania, the State was the first to establish a State-wide authority responsible for electricity generation. The Hydro Electric Department (HED) was formed in 1914 to take care of the development of the electricity industry. The pattern of economic development in Tasmania then followed on the basis of the continual development of hydroelectric resources, advised by the HED. This pattern of development latter became well-known as ‘hydro-industrialisation’ policy (Booth 2003, p. 117). The major organisational body for the hydro-industrialisation policy was the Hydro Electric Commission of Tasmania (HEC), created from the HED in 1930. The HEC acquired the distribution networks operated by private companies. Thus, it became a vertical integrated organisation responsible for generation, transmission, and distribution in Tasmania (McColl 1976, p. 5).

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[19] In ESAA (1973), the years for this Act are mentioned as 1945–53, whereas the abovementioned information is taken from Western Power (2004). Thus, the Act is referred to as the older version.

2.4.3 Ownership: Mixture of Private and Public

During this period, it was widely argued that the industry was under an increasing returns to scale or natural monopoly condition. This means that 'total costs of production are lower when a single firm produces the entire industry output than when any collection of two or more firms divided the total among themselves' (Eatwell et al. 1998, p. 603). Under this condition, formation of a monopoly would be a natural outcome of free competition. This was the same argument that Insull stated in 1898 (Stoft 2002, p. 6). The argument appeared in almost every textbook in the economics of electric utilities, from then until the late 1980s, when the soundness of the argument was challenged (see Hunt & Shuttleworth 1996, p. 2).

During this period, two different types of ownerships were observable across the states. In NSW and Victoria, the industry was largely handed over to the public sector. In the 1930s, Queensland and Tasmania also moved their electricity industry to the public domain, while the electricity industries in South Australia (SA) and WA remained under private ownership, albeit under a strong regulatory framework.

2.4.4 Other Features: Informal Provisions for Co-operation

The Electricity Supply Association of Australia (ESAA) was founded in 1918. The main reason behind the formation of ESAA was the importance of the co-operation and organisation of its members. The membership of the ESAA was open to: '(i) any State Authority constituted by statute for the purpose of regulating or controlling the supply or use of electricity throughout the State; and (ii) any properly constituted body whose principal function and activity is the generation, transmission or distribution under statutory authority of electricity consumed primarily by the general public' (EANSW 1986, p. 7). The organisation was expected to facilitate further standardisation and organisational convergence. Such an objective informally puts forward the need for co-operation and co-ordination at state and national levels. This seems to have become more evident in the years after World War Two.

2.5 Industry Consolidation (1945–1985)

After the end of World War Two, the reconstruction from the ruins of the War resulted in the establishment of massive electrification programs around the world. Electricity demand started to increase rapidly during this period. In Australia, the state governments began to realise the increasing development potential and the political appeal of their electricity industries. Therefore, the states started to progressively enact new legislation to own and directly operate their electricity industries (Sharma 2003b).

In the following analysis the main aspects of the institutional environment of the electricity industry are analysed in global and national contexts.

Global Context

In the global context, some of the most important events included: the establishment of the United Nations (October 1945) and the emergence of humanitarianism; the wave of nationalisation and independence of formerly colonised countries; the emergence of the Keynesian economics; the rise and fall of the Bretton Woods system (1944–1971) and the formation of the World Bank and International Monitory Fund (IMF) in 1944; the two oil shocks of 1973 and 1979; the stagflation of the 1970s and early 1980s; the peak of the Cold War in the 1980s; and the fade-out of Keynesianism, particularly from government's rhetoric in their macroeconomic policies.

A quick look at these events reveals that the nature of changes in the institutional environment of the electricity industry significantly varies from the beginning to the end of this relatively long period. The following discussion is only focused on those institutional aspects that contributed to shaping the organisational structure of the electricity industry during this period. This relates to the events before the 1970s. The events of the 1970s and the 1980s in global and national contexts are analysed in the next section of this chapter. This is simply because the events of the 1970s and 1980s significantly influenced the electricity reforms of the 1980s and 1990s.

One of the most important institutional changes in terms of economic ideologies that had a great influence on the re-formation of the industry's organisation during this period was the rise of the Keynesianism as an intellectual and philosophical force in the western economies, including Australia. John Maynard Keynes (1883–1946), a British economist from Cambridge, published his famous book, *The General Theory of Employment, Interest and Money*, in 1936. This book formed the foundations of a new branch of economics (that is, *macroeconomics*) and played a major role in the post-war economic boom of the western countries.

In order to understand the importance of the Keynesian school of thought, there is a need to compare it with the Marxian school of thought. Both Marxian and Keynesian schools of thought provided non-classical approaches and criticised the doctrine of *laissez faire* – for its inefficiency in terms of problems such as high unemployment and inflation. The Marxian approach claimed that western economies required a radical change and that such change would inevitability occur in the form of a proletarian revolution. The Keynesian approach argued reform would resolve the inherent problems of the *laissez faire* doctrine instead of an inevitable revolution. This approach argued that some government intervention in the economy would help overcome problems such as high unemployment or inflation. This approach successfully helped western economies to recover from the Great Depression. Although neoclassical economists were deeply unhappy with both approaches and opposed them, the Keynesian approach soon found its political acceptance in western countries and eventually proved its workability. As mentioned in section 2.4, Keynesianism was well received throughout the western countries also because, from a political point of view, it provided a non-Marxian approach. This implied that a reform can be launched by governments before it is too late (that is, when a proletarian revolution becomes inevitable). In other words, the Keynesian approach provisioned an active role for governments in response to inherent social problems of capitalism and *laissez-faire* doctrine – as raised by Marx.

The other important institutional change that had a significant influence on the post-War economic boom, but has not been given adequate attention, was the agreement achieved at the Bretton Woods Conference. The Bretton Woods Conference led to a new institutional arrangement for governing the international economy. Keynes played a key role in this agreement as well. In fact, during those days, many experts argued that the emergence of Nazism in Germany and Communism in Russia (although the latter was not directly mentioned due to the presence of the Soviet Army on the Allies' side) were a direct consequence of the lack of any consistent and fair international monetary system (for example, see BBC Persian 2004). Further, some people still believe that much of the credit for the post-War economic boom should be given to the Bretton Woods agreement (as an institutional achievement). The principal institutional arrangements of the Bretton Woods agreement were to: (i) promote fair international trade and economic harmony, (ii) fix exchange rates between currencies, and (iii) agree on convertibility between gold and the US Dollar. Except for the first item in respect of which the world has adopted an alternative (yet controversial) arrangement, none of these arrangements have survived after the demise of the system in 1971. The roles of the World Bank and the IMF were also significantly changed after 1971 (Soros 2002) and eventually became political tools of the USA dominance. International effort to create an alternative for Bretton Woods agreement (for example, the World Trade Organisation) is far too controversial. While the rise of Bretton Woods system helped economic boom during post-War era, its fall led to issues which will be discussed in Section 2.6.

National Context

At the national level, the most important historical events included: the general wave of nationalisation in a number of industries, including electricity industries, new waves of immigration, full employment and the increase of social welfare pre-1970, and stagflation in the early 1980s. Two other important events included the formation of the Liberal Party of Australia (in 1944) and, a strong mobilisation of the mainstream political desires for outlawing the Australian Communist Party (in 1950). These events, as mentioned earlier in section 2.4, eventually led to successful marginalisation of the Australian Communist Party in the post-War era.

Regarding the impacts of the above-discussed global issues on the Australian economy, each issue had a unique story in the Australian national and state context. For example, Keynesianism, as a non-Marxian approach (mentioned earlier), played a significant role in the marginalisation of communism in Australia. In this regard, Spoehr (2003) explains how Keynesian ideas legitimised nationalisation policy under a liberal government in South Australia, after World War Two. Spoehr also comments that in this case, notwithstanding the original neo-liberal economic views about the sanctity of private ownership, the political acceptance of Keynesianism was mainly because of its non-Marxian approach (Spoehr 2003p. 9–26). Further, Keynesian policies were already adopted by the UK and energy industries were nationalised on a large scale in the UK.

It was under such an institutional environment that the electricity industry was developing rapidly during this period. The post-war era, until the end of the 1960s, was called the *golden age* for the electricity industry. Three main factors contributed to the rapid development of the electricity industry during the golden age: (i) economic growth that, in turn, increased electricity demand, (ii) economies of scale of large capacities because of technological improvements, and (iii) future certainty due to a relatively stabilised international economy (Johnson & Rix 1991, p. 78).

The following sub-sections present the industry's organisation in terms of its main features during this period.

2.5.1 Technology: Giant Plants, Inter-state Interconnections

Due to the increasing returns to scale of the electricity industry, most of the research and development activities were directed towards larger-sized designs for generation and transmission. Significant developments were made. As a result, during this period, many large hydro or thermal plants were designed and constructed. For example, the Snowy Mountains Hydro Electric Scheme (SMHES) was one of the largest plants of its type in Australia. It is still known as 'the largest engineering project ever built in Australia' (Pyers 2001, p. 16). The SMHES started in 1949 and finished in 1974.

The uniqueness of the SMHES in the Australian electricity industry was not limited to its large size. It was also the first reliable inter-state interconnection in Australia. The 330 and 132 kV voltage levels were adopted for this interconnection (between NSW and Victoria). This helped the two states benefit from their peak/off-peak time lags (McColl 1976).

2.5.2 Structure: Vertical Integration (Central Statutory Authority)

Power development in Australia during this period – as in the previous periods – was a state matter. However, establishment of the SMHES gave a national dimension to the industry's organisation. The following analysis is thus presented in national and state contexts.

National Context

Before the SMHES, although some power lines occasionally crossed states' borders to supply nearby towns, those lines were not able to provide appreciable power transmission between states (see Boehm 1956). The situation was understandable, especially in the early stages of the industry, because of Australia's special topology. However, as the country started to enjoy the post-war economic boom, needs emerged for construction of inter-state interconnections. In those days, Boehm (1956) argued that there was little doubt about the economic justification of inter-state interconnections for the same reasons that had brought integrated state systems inside each state.

In Section 2.3, it was mentioned that the electricity industry in Australia is constitutionally a state matter. This made any national approach for the electricity industry politically very challenging, regardless of its economic merits. Quiggin (2001), in this respect, argues that the example of railways suggests the fact that inter-state interconnection would have happened regardless of its economic soundness, if there were no such political complexity. The case of SMHES practically supports this argument. The results of some economic analyses on SMHES suggested that the scheme was not fully justified from an economic point of view (see McColl 1976). It was argued that the private sector would have never been interested in constructing such a scheme (Johnson & Rix 1991, p. 19). Therefore, the economic gains of a national approach towards electricity industry could not be the only criterion behind the decision for such an approach. Political acceptability and social gains should also have been taken into account.

The organisational structure of the SMHES is jointly operated and financed by the Australian Capital Territory, New South Wales, and Victoria. The Australian Capital Territory is allocated a fixed energy output of 670 GWH per annum and the surplus is shared between New South Wales and Victoria on a two-thirds and one-third basis, respectively. The operation of the scheme is directed and controlled by the Snowy Mountains Council (another Statutory Authority), a body constituted under the Commonwealth-States Agreement of 1957 on the basis of the *Snowy Mountains Hydro-Electric Power Act 1949/1958*. This Council consisted of representatives of the Commonwealth Government, the Authority, and the State Electricity Commissions of New South Wales and Victoria (EANSW 1986).

State Contexts

So far it has been observed that various organisational structures were used in the Australian states' electricity industries. One such organisational structure was the Statutory Authority, which was adopted during the previous period by New South Wales, Victoria, Queensland, and Tasmania. Further, it has been noted that Victoria and

Tasmania applied a completely central Statutory Authority (that is, a single vertically-integrated body), whereas the cases of New South Wales and Queensland mainly consisted of a number of such authorities.

The pace of changes towards the adoption of Statutory Authorities was different from state to state (see Boehm 1956). In New South Wales, as early as 1904, the Municipal Council of Sydney began to take control of reticulating electricity, when its first power station (that is, Pyrmont) was opened. The first serious movement towards a kind of Statutory Authority started when the State Government introduced the *Gas and Electricity Act 1935*, which established the Sydney County Council. The electricity industry of this State gradually moved from a set of isolated authorities to a central body.

In the post-War era, the need for such a central body became increasingly evident. The State Government passed the Electricity Development Act in 1945. This Act led to the establishment of electricity authorities 'with powers to promote and regulate the co-ordination, development, expansion, extension and improvement of electricity supply throughout the State' (EANSW 1986, p. 2).

Between 1946 and 1953, there was power shortage in New South Wales. This was mainly because of the drastic increase in post-war electricity demand. The power shortage became extremely serious by early 1949, and in May 1949 an Emergency Electricity Commissioner was appointed with the power to direct supply authorities to ration electricity supply and interrupt it in any area if necessary. The centralisation of the electricity industry officially started in the State through the establishment of the Electricity Commission of New South Wales (ECNSW) in 1950 on the basis of the *Electricity Commission Act 1950*. This was a vertically integrated body formed by the amalgamation of the main transmission and the four former generation authorities. The ECNSW quickly installed some diesel and small steam power stations to manage the immediate power shortage, and initiated the development of large power plants. This eliminated of all power restrictions by the winter of 1953 (ibid).

The next structural change in the state's organisation was when the *Energy Authority Act 1976* constituted the Energy Authority of New South Wales (EANSW) as an independent regulatory body of the industry. 'The principal activities of the Authority included the promotion of development of and wise use of energy and energy resources in the State' (ibid, p. 4). Therefore, the approval of the EANSW was required for every new generation station or transmission line.

Further, from 1945 to 1980, the process of the horizontal consolidation of the electricity supply authorities in New South Wales was occurring as well. Such horizontal consolidations were taking place within different types of electricity supply authorities. The number of County Councils, Municipal/City Councils, Shire Councils, Franchise Holders, and Government Undertakings in 1947 was 11, 82, 45, 47, and 3, respectively. The number of County Councils operating electricity supply authorities increased to its maximum, 37, in 1959, and then decreased to 23 in 1980. The number of other authority types continuously decreased and reached to 1 by 1980 (for further details see EANSW 1986, p. 4).

In Victoria, a centralised Statutory Authority was already in place as early as 1921, when the SECV was established. Thus, generally no significant organisational change occurred during the period 1945–1980. However, two new Acts, passed in 1958, further enhanced the integration of the SECV. The *State Electricity Commission Act 1958* set significant roles for SECV in the operation, management and development of the generating and transmission functions of the industry.

Further, the *Electric Light and Power Act 1958*, while providing for the granting of Orders by the Governor in Council to a distribution or reticulation body within a specific franchised area, further provided for supervisory and control responsibility over these bodies to be exercised by SECV (ESAA 1973, p. 33). In Victoria, therefore, there was no independent regulatory body as there was in New South Wales (that is, EANSW). However, the State's electricity industry was governed on the basis of statutory regulations. Such statutory regulations were administered by the SECV. Details of these regulations are listed in ESAA (1973, p. 34). Therefore, the industry and the regulatory body were the same entity.

In Queensland, while the organisational structure remained unchanged, new legislation further provided more central responsibilities to electricity authorities by regions. The

Regional Electric Authority Acts 1945/1964 'provide(d) for the constitution of and define(d) the functions of regional Electric Boards … Each Board (was) empowered to supply electricity and to trade in electric appliances …' (ESAA 1973, p. 36). The *Southern Electric Authority of Queensland Acts 1952/1964* 'established the Southern Electric Authority of Queensland' (ibid). Finally, the *Northern Electric Authority Act 1963/1964* 'established the Northern Electric Authority of Queensland as the authority responsible for generation and main transmission in North Queensland generally and supplies electricity to Cairns, Townsville, and Mackay Regional Electricity Boards …' (ibid).

In South Australia, the *Electricity Trust of South Australia Act 1946* established the Electricity Trust of South Australia (ETSA) and substituted it for the Commission. This Act defined ETSA's 'power and duties, and vested in the Trust the undertaking of Adelaide Electric Supply Company Limited' (ESAA 1973, p. 38). Three other Acts were also passed in 1950, 1962-65, and 1963, respectively, that gave ETSA more central power regarding country areas, subsidies, and industries (see ESAA 1973).

In Western Australia, three Acts shaped the new organisational structure of the electricity industry of this State in 1945. The State Electricity Act of 1945–1966 constituted the Commission and gave it 'necessary powers to generate, transmit, supply, and control development of electricity throughout Western Australia' (ESAA 1973, p. 40). The *Electricity Act 1945/1953* set out the rights and obligations of supply authorities and enabled regulations to be made covering various matters relating to electricity. Finally, the South-West State Power Act of 1945, 'empowered the State Electricity Commission to establish the South-West Power Scheme' (ibid).

In Tasmania, no significant organisational change took place over this period, and, based on the *Hydro-Electric Commission Act 1944* and its amendments in the following years the Commission took control of the electricity industry all over the state.

In the Australian Capital Territory (ACT), *the ACT Electricity Supply Act 1962/1966* established the ACT Electricity Authority and defined the powers, duties and responsibilities of the Authority. Further, the *Electricity Ordinance 1963* gave more responsibilities and powers to the Authority in the installation of equipment and wiring works and similar matters (ESAA 1973, p. 44).

2.5.3 Ownership: Predominantly Publicly-owned

The electricity industry in Australia during this period underwent a secular movement away from its original pattern of many independent privately- and publicly-owned undertakings to a co-ordinated industry under a more central statutory authority (one or a few of such authorities) in each state (Boehm 1956). The assets of electric utilities were fully owned by the governments. In other words, the means of production were owned publicly. There still remained some small private franchise holders (for example, one at Wilcannia in New South Wales), but with regard to the size of their supply, they were negligible (see also EANSW 1986). The main reasons behind public ownership, as discussed earlier, were the influence of Keynesian economics and the argument that the industry is a natural monopoly.

Further, a full harmony in public policy of the Australian governments with those of the UK government was notable. In the UK, public ownership was opted through a process of nationalisation for various infrastructure industries (for example, coal and electricity industries). This was while the USA chose to not adopt the public ownership. Instead, the USA opted for private ownership for most of its industries, with heavy government regulation.

2.6 Internal Reforms (1986–1993)

During this period, electricity demand, due to a series of events in the 1970s increased at a much slower rate than originally expected. Demand forecasts, which were generally made on the bases of generous engineering calculations, proved to be overoptimistic. Consequently, the sustainability of the organisational structure of the electricity industries was challenged.

In this section, the events of the 1970s are analysed in global and national contexts. This is because those events influenced the organisational changes of the industry during this period. The events of the 1980s and the early 1990s will be analysed in the next section because of their influence on the most recent reforms.

Global Context

The most important aspects of the institutional environment of the electricity industry during the 1970s included two oil shocks in 1973 and 1979. Increasing concerns about the environmental was another important aspect.

Oil is widely viewed as a strategic energy resource. It has some advantages over other kinds of fuels, especially coal. In the transportation sector, oil is largely non-substitutable. It has also been one of the main fuels for the electricity industry (this is not the case in Australia though). The world economy was therefore significantly impacted by the 1970s oil crises; this impact expressed itself in the form of high inflation. Further, this happened at a time when the world economy was experiencing recessionary business cycles with high unemployment. According to Keynesian theories, the economy might either be in a stagnation or in an inflation situation. During the 1970s, both situations were experienced simultaneously in most of the western countries. The term stagflation was introduced to explain this situation. This situation overwhelmed Keynesian economists and provided a chance for neo-classical economists to criticise the Keynesian theories with the argument that this situation was the result of too much government intervention. This situation, together with a series of other institutional changes, provided a chance for neo-classical ideas to gain ascendancy again after four decades of dominance by the Keynesians.

Further, by the early 1970s, serious concerns also emerged about the environment and ecosystems. In the early 1970s, a team of scientists gathered and published a pessimistic outlook about the future of the world, emphasising that there are substantial limits to growth (Meadows et al. 1972).

National Context

Australia is a rich country in terms of energy resources. This kept electricity prices in Australia among the lowest in real terms during the 1970s and 1980s. Despite this, the energy crises of the 1970s affected the Australian economy and its electricity industry as well. This essentially happened through the stagflationary effect of the early 1980s. According to Beardow (2002), in electricity industry:

> In the five years to 1985, average costs jumped by 53 per cent … tight monetary policy to counter the inflationary spiral contributed to a further 73 per cent rise in costs … interest rates reached unprecedented levels … it was not possible to contain such huge cost increases and in the first half of the 1980s, real electricity prices rose for the first time in nearly 30 years.

In addition, another crucial institutional factor contributing in this situation was the strategic development programs initiated at the federal level. It was argued that, in federal systems, interstate competition – to attract resource development – might have harmful impacts, with states bidding down social returns (including acceptance of greater environmental damages) in order to obtain the benefits of development (Stevenson & CRFFR 1976). Such view, according to Kellow (1996, p. 8):

> became entrenched as orthodoxy about resource politics in Australia during the 1980s. It seemed to strike a particular resonance with the so-called resource boom in Australia in the late 1970s and early 1980s, a period of considerable investment in resource projects, which were mostly energy-based and which stemmed from international restructuring in the wake of rises in the price of oil. The scramble by the states for a share of the 'bonanza' … was most evident with the relocation of aluminium smelting capacity to Australia and the related electricity construction projects.

Heavy investments in electricity projects in the early 1980s to order to back up ambitious resource development programs, for example, aluminium smelting, together with extraordinary increases in interest rates, led to huge increases in the real average costs of electricity. Electricity authorities, due to their organisational structure that were the preserve of professional engineers and technocrats, were not going to allow prices to be kept below the costs. Thus, the industry transferred cost increases to the end-users through price rises. This was while some governments, for example, in Victoria, agreed to provide electricity below-market prices to the aluminium smelters in the early 1980s. Such an arrangement in Victoria is locked in until 2016 (see Turton 2002, pp. vii).

The information about electricity subsidies for aluminium smelters is scattered and the inter-relationship between electricity projects and the aluminium industry has been very controversial (Rosenthal & Russ 1988; Turton 2002). One evident conclusion of the situation in the five years to 1985 was that the price rises were not appealing for the state and federal governments that were responsible for such arrangements. As a result, the electricity industry was blamed harshly for being inefficient (see also Beardow 2002, pp. 6-11) and the debate on the inefficiency of the industry became intense by the mid-1980s. According to Sharma (2003b):

> excess generating capacity, overstaffing, inflexible pricing, and lack of accountability were the often cited reasons behind such inefficiency. Further, the traditional view on the 'control of industry by technical experts only' came under challenge due to technological innovations, public awareness, and changes in the political climate. The political authorities viewed these concerns as an opportunity to tame the hitherto largely unaccountable electricity monoliths and at the same time improve their credentials as responsible economic managers. The electricity utilities viewed these concerns as an opportunity to undertake strategic initiatives to improve their image and to ensure their longer-term survival.

It was in such an institutional environment that state electricity authorities embarked on a set of internal reforms. The following are the salient features of the changes during this period.

2.6.1 Structure: Firmer Command-and-Control

The essence of the organisational structure of the Australian electricity industry (that is, Statutory Authority) basically remained unchanged until the early 1990s. As noted in the previous section, this organisational structure because stabilised in the early years of the post-War era. The reason behind such stability, as noticed, and also nicely stated by Sharma (2003b), was basically because of a confluence of various institutional forces, which created 'a system of mutually beneficial symbiosis between the political, cultural, social and technical interests'.

As a result of the above-discussed institutional changes, state governments and authorities undertook a number of measures in order to improve the performance of the electricity utilities. State governments blamed the electricity authorities for being unaccountable and inefficient and, often in the face of opposition from the electricity authorities, forced them to reform. The electricity authorities, on the other hand, wanted to use this opportunity to undertake strategic measures to improve their efficiency (Sharma 2003b). These measures essentially emphasised a firmer control and accountability by the utilities. Sharma (2003b) explains these measures as follows:

> establishing independent enquiries to review industry performance; appointing outside (i.e., non-electricity-industry) experts to the boards of electricity utilities; developing accountability criteria; tightening the scrutiny of industry plans; changing accounting practices; restructuring utilities and commercialising their operations (see Johnson & Rix 1991; and Kellow 1996 for a fuller detail of these measures).

2.6.2 Other Features: Commercialisation, Corporatisation

In terms of technology and ownership arrangements, no change took place during this period. However, two important changes took place in the industry's organisation: commercialisation and corporatisation.

Electricity authorities decided to restructure the organisation of the industry with a view to creating stand-alone entities with commercial and business focus similar to private enterprises. It was argued that these changes would improve reliability, safety, cost, price, labour and other factor productivities, employment, community service obligations, and rural electrification (Sharma 2004b). However all this restructuring did not change the essence of the organisational structure (that is, statutory authority and vertical integration), which at this stage had become an institution in the mindset of the Australian states. It is important to note that the initiatives undertaken in this period were under the same institutional settings of the electricity industry (that is, vertically integrated, publicly-owned statutory authorities).

Different states adopted different approaches. For example, 'in Victoria, a process of substantial organisational reform was initiated which resulted in the restructuring of the electricity utility into three ring-fenced and commercially-oriented strategic business units linked through transfer pricing' (Sharma 2003b). In New South Wales, by 1991, 'the generation segment of the principal electricity utility had been restructured as a stand-alone business and commissioners with non-engineering background had been appointed (ibid). Further, according to Sharma (2003):

> A review of the history of electricity in Australia also reveals that reform measures actually adopted by the respective state governments (from among those recommended/dictated by various inquiries/economic analyses) were well circumscribed by the political exigencies of the time. Selected excerpts from Kellow (1996) should substantiate this observation: '… in Victoria … the recommendations to ensure public consultation in energy policy were not implemented as they did not find favour with the Government … the Government did not take initial steps to implement recommendations arising from an integrated least-cost planning study … [and] found the electoral attraction of power station construction irresistible … the energy policy document was carefully crafted to woo swinging voters … addressed concerns about employment and environmental protection … [the] decision to proceed with a (particular) project was not based on careful economic analysis but on the fact that it would provide continued employment … [and was an example of the] government's flip-flopping before and after the election.

2.7 Market Reform (1994–Present)

The speed of institutional changes that commenced in the 1970s became more rapid in the 1980s and early 1990s. Although the policies undertaken brought about significant improvements in the performance of electricity authorities, various empirical studies verified this fact[20], in the early 1990s the Australian governments agreed to launch a broader economic reform program. This reform was designed to change almost every aspect of the organisational structure and institutional environment of the industry. These changes were driven by a substantial institutional momentum that was mostly stimulated by external focuses at the international level. This institutional momentum is analysed in this section, followed by features of the Australian electricity industry.

[20] This will be comprehensively discussed in Chapter 4.

Global Context

As noted earlier, the Cold War started in the mid-twentieth century. The reasons behind this war were essentially ideological. The world was primarily divided into two blocs: West and East. By the end of the 1970s, there seemed to be a convergence of ideas evolving from each bloc. In the western bloc, Keynesian and institutional[21] economics legitimised public ownership and government intervention/planning. On the other hand, in the eastern bloc, ideas emerged (for example, Oscar Lange's) that a decentralised socialism or market socialism is superior to a central planning system[22]. The case of the Yugoslavian economy – prior to the turmoils of the 1990s – was a good example of this type of decentralised socialism.

Analysis of how and why the Cold War ended is very complicated and it is beyond the scope of this thesis. However, a brief analysis would be as follows. During the Cold War, there existed fierce space and military competition between the Soviet Union and the USA. This competition eventually led to economic bankruptcy of the Soviet Union. The west did not mind to link this economic bankruptcy to the command-and-control and planning system of Soviet economy, in order to emphasise the ideological supremacy of the market economy. This was widely advertised in the world media. However, an objective review of the Soviet's economic performance, both in terms of economic efficiency and equity, would prove otherwise. The economy was working reasonably well for public's social well being. However, there was another problem in the Soviet Union which was more fundamental and that was human right violation in order to win in the ideological war. Individual freedom was tremendously curtailed by the Stalinist governments. No one could criticise the ideological settings of the Soviet system. These were the main issues that called for a reform in the Soviet Union.

A serious movement that eventually ended the Cold War happened when a generational shift occurred in the leadership of the Soviet Union through the rise of Mikhail Gorbachev. Gorbachev launched two reforms titled *Perestroika* (economic restructuring) and *Glasnost* (political openness). Though a process of several political

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[21] Here the term institutional economics is used in relation to its general theme (Stilwell 2002).

[22] In Soviet Union type of state socialist economies, a rational central planning or central command-and-control was the essential feature of the economy. In the Lange's decentralised socialist states, there were less of central planning conducting by the government and more of sectoral planning managed by individual industries (Lange 1964). This was like statutory authorities in the electricity industry.

events in the 1980s, this ended the Cold War and the western bloc supposedly was the victorious side.

In the aftermath of these changes, the leadership of the western countries, especially the US and the UK, launched a set of institutional reforms in the international arena under the title of globalisation of the world economy and the new international order. The free market model was set as the main institution for this reform with the argument that it was an all-encompassing institution required for the well-being of all nations. This approach is loosely called 'market ideology' or 'market faith' (see, for example, Johnson & Rix 1991; Stilwell 2002).

National Context

The reform of the electricity industry in Australia was influenced by the victory of the market industry. The electricity reform became an integral element of the wider economic reform program of the Australian Governments under the title of the National Competition Policy (NCP). Through the NCP, a significant role was given to the introduction of competition and private ownership. It was argued that these measures would further improve the performance of not only the electricity authorities but also of the broader economy (ICOIICPIA 1993). The National Electricity Market (NEM) was designed on the basis of the UK-style model. The main steps towards the operationalisation of the NEM were: operation of the Victorian pool (VicPool), which was known as the Victorian Power Exchange (VPX), in January 1995; operation of the New South Wales separate "State Electricity market" in May 1996; harmonisation of these two state pools (known as "NEM1"), in May 1997; the intention of Queensland to join the NEM, in December 1997, since when the term NEM has been used; and official operation of the NEM in December 1998 (Booth 2003, p. 209).

In Victoria the assets of the Statutory Authority were sold to the private sector. Other states did not follow the Victorian model in terms of organisational changes, but generally the reforms moved the industry into a state in which organisational and institutional arrangements differed significantly from the past. Western Australia and Northern Territory were exceptions. Western Australia had nonetheless commenced a similar reform program by 2003.

The following discussion describes the main features of this period. The discussion is mainly taken from Sharma and Fathollahzadeh (2004).

2.7.1 Technology: Distributed Generation

In this period, small-scale generators or distributed generators, especially Combined Cycle Gas Turbine (CCGT), became practicable. This reduced the minimum efficient scale for generation. Further, steadily decreasing Information Technology (IT) costs reduced the costs of sophisticated metering and grid control equipment (IEA 1999). These technological improvements triggered the decentralisation of the electricity industry. It should be noted that much of the technological advancements were kept confidential during the Cold War, and therefore the end of the Cold War facilitated the release of these technologies in the public sphere. For example, the first successful gas turbine was built as early as 1903 in France, but later this technology was classified as specialised for military purposes in jet engines (Hyman & Public Utilities Reports Inc. 1983).

Further, oil crises in the 1970s and the environmental movements, of the following years prompted a series of research and developments that brought about significant improvements in energy efficiencies. The improved efficiencies had two impacts. They (i) increased energy supplied per unit of fuel consumed in electric utilities, and (ii) slowed down the growth of demand as a result of more energy-efficient end-use appliances (for example, a new generation of refrigerators and microwaves).

2.7.2 Structure: National Approach, Functional Unbundling

A central element of this reform program was its national approach and the creation of the National Electricity Market (NEM) in accordance with the principles of the National Competition Policy (NCP). The NCP emphasised efficiency gains through the creation of competitive markets. In order to comply with the requirements of the NEM, the Australian states which were party to the NEM began a phased restructure of their electricity industries in the early 1990s. The first phase, called NEM1, envisaged a commencement of operations in 1997 with New South Wales and Victoria as participants, and it was expected that South Australia, Queensland, Tasmania, and the Australian Capital Territory would join later (Sharma & Fathollahzadeh 2004).

Further, as electricity is constitutionally a state matter in Australia, each state followed a different approach to restructuring with regard to the shape and size of its restructured industry and the speed of restructuring. For example, in New South Wales, the steps taken included corporatisation of the integrated generation/transmission business in 1991; unbundling of generation and transmission in 1994; the break-up of generation into three competing entities in 1996; amalgamation of 25 load distributors into six corporatised businesses with separate retail and network activities in 1996; and the introduction of a wholesale electricity market in 1996. A noteworthy feature of the New South Wales reforms was the introduction of a load-based, location-specific pollution fee (PC 1996). In addition, electricity retailers were required to develop strategies for achieving a reduction in greenhouse gas emissions.

The Victorian Government opted for a more radical approach aimed at widespread privatisation. In 1993, the generation, transmission, and distribution functions of the vertically integrated state-owned monopoly, the SECV, were unbundled and corporatised; distribution was split into five corporatised regional businesses in 1994 and sold to private investors in 1995; transmission was split into two – high-voltage transmission and electricity trading; generation was broken into five independent corporatised businesses in 1994, two of which were sold to private interests initially, one was 51% privately owned (SMH, 1997) and plans were announced to sell the remaining two within the next year (PC, 1996); and a wholesale market, known as the VPX, was established in 1994 (Ray 1997).

In Queensland, the electricity system was broken up in 1995 into two corporatised entities – generation, and transmission/supply. The transmission/supply business was organised as a holding company with eight subsidiary corporations – one for transmission and seven for distribution.

The network and retail supply functions of the distributors were envisaged to be separated (PC 1996). The Electricity Trust of South Australia (ETSA), the vertically integrated state-owned monopoly electricity business in South Australia, was corporatised in 1995, and re-established as a holding company with four subsidiary companies involved respectively in generation, transmission, distribution, and trading.

The power, wires, and retail supply units were subsequently planned to be functionally separated.

In Western Australia, some electricity generation and transmission was privately owned. The government-owned electricity and gas supply business was separated into two corporatised businesses – electricity and gas. It was proposed that the electricity business be functionally separated, and that separate accounts be established for services to remote areas. From January 1997, progressively increased access to the grid was provided to independent producers (PC, 1996; ESAA, 1997).

Electricity reforms in other states included easier entry for new participants in Tasmania and the corporatisation of the principal energy and water company in the Australian Capital Territory in 1996 (Sharma & Bartels 1997). In the mid- to late 1990s, the pace of reform was considerably accelerated in all states in the NEM, but the state control of industry continued to exert significant influence on the final industry structures. Notwithstanding these differences, the general nature of structural changes in each state included the separation of the generation, transmission, distribution and retail segments of the industry; introduction of competition in generation and retail, and the re-orientation of transmission and distribution to support and encourage competition.

2.7.3 Ownership: Return to Mixed Ownership

As mentioned in the previous sections, the type of ownership was tightly related to social beliefs and economic ideologies. The market reform encouraged industry privatisation. However, different approaches were undertaken, by various states, in terms of ownership arrangements. While New South Wales, Queensland, and Tasmania have retained public ownership, Victoria has privatised its entire industry. South Australia leased its electricity assets on a long-term basis to the private sector. Public pressures and, hence, political acceptability have played a significant role in the diversity of industry ownership in various states (Sharma 2004b).

2.8 Summary and Conclusions

The main points of this chapter are summarised as follows:

- Human knowledge about electricity predates the inception of the electricity industry in the 1880s. The cultural and political affinity of Australia to Britain has been one of the most influential institutions in shaping the Australian electricity industry.

- In the early years (1888–1913), electricity demand in Australia was low. Technology lacked standards and there were no transmission interconnections. The organisational structure of the industry was fragmented. There was free and fierce competition among numerous players in the industry. The ownership of the industry was predominantly private. Such industry organisation was essentially shaped under the institutional environment that prevailed in the pre-electrification period. This environment was typified by the belief in the principles of democracy, capitalism, and free market.

- In the War and Depression years (1914–1944), the industry developed slowly, mainly because of the complicated socio-political turmoils caused by the two world wars and the Great Depression. In spite of these conditions, many technological and scientific developments took place during this period. The process of standardisation (that is, DC/AC, voltage, and frequency) took place at the state level. The organisational structures and legislation were however different across the States. Further, inter-state interconnections were developed but no meaningful inter-state interconnection existed. A mix of public and private ownership was another feature of the industry in this period.

- In the industry consolidation period (1945–1985), there was significant expansion of the state-based electricity industries as the governments realised the significant development potential and the political appeal of electricity. This development of the industry resulted in the creation of vertically-integrated, publicly-owned and self-planned electricity utilities structured as central Statutory Authorities. The emergence of Keynesianism as a non-Marxian solution for the problems faced in those years (for example, mass unemployment, the gap between rich and poor, the unequal ground between nations in international trade, inter-individual and inter-national aggressions) influenced the formation of such organisational structures. Further, economies-of-scale and large technologies, especially large-scale hydro plants such as the Snowy Mountains Scheme, also strongly encouraged such vertical integration. The Snowy Mountains Scheme became the first large inter-state interconnection in Australia. Nonetheless, although proven to be successful and mutually beneficial for NSW, Victoria, and ACT, this scheme was never considered as an example of a national approach for electricity development.

- In the internal reforms period (1986–1993), concerns began to be expressed about inefficiencies in the electricity industry. Many of these concerns originated from changes in the global institutional events during the 1970s. For example, environmental movements, the demise of the international monetary system (the Bretton Woods agreement), the energy crises in 1973 and 1979, and the stagflation in major developed countries. The failure of Keynesianism in explaining and satisfactorily addressing the effects of these unexpected events brought about new challenges for the governments. Although Australia has always had relatively cheap natural energy resources, those worldwide institutional changes also affected the Australian economy and its electricity industry (through imported inflation and governments' tight monetary policies to counter the inflationary spiral). While the essence of the industry's organisation during this period remained unchanged, its operating practices were considerably changed. The main changes in the industry included its commercialisation and corporatisation. These, in turn, contributed to industry's productivity.

- In the market reform period (1994– present), Australian governments embarked on a program of radical reform. This was despite significant efficiency improvements in the electricity industry in the late 1980s and early 1990s. The free market ideology was the main impetus behind this reform. This ideology was strongly supported by neo-liberal beliefs in opposition to Keynesianism and Soviet-type Marxism. This ideology supposedly reflects the victorious side of the Cold War after the collapse of the Soviet Union. In Australia, although the market reform became the first comprehensive national approach towards electricity programs, each state tailored the reform program to its own political interest. Hence, a huge divergence is observable in the different states' approaches to electricity reform during this period. One such divergence can be observed in the type of ownership adopted by various states. In addition, technological improvements, especially small-scale and distributed generators and information technology (IT), allowed the industry to be functionally unbundled.

This chapter provided a description of organisational changes of the Australian electricity industry. In this description, the main research hypothesis was to examine how organisational changes are influenced by the industry's underlying institutional environment at state, national, and global contexts.

On the basis of the above, the following is a summary of the **main findings** of this chapter:

- Electricity reforms are institutional phenomena implying that these reforms are highly driven by significant changes in institutions. As noted from the analysis of this chapter, cultural, social beliefs, and economic ideologies both at national and global contexts have influenced and been influenced by changes in organisation of electricity industry in Australia.

- These institutional phenomena arose from a continuous and complex interplay between the electricity industry's organisations and institutions over time. For example, vertical integration of the industry during consolidation era (1945–1985) was associated with particular social belief and economic ideology – Keynesianism. This ideology encouraged government ownership and regulation of strategic industries including electricity. The main rationale behind the debate was that if industry is under 'natural monopoly' condition and has 'increasing returns to scale', government intervention in economic activities is justified. This is while, the essence of Western capitalism opposes any large-scale governmental interventions in economic activities. These debates were influenced by Keynesian economic ideology. Such beliefs also affected the organisation of the Australian electricity industry. However, once energy crises took place in the 1970s, foundations of Keynesianism started to be questioned by the proponents of neo-liberal ideology (also known as the 'market ideology'). The aim of this questioning was to remove the influence of Keynesianism, which had by then been prevalent for nearly four decades. Of course, as discussed in this chapter, influence of Keynesianism in macroeconomic management has not totally vanished; it is only that neo-liberal ideology has become more prevalent. Analysis of the causality of such a complex interplay, this chapter demonstrated, would explain the nature of electricity reforms in Australia.

- The understanding of the causality of the complex institutional phenomenon, this chapter has demonstrated, could benefit from a comprehensive historical review. Such review could facilitate the understanding of how organisational and institutional dynamism at a particular time is shaped by the dynamism of previous time periods. It also enables one to delineate the influence of political, cultural, social and other factors on the shaping of institutions and organisations. Such approach, by implication, could be helpful in developing a more balanced perspective on the impacts of electricity reform on future outcomes.

These points, while useful for explaining the reasons behind electricity reforms, are still inadequate for fully explaining the true nature of electricity reforms as institutional phenomena. Such explanation, this thesis suggests, requires an examination of human behaviour, that is, how humans – through motivation and cognition – constantly create and recreate institutions and organisations. This examination will be the subject of the next chapter.

3 FUNDAMENTAL REASONS BEHIND ELECTRICITY REFORMS

3.1 Introduction

In the previous chapter, it was argued that electricity industry reform is an *institutional phenomenon*. Such phenomenon is an outcome of a complex interplay between industry's organisations and institutions over time. This argument – while useful – is inadequate for fully understanding the true nature of this institutional phenomenon. It is inadequate because it does not explain how organisations and institutions are created in the first place, and how they evolve over time. This explanation would – this research contends – require an examination of the 'human behaviour', that is, how humans – through *motivation* and *cognition* – constantly create and recreate institutions and organisations. It is in this examination therefore resides a fuller understanding of why electricity reform has taken place in Australia, why it has a particular shape and size, why there is disparity between our expectations from reform and its actual outcomes, and what could be done to progress the current reform program. This chapter is devoted to examining this human behaviour and its influence on shaping organisations and institutions.

This is a prevalent methodology in social and human sciences, particularly in economics and sociology. The methodology of examining an institutional phenomenon in terms of the underlying individual behaviour is called *methodological individualism*. The term methodological individualism, for the first time, was explicitly stated by Schumpeter in 1908 (cited in Mantzavinos 2001, p. 3; Schumpeter 1908). According to Schumpeter, 'the term "methodological individualism" describes a mode of scientific procedure which naturally leads to no misconception of economic phenomena … and has nothing whatever to do with the great problems of individualism and collectivism' (Schumpeter 1909). The most important point about methodological individualism is that it consistently distinguishes between changes in organisations and institutions. While organisational changes are described by the changes in collective *ends* of organisations (for example, changes in the structure of an organisation); the institutional changes are captured by changes which take place in the social *means* of the individuals and organisations (for example, changes in culture, social norms, rules and regulations).

Methodological individualism has been used in various ways in social and economic theories. In order to incorporate the premises of methodological individualism in a theory, there is a need for an analytical framework. In social and human sciences, there are two main analytical frameworks – often used in economics and sociology – guided by two different conceptions of human beings and particularly of human behaviour. One such framework considers human as *Homo oeconomicus* and the other, *Homo sociologicus*. Homo oeconomicus is about the calculus of human choices. In neoclassical economics, this conception is immediately translated in terms of "optimisation" and "rationality" of human behaviour (hypothesised as utility/profit maximisation). Homo sociologicus, on the other hand, is about the quasi-inertial forces or institutional coercion behind human behaviour that leave no choice as such for human actions.

This research adopts an alternative analytical framework – a *problem-solving framework* – in order to examine the question raised above. The problem-solving framework has been developed by Mantzavinos (2001). It incorporates some of the recent theoretical achievements in economics and social philosophy, as propounded, for example, by Campbell (1987), Lorenz (1941), Newell & Simon (1972), Popper (1979). These theoretical achievements have generally contributed to *institutional economics* and sociology for elaborating the nature of an institutional phenomenon. The selection of this framework will be justified in this chapter on the ground of its: (i) consistency with the premises of the methodological individualism; (ii) more realistic conception of human behaviour (as compared with Homo oeconomicus and Homo sociologicus) that captures an adequate account of the *motivational* and *cognitive* aspects of the human behaviour; (iii) usefulness for analysing the institutional phenomena by calling for a *political economy* approach that fills the institutional vacuum of neoclassical economics; and (iv) philosophical underpinnings – inspired by *cognitive psychology* and *evolutionary epistemology* – which provides a useful synthesis of two main analytical frameworks (that is, Homo oeconomicus and Homo sociologicus).

The application of Problem-Solving framework in this research, however, has some limitations and is, at best, able to provide a somewhat 'global' understanding of the fundamental reasons behind electricity reforms. This is so because cognitive psychology and evolutionary epistemology that underpin Problem-Solving framework, while useful for explaining individual behaviours, can only capture one aspect of organisational behaviour, namely, 'organisational learning'. It is unable to robustly capture other aspects of organisational behaviour, for example 'quasi resolution of conflict', 'uncertainty avoidance', and 'problematic search' (often discussed in theory of the organisation), which are also required for appreciating the fundamental reasons behind electricity reform. A more robust explanation of organisational behaviour, hence, needs a much sophisticated theoretical conception, requiring recourse to a broad class of analytical frameworks from social theory, organisation analysis and decision theory. This is beyond the scope of this study and should be followed up as a continuation of this research (as suggested in Chapter 6).

This chapter is organised as follow. Section 3.2 describes key features of the problem-solving framework, including justification for its selection in this research. Section 3.3 analyses electricity reforms in Australia using this framework. This analysis explains how institutional dimensions of human behaviour and actions have formed and reformed organisations and institutions in the Australian electricity industry. Section 3.4 summarises this analysis and presents conclusions of this chapter.

3.2 Problem-solving Framework: A General Description

3.2.1 Theoretical Foundations

In order to theorise how temporal interactions between individuals, organisations, and institutions (see Figure 1 in Appendix 1.1) shape institutional phenomena, two principal questions should be addressed:

(i) how do individuals and organisations behave or act under given institutional environment at a certain time and space?

(ii) how do institutions emerge or decay as a result of individual and organisational actions over time and space?

Addressing these questions requires an analytical framework that takes account of the motivational and cognitive aspects of human behaviour. Mantzavinos (2001) formulates three essential criteria for such an analytical framework. These take into consideration the:

(1) *nomological* character of human behaviour, which allows for *objectivism*;

(2) *static* as well as *dynamic* aspects of human behaviour; and

(3) differences in behaviour among individuals, which allows for *subjectivism*.

The first criterion relates to the fact that any analysis of human behaviour should be able to capture the nomological character of that behaviour on the basis of empirical observations rather than being a presentation of the pure logic of choice. ‘A genuine explanation of behaviour involves subjecting the observable behaviour to general law’ (Mantzavinos 2001, p. 5). The second criterion emphasises the role of time and space for an analysis of human behaviour. This criterion is about the link between individual and organisational learning and how such a link leads to the emergence of institutions over time and space. Finally, the third criterion relates to the fact that all individuals ‘possess a uniqueness manifested in … individual history, deeds, and thoughts’ and theorising human behaviour ‘should take into consideration the differences in behaviour among individuals’ (ibid, p. 7).

The first and third criteria represent the polarity of the theoretical approaches taken by theorists of social and human sciences. Theorists should be able to make a balance between these two extremes. A good analytical framework should be as objective as possible on the basis of empirical observations, and at the same time as subjective as possible, considering the uniqueness of every individual. Mantzavinos asserted that these three criteria can be well attained for an adequate explanation of human behaviour, if individual behaviour is to be viewed as a problem-solving activity. ‘People are continuously confronted with problems, and they mobilize their energy in trying to solve them. Problems arise from the environment of an individual, and each solution to a problem generates (another) problem’ (Mantzavinos 2001, p. 7). This thesis further contends that these three criteria can be better attained if organisational behaviour – alongside individual behaviour – is to be viewed as a problem-solving activity.

Organisations are specialised for solving certain classes of problems. This contention has been well received by Mantzavinos (personal communication with Mantzavinos 2004).

Every human action – individually or collectively – involves a problem. The problem may be very simple (deciding which TV program to watch) or very complex (deciding which electricity to dispatch). It may be very tangible (an apple to eat) or very abstract (an elegant proof for a mathematical theorem). It may be very specific (switching-on a particular light over there) or very general (something to light a room in dark). It may be a physical object (an apple) or set of symbols (the proof of a theorem). It may be merely a personal issue of an individual (in the context of this thesis, an *individual problem*) or a public affair of an organisation, socio-economic sub-system or the society as a whole (in the context of this thesis, an *organisational problem*). Further, actions to solve the problem may include physical actions (walking, reaching, writing), perceptual activities (looking or listening), or purely mental activities (thinking, reasoning, remembering, evaluating, or judging) (Newell & Simon 1972, p. 72). They may be the personal actions of individuals (in the context of this thesis, *individual actions*) or the impersonal/collective actions of organisations (in the context of this thesis, *organisational actions*).

Among the infinite moments in which individuals/organisations are confronted with problems every day, there are moments when they do 'not know immediately what series of actions (they) can perform' (ibid). Newell and Simon (1972) consider these moments when they are confronted with a *problem*. Mantzavinos, however, names these moments when the individuals/organisations are confronted as *new problems*. According to Mantzavinos, problems that have been 'classified under an already existing category of mind that prescribes the appropriate solution' (Mantzavinos 2001, p. 35) are called *old problems*. The solution for old problems 'has been more or less standardised to become an unconscious *routine*' (ibid, p. 34, emphasis in the original). One should, however, keep in mind that there always exists the possibility that an old problem may be considered as a new problem. This, as will be explained later in this section, is essentially because the nature of human cognition always remains entirely *conjectural*. 'The possibility, in other words, that even a standard solution will be proved unsuccessful in the future always exists' (ibid). Therefore the term "solution" in the problem-solving framework does not imply its absolute terminological meaning and only implies the *partial resolution* of a particular problem at a given time, space, and resources.

Further, it should be noted that the nature of individual and organisational problems – while highly inter-related – are different for two reasons: (i) individual problems may be solved by independent action of the individual, while organisational problems – as most of the problems in society are – require coordinated collective actions; and (ii) while both problems are solved ultimately by the actions of individuals, the motivational aspects of these two problems are significantly different from each other. In organisational problems, it is not just individual interests which matter. On the contrary, it is always collective or public interests, which dominantly matter.[23]

The problem solving framework, as Mantzavinos describes it[24], is:

> … a process of searching through a *state space*. A problem can be defined by an *initial* state, by one or more goal states to be reached, by a set of *operators* that can be transformed from one state into another, and by *constraints* that a solution must meet ... The procedure of problem solving can be perceived as a method of applying operators so that the goal states can be reached. The set of operators are information processes, each producing new states of knowledge (Mantzavinos 2001, p. 8, emphasis in the original).

Learning about the motivational and cognitive aspects of human behaviour in solving individual and organisational problems is essential for understanding the problem-solving actions. This helps to explain the process of individual and organisational learning and, in turn, institutional phenomena. Under this framework, there is no motivation per se, but rather motivations associated with a problem. 'There is no

[23] Often contradiction exists between individual and organisational interests. The *free-rider* phenomenon (a situation when all individual members of a group – without having an effort – can benefit from the effort of one particular member) could further complicate the resolution of organisational problems.
[24] In formulating the problem-solving framework, it appears that Mantzavinos is mainly inspired by the following works: Albert (1978), Holland et al. (1986), Newell & Simon (1972), Popper (1972).

perception per se, but always perception about a problem. And there is no learning per se either, but always learning about ways to solve problems' (ibid). In the following headings, motivational and cognitive aspects of human behaviour are discussed.

Motivations

Motivation is the actual reason for an action or behaviour. It is an abstract concept and lies behind every preference, penchant, purpose, intention, interest, and objective or, in short, the "ends" of an action. Motivation is one of the most important topics in the discipline of psychology. There is a wide range of theories in psychology about motivation.[25] From such a spectrum of theories, two theories, namely Maslow's hierarchy of needs and arousal theory, are briefly explained here, because of their relatively broader acceptance among psychologists and because of their more relevance for the purpose of this thesis.

Maslow's theory of the hierarchy of needs states that human beings are motivated by unsatisfied needs, and that higher needs will not be satisfied unless certain lower needs have been satisfied. Maslow makes a distinction in a bottom-to-top hierarchy between 'biological needs (i.e., for water, oxygen, etc.), safety needs (i.e., for comfort, security, etc.; a need for electricity as a commodity fits in this hierarchy), attachment needs (i.e., to belong, to love, to be loved), esteem needs (i.e., for confidence, respect of others, etc.), cognitive needs (i.e., for knowledge, understanding, etc.), aesthetic needs (i.e., for order and beauty), self-actualisation needs (i.e., to fulfil one's potential and to have meaningful goals) and transcendence needs (i.e., spiritual needs for cosmic identification)' (Mantzavinos 2001, p.10).

Arousal theory, on the other hand, is essentially based on the idea that individual performance depends on the level of arousal. The level of arousal specifies the intensity of individual motivation and can be expressed by people's emotion, passion, courage, thrill, stress, anxiety and so on. This theory is basically associated with the so-called Yerkes and Dodson Law, which contends that the relationship between arousal (on the

[25] For example: drive reduction theory (Hull 1943); arousal theory, associated with the Yerkes-Dodson law (Yerkes & Dodson 1908); the theory of cognitive dissonance (Festinger 1962); and the humanistic theory of growth motivation or Maslow's hierarchy of needs (Maslow 1987/2000).

horizontal axis) and performance (on the vertical axis) resembles a Gaussian-like bell-shaped curve, as is shown in Figure 3.1. Yerkes and Dodson (1908) concluded this law from experiments on rats. However, by now there are a sufficient number of empirical studies based on experiments on human behaviour, so that this relationship is often referred as ‘law’, giving it equal status to the ‘law of demand’ in economics (Kaufman 1999).

Mantzavinos (2001), however, argues that motivation theories in psychology explain too much for the purpose of social and economic theory and thus argues that ‘it is futile to give a detailed account of motivational forces per se without taking into consideration the cultural and social environment of the individual’. Hence, Mantzavinos re-establishes the classical hypothesis often used in economics about the nature of human motivation: ‘Every individual strives for an increase in his own utility’ (Mantzavinos 2001, p. 11).

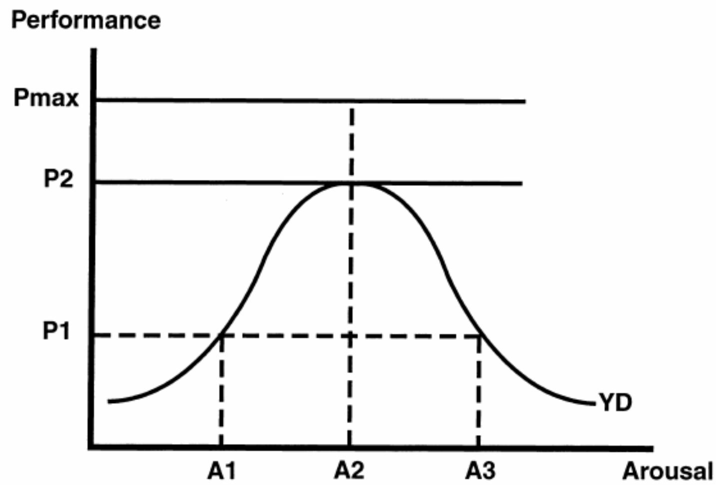

Figure 3.1 The Relationship between Arousal and Performance (Source: Kaufman 1999)

Being at the core of economic theories since at least the time of Adam Smith (2001), the hypothesis of *striving for increasing own-utility* is indeed an influential hypothesis for the motivational aspect of human actions in social and economic theories and definitely consistent with the problem-solving framework. However, in contrast with Mantzavinos, this thesis contends that motivation theories are not futile because they would better explain the nature of problems in societies. In the definition of the problem-solving framework (as a process of searching through a state space), the motivational aspects are a part of the problem and, beside cognitive aspects, act as the sensors for the set of operators. One can consider that organisations (or society as whole) also have different levels of arousals in different times and spaces. Such arousals are, however, a result of the resonance of the motivations of organisations' individual members. In the classical hypothesis, in contrast, all problems are condensed under the concept of "utility", while the type of utility is totally ignored (that is, whether it relates to basic needs or spiritual needs; whether it is a pleasure or self-harming; how intense it is; and so on). As North also argues, 'The motivation of the actors is more complicated (and their preferences less stable) than assumed in received *conventional economic and social* theory' (1990. p. 17, emphasis added).

Thus, it will not be irrelevant if one argues about the applicability of motivation theories in the problem-solving framework. In the case of arousal theory, the issue becomes especially more useful, when the question arises about how well individuals and organisations have solved their problems. This question relates to the relative performance of individuals and organisations (their productivities and efficiencies) to which motivational theories are definitely applicable (see, for example, Kaufman 1999; Leibenstein 1998). The concept of individual and organisational performance will be discussed in more detail in Chapter 4.

This thesis puts forward the motivational hypothesis that every individual *strives to solve her/his own-problem*. The nature of the problems differ according to the source of and intensity of motivations, which, in turn, largely relates to the hierarchy of needs and levels of arousal, respectively. Further, an individual's own-problem is not just limited to his/her personal problem. On the contrary, it is largely an organisational problem. It should be noted that *strive to solve problem* from a theoretical point of view is neither an exclusively egotistical nor a rationalistic character (Schumpeter 1909, p. 215). The moral philosophy behind this hypothesis is very complex, but it appears that most of the time individuals find themselves in conditions that they should strive persistently to solve others' problems. This moral philosophy further substantiates the distinct nature of motivational dimensions of individual and organisational problems.[26]

Cognitions

Cognition is about the faculty of knowing or human knowledge. It is about how individuals perceive and learn. Theorising cognitive aspects of human behaviour mainly falls in the domain of philosophy, although various natural and human sciences, especially biology, psychology, and – more recently – cognitive neuroscience[27], have significantly contributed to this area. It is beyond the scope of this thesis to review all theories about the cognitive contents of human behaviour because the literature is massive. However, significant developments in this area are indebted to the works of Lorenz (1941; 1973), Campbell (1987), and Popper (1979; 1982) who have formed the foundation of *evolutionary epistemology* (Mantzavinos 2001, pp. 16–22). The main idea behind evolutionary epistemology is that 'the process of knowledge growth is Darwinian' (ibid, p. 17). Campbell (1987) carefully formulates the fundamental mechanism for the growth of knowledge and states that this mechanism from amoeba to human beings is of the type of 'blind-variation-and-selective-retention'.

Popper's contribution has been significant, mainly because of his special focus on human mind. Popper describes human mind as a 'multidimensional problem solver' as compared with animal mind, which is largely a 'one-dimensional' problem-solver (Mantzavinos 2001, p. 21). Popper calls the mechanism for the growth of knowledge 'tentative-solution-and-error-elimination'. His simplified problem-solving scheme, with regard to the process of learning, suggested a better explanation about *scientific*

[26] The following Persian poem from Sa'di Shirazi (1184-1291), which decorates the entrance of the United Nations Headquarter, best describes the moral philosophy behind the motivational aspects of the individual and organisational problems:
بنی آدم اعضای یک پیکرند   که در آفرینش زیک گوهرند   چو عضوی بدرد آورد روزگار   دگر عضوها را نماند قرار
'Human beings are members of one body (that is, family/organisation/society); (that they are) created from one essence. If fate brings a problem to one member; the other members cannot stay at rest' (Sa'di 1257/1987, p. 88, translated by Fathollahzadeh A., R.). In this poem, Sa'di uses exactly the same metaphor as used in Table 1 in Appendix 1.1 (that is, society's member/body as equivalent to the human body's organ/organism). It is interesting that in the next verse of this poem, Sa'di takes an admonitory position to those people (specially rulers) who have ignored this moral fact and advises them that they do not deserve to be named "human beings", if they continue with their ignorance (see also Dastjerdi 2004).

[27] The cognitive neuroscience is a newly established (cognitive) science (only about three decades) that relates to interdisciplinary approaches to understanding the nature of thought (see Cognitive Neuroscience Society 2004).

approach than his predecessors' since Bacon (1561–1626). In practice, his scheme, which is constructed on the basis of the processes of 'conjectures and refutations', had never seemed to conform to the rationalistic principles of scientific approach as described by his predecessors. His comment about 'how Einstein could study the universe with no more than a piece of chalk' (friesian.com 2004), was one of his interesting remarks about the scientific approach in which it is 'not induction' but only 'imagination and creativity' (ibid).

Evolutionary epistemology provides a uniform theoretical platform for a variety of natural and human sciences (for example, physics, biology, ethology, psychology, linguistics and so on) through the theory of evolution. It also provides a useful foundation for economics and social sciences. Karl Marx's work in periodising the paths of history in terms of the *mode of production* has been the first focused work in applying evolutionary epistemology in economics (Diakonov & Ebrary Inc. 1999). Marx, as Kühne (1979) pointed out, 'for the first time … created the basis for modern macroeconomic theory' (Bottomore 1985, p. 1). Evolutionary epistemology essentially contends that the cognitive architecture of Homo Sapiens Sapiens has evolved through a long evolutionary process of blind-variation-and-selective-retention or tentative-solution-and-error-elimination and is 'thus "designed" to solve the specific problems of its environment', or briefly '*adaptive problems*' (Mantzavinos 2001, pp. 18–20, emphasis in the original). Three sources of changes, on the basis of evolutionary epistemology, have been identified for the growth of human knowledge (Mantzavinos 2001, pp. 19, 69, 67), as follows[28]: (i) genetic, (ii) institutional, and (iii) individual.

Genetic change, according to Popper (1978; 1979; 1982), has been the most important change in the emergence 'of the human mind and of human reason' (1982, p. 122). This change is related to the *biological dimension* of knowledge growth. The environment of human actions for genetic change is the biological environment. The human brain has evolved as the result of a natural 'selective-retention' process. The brain of the species, unlike a computer, which is programmed, is rather self-programmed. Such self-programmed brains help species to perceive their environment and enable them to solve

[28] Mantzavinos uses the following terminologies: (i) genetic, (ii) cultural, (iii) atomistic, respectively. The terminologies used in this thesis, however, are conceptually consistent with those used by Mantzavinos.

adaptive problems. 'The fundamental genetic self-program is coded in the DNA tape' (Mantzavinos 2001, p. 20). As a result of the evolution of the human brain, the cognitive aspect of human behaviour changed from a relatively more closed behavioural program, which is characteristic of animals, to a relatively more open behavioural program. 'An open behavioural program is the differentia specifica of humans; it does not determine all steps of behaviour but leaves open certain alternatives, that is *the possibility of choice*' (ibid, emphasis in the original), which will be discussed in more detail in the next sub-section. Genetic change can be best conceptualised by the process of genetic learning. Genetic learning may occur at any time in the future, like an eye-blink, or may happen continuously with a positive zero rate of growth. In other words, the process of genetic learning has shown to be extremely slow in the way that the DNA structure of the Homo Sapiens Sapiens has remained almost absolutely unchanged at least for the last 30,000 years (ibid, p. 19). Some scientists even estimate the age of the Homo Sapiens Sapiens (that is, the time of the last significant genetic change) to about 300,000 BC (Roper 2004). Therefore, for the purpose of social and economic theories it is futile to pay attention to genetic change for the growth of human knowledge.

The second source of change behind the growth of human knowledge is institutional change. This change is related to the dynamic social and economic dimensions of knowledge growth, with the dominance of the *social dimension*. The environment of human actions for institutional change is the institutional environment. This change, although much faster than the genetic change, largely happens over periods which are far beyond the life-span of single individuals and are often epitomised as *generation gap*. Institutional change can only be observed through long-term historical surveys. This change can be best conceptualised as a process of collective or *organisational learning*. Organisational learning, through acts of communication, takes place from generation to generation, first within families and then within communities, schools, firms, and the whole of society. Organisational learning thus, in general, takes place within organisations[29] for the purpose of solving organisational problems.

[29] Even primitive societies had some kind of organisations (that is, tribes) for organisational learning. Some of the products of such organisational actions are still with us in various forms. This, for example, includes both kinds of knowledge: theoretical knowledge, for example, oral literature that has mainly remained in the form of mythology; and practical knowledge, for example, hunting skills. The invention of the alphabet indeed enhanced the process of organisational learning.

Organisational learning may also take place across organisations, but this only means that organisational learning is captured within a higher organisational hierarchy (for example, instead of being at the national level, being at the global level or so on). Science, technology, beliefs, culture, or, in general, the institutions, are various products of the organisational learning. It is through understanding the process of organisational learning that one can capture organisational action and behaviour.

In spite of the complexity of the mechanism behind organisational learning or organisational behaviour, this mechanism, on the basis of historical evidence, can be best explained by the same processes of 'tentative-solution-and-error-elimination'. However, in contrast to individual behaviour (which will be discussed shortly), organisational behaviour is, to a large extent, impersonalised (because it relates to organisational problems). Mantzavinos, North, and Shariq (2004) provide a useful approximation of how such a mechanism works over time. They demonstrate how organisational action leads to the emergence of new institutions and their attached enforcement organisations. Organisational learning – and, hence, institutional changes of human knowledge – is often totally ignored in neoclassical economics. It was Karl Marx who, for the first time, brought the importance of this notion into the attention of economists, and it was John M. Keynes who first made a practical application of this notion possible in the western economies by introducing macroeconomics.

Finally, the third source of change behind the growth of human knowledge is individual change. Individual change is related to static social and economic dimensions of knowledge growth, but with the dominance of the *economic dimension*. Being static, the constraints (time, resources, and institutions) are given for every individual. This is the main reason behind the dominance of economic dimension. In this regard, the environment of human actions is the immediate social environment (that is, inside family or firm) and personal environment (that is, inside the individual mind). The speed of this change is instant and is happening in every single individual mind, totally independent from other individuals.[30] This change happens independently in everyday life and in every action of every individual and organisation, through the process of

[30] As noticed in Chapter 2, for example, Joseph Swan (UK) and Thomas Edison (US) in two absolutely independent activities almost simultaneously invented the incandescent lamp in 1879.

their individual learning and for solving their problems. Individual changes in knowledge can , however, be at organisational level, if the gained knowledge – under, for example, certain patent – has not been shared with others. Under such conditions, the diffusion of knowledge would be slow. If otherwise, the change in knowledge would be impersonalised and become an institutional change. In this process, the factor of time is indeed the most crucial constraint.

3.2.2 Problem-solving Framework

This section presents the problem-solving framework employed in this thesis, with a view to elaborating how static and dynamic dimensions of interactions between individuals, organisations, and institutions shape institutional phenomena (that is, electricity reforms). Figure 3.2 is developed to describe this framework. In this figure, individuals and organisations – identified by their objectives and functions – are considered as active elements of society. With regard to organisations, one should note that there are two types of organisations: (i) organisations whose objectives and functions are directly involved with the production of marketed goods and services, such as socio-economic sub-systems; and (ii) organisations whose objectives and functions are governance, rule-making and regulation, such as government departments, parliament, and regulatory organisations.

Socio-economic sub-systems are usually considered as the first type of organisation, because the focus of their functions is on production of goods and services. However, they may be considered as a combination of both types of organisations, if rule-making and governance are also included as some of their main functions. This type of socio-economic system relates to the self-regulated industries, for example, the State Electricity Commission of Victoria (SECV) prior to market reform (see Chapter 2). Individuals and organisations have their motivations and cognitions. Their actions are constrained by the institutions – the passive elements of society – imposed from the environment surrounding them. Three levels of environment are shown in Figure 3.2: individual, institutional and biological. Hence, the constraints of human actions could be time, personal budget, natural resources, conventions, moral rules, social norms, beliefs, laws, ecological, and genetic. These constraints, in the short term, are invariable, while in the long term they may be affected by human actions.

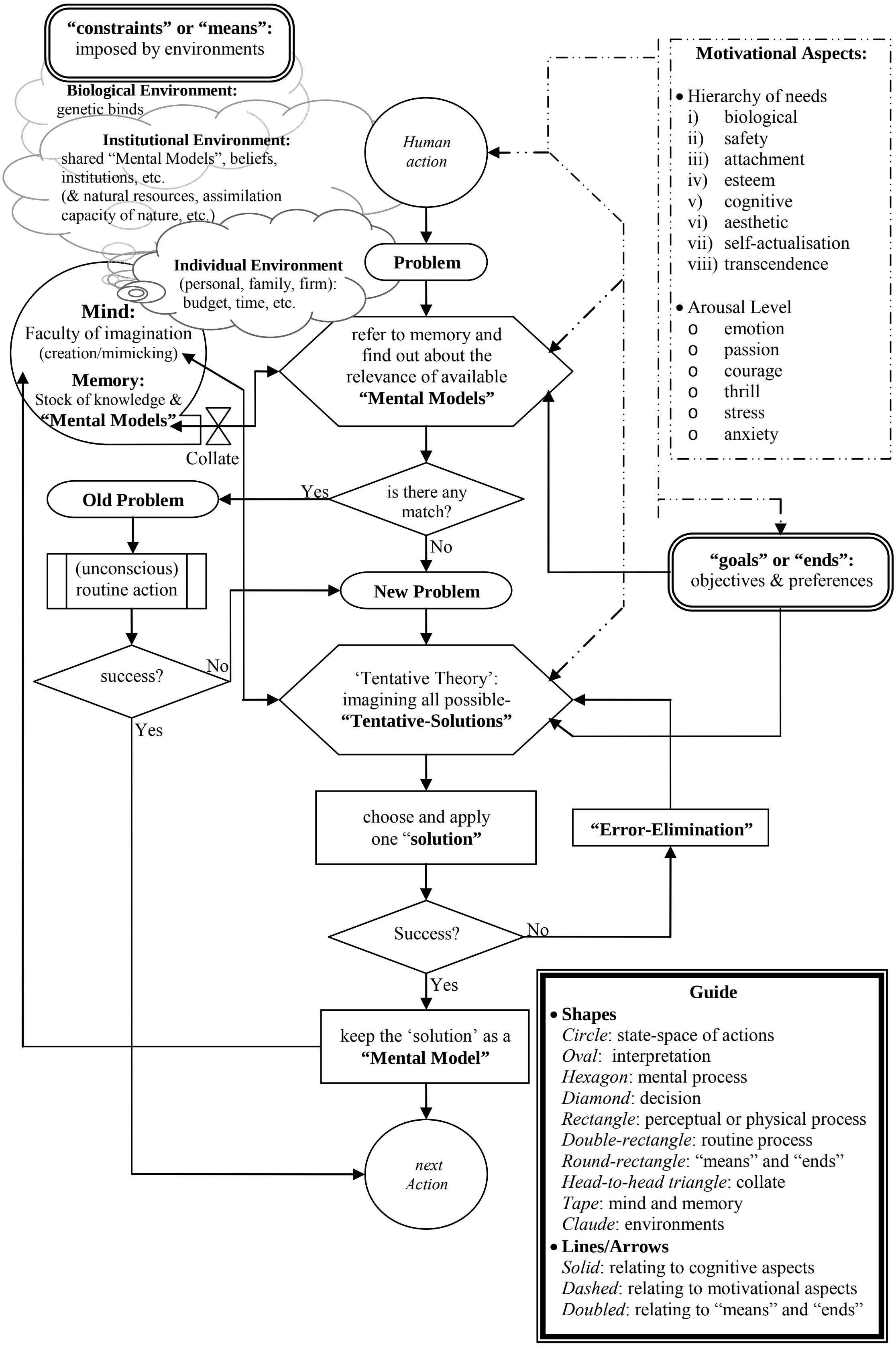

Figure 3.2 Problem-solving Framework
Source: adopted from Mantzavinos (2001, p. 41)

Individuals and organisations essentially act in order to solve their problems. The nature of each problem is characterised by their "ends", given their "means", in every moment of time. Every human action (individually or organisationally) always commences when there is a stimulation driven by motivation, which, in turn, stems from their unsatisfied needs. The level of arousal is also an important factor in every problem-solving action. The motivational aspects act as the sensors of human action and directly influence the "ends" of every mental action of humans. The motivational aspects of individuals and organisations are shown by the dashed lines, and cognitive aspects by solid lines (Figure 3.2). Human actions include all types of operating processes (that is, mental, decision, perceptual or physical, routine, and collate processes). Each of these processes is shown differently in Figure 3.2 (for example, mental processes by hexagons and decisions by diamonds).

The initial state of every action is when individual/organisation has identified a problem. The first stage for the individual/organisation is – by referring to the mind[31] – to think whether the problem is an old or new. Such a mental process (shown by hexagons in the Figure 3.2) is simply undertaken by collating the problem's condition (that is, the condition that stimulates human to act and that is associated with "ends" and "means" corresponding to the identified problem) with the conditions associated with the available "mental models" in the mind. The structure of human mind, as described earlier, consists of a self-programmed brain, which is conditioned by its environment to solve adaptive problems. The brain also has the ability to store knowledge in the form of certain mental models, which is known by the individual/organisation as a certain operating package that identifies which *response* must be made in respect to which *stimulation*. Therefore, human knowledge is the store of mental models and includes both kinds of knowledge, namely theoretical (that is, *knowing what*, for example, literature and science) and practical (that is, *knowing how*, for example, skill and technology). Every mental model is a certain set of operators that humans can apply to solve a certain problem. Every mental model can be described as a conditional logic of a "IF … THEN …" statement: "IF *stimulations* are such and such, THEN the *response*

[31] The mind, at the organisational or societal level, as mentioned earlier, is totally impersonalised, while still working through individual brains. It is associated with organisational learning and the concept which Donald (1991) has named as 'External Symbolic Storage' for the trans-generational transmission and accumulation of knowledge (cited in Mantzavinos, North & Shariq 2004, p. 77).

must be so and so".[32] Therefore, in the first stage, the human action is more or less analogous with searching in a troubleshooting procedure.

If the individual/organisation identifies a problem as an old problem, the corresponding relevant mental model will be picked up and a set of operators, as instructed by that particular mental model, will be unconsciously processed. Hence, the solution of every old problem is a *routine action* (see Figure 3.2). Many of human's day-to-day actions are of this kind. However, as mentioned earlier, the possibility of failure of a solution to an old problem always exists. This is when the individual/organisation will identify the problem as a new problem.

Alternatively, if the problem is identified as a new problem, the second stage of human action starts. At this stage, the individuals (independently or collectively) will be thinking of finding a solution for the new problem. They will therefore refer to their faculty of imagination in order to make a tentative theory and some "tentative-solutions". The "tentative-solutions" essentially include the acquisition of ready-made solutions from the external environment (for example, mimicking other individuals/organisations, species, or relevant phenomena) or the creation of new alternatives with the aid of imagination (Mantzavinos 2001, p. 41). Then, they will choose one of the tentative solutions and will actually process it. This is shown by the rectangle in Figure 3.2. If the result of the actual process was a success they will keep the solution as a new "mental model" in their mind and will face their next action. Otherwise, the second stage may be repeated over and over again by the process of "error-elimination" for imagining more alternative "tentative-solutions", and so on (see Figure 3.2).

Human actions have two main dimensions: static and dynamic. In the following two headings, these dimensions of human actions are described. Understanding these dimensions would help to provide a description of a 'political economy' approach,

[32] This could be as simple as "IF you are thirsty, THEN you must drink" in the case of individual problems, or as complex as "IF the electricity industry is not productive, THEN certain policy actions must be imposed" in the case of organisational problems.

which the problem-solving framework suggests could be used to analysing institutional phenomena (such as electricity reforms).

Static Dimension: Individual Learning and Invariable Institutions

In static dimension, the dominance of economics is evident in the growth of human knowledge, which takes place independently inside the minds of individuals. The environment of human actions in the static dimension is the immediate individual environment. The static dimension refers to the process of individual learning. Hence, due to the scarcity of time and resources, institutions remain largely unchanged (see Figure 1 in Appendix 1.1). This implies that independently memorised new "mental models" may not be shared with others, due to a lack of adequate communication. In this case, two independent individuals or organisations may simultaneously find two identical solutions for one particular new problem.[33] Diffusion of shared "mental models" requires adequate time, mutual interest, and social interactions, but in static dimension of human actions these conditions do not exist as such.

Static dimension of human actions is the subject matter of *microeconomics*, in which analyses are often *ceteris paribus*. In traditional microeconomics, the "ends" are usually defined by utility functions for the individuals or by profit functions for the organisations. The "constraints", on the other hand, are usually symbolised by the budget line. The theoretical narrowness of traditional microeconomics is in its conceptions about human behaviour. According to the behavioural assumptions in microeconomics, there seems to be one-and-only-one general mental model for every human action. This mental model is described by maximising utility/profit, minimising costs or, in short, optimising utility. This mental model is often elaborated in the theory of rational choice. Hence, in traditional microeconomics, the concepts of "optimisation" and "rationality" are used almost equivalently to Homo oeconomicus. In problem-solving framework, on the other hand, the optimisation or generally the application of calculus and mathematics is considered as one possible mental model. Therefore, irrespective of whether human action is rational, boundedly rational, or irrational, the problem-solving framework provides a robust theoretical foundation to explain

[33] For example, J. Swan (UK) and T. Edison (US) invented the incandescent lamp in 1879, simultaneously.

individual actions. Therefore, the notion of *choice* does not reflect economic rationality of individual actions at all. The notion of choice merely reflects the multidimensionality of human cognition for solving problems. The extents of economic rationality, however, depends highly upon the process of learning and human cognition, which are dynamic.

Dynamic Dimension: Organisational Learning and Emergence of Institutions

Human actions also have a dynamic dimension over time and space. In this dimension, time is not a constraint and thus acts of communication are possible (sharing mental models). The environment of human actions in this case is the institutional environment and the possibility of mutual interaction between "ends" and "means" exists. As noted earlier, the growth of human knowledge in this case is related to "institutional change"[34] prompted by organisational learning. One of the most important aspects of the social environment is that it is very likely that solving some one's problem may lead to the creation of one or more problems for others. Consequently, while individuals and organisations are striving to solve their own-problems, there is huge potential in society for uncontrollable chaos rooted in inter-individual conflicts and aggressions. This is a social conundrum known as the *Hobbesian problem of social order* (Mantzavinos 2001). Many problems in society have such a nature. Coase (1960) describes the nature of these kinds of social problems, as follows:

> The question is commonly thought of as one in which A inflicts harm on B and what has to be decided is: how should we restrain A? But this is wrong. We are dealing with a problem of a reciprocal nature. To avoid the harm of B would inflict harm on A. The real question that has to be decided is: should A be allowed to harm B or should B allowed to harm A? The problem is to avoid the more serious harm (Coase 1960, p. 2).

The interesting point in Coase's description about these problems is that he uses the pronoun 'We' as if presumably the problems should be solved by a third party agency. Such a third-party agency refers to external enforcement organisations (for example,

[34] For the purpose of social theory, the "genetic change" of human knowledge is irrelevant. The growth of knowledge relating to the ecological environment (for example, relating to the assimilation capacity of ecosystems, exhaustible resources, and so on) is also captured as "institutional change" of human knowledge, because such growth of knowledge is also gained as a result of organisational learning.

state) required for monitoring the compliance of the formal institutions, and – at least – for the establishment of *law and order* in the society. Therefore, the dynamic dimension of human actions and human learning (that is, the process of organisational learning) causes changes to the institutions. This is how institutions emerge or decay, which is described in this thesis as institutional phenomena.

Institutions provide a twin solution for the Hobbesian problem of social order. The solution is twin, firstly because it is about two main social concerns (political and economic) and secondly because it emerges in a dynamic chain of the two-stage process of "tentative-solution-and-error-elimination" (see Figure 3.2). In the first stage of this process, the solution is about the possibility of inventing certain rules to restrict self-interest of all or some of the individuals/organisations – the establishment of a rule. Therefore, the solution is definitely about restricting human freedom of choice for social fairness. The action of rule-making requires a third-party agency as the external enforcement organisation to monitor compliance with the rules. While restricting the freedom of choice (for some or all) is the immediate outcome of the first solution, the likelihood of social fairness requires the second solution, essentially because in the first stage it is more likely that the interests of one or some groups are better served than those of others. The first solution is therefore about political concern in society. This solution is hence addressed by political theories and works practically through *political processes*. The political processes relate to the establishment of, or the action of the external enforcement organisation (that is, rule making and governance). This is the main rationale behind the government and its critical role as the main problem-solver organisation in modern societies. Enforcement organisations are not limited to the government only. There are also, for example, independent regulators, judiciary system, opposition parties, federal reserve or central banks, and more recently, non-governmental organisations (NGOs)). However, the position of the government is often considered to be at the highest level of hierarchy of power in political processes of modern societies (or, according to John Kenneth Galbraith (1908–2006), in the anatomy of power of modern societies). Therefore, the dynamic dimension of human actions, in the first-stage, is the subject matter of *politics*.

In the second stage, the solution is about the realisation of whether each enacted solution in the first stage (that is, formal institution) has created a mutually beneficial institutional environment between different individuals and organisations with diverse interests. Such realisation is about the likelihood of social fairness and the success of the solution in the first stage. The solution in the second stage is usually addressed by economic theories and works through exchange processes. The exchange processes are about the emergence of "markets" as informal institutions. The concept of market, in this context, is much broader than the notion of market often used in the recent literature on market reform. In the latter case, the market is narrowly referred to as a certain type of financial market, which focuses on finance and pricing. A typical example of such a market is stock exchange, where numerous buyers and sellers bid prices.

The broader concept of market refers to all kinds of exchange processes for every type of "mental models" and thus includes scientific, technological, economic, and political markets. If an exchange process meets the lowest "transaction cost", then the best solution in the second stage is achieved. This condition refers to a market that provides a fair and mutually beneficial environment for all interested parties (individuals/organisations) with least intervention from the external enforcement organisations. This occurs when a market institution has found wide acceptance among all beneficiary parties and has turned into a kind of informal institution (a social norm, for instance). This occurs when mutual trust has diminished inter-individual and inter-organisational aggressions, which, in turn, has reduced the involvement of the external enforcement organisation to minimum possible (that is, the lowest social cost and the lowest transaction cost).

The dynamic dimension of human actions is the subject matter of *macroeconomics*, whose theoretical basis, as Kühne (1979) elaborated, was firstly created by Marx (cited in Bottomore 1985, p. 1) while practically introduced by Keynes (1936). Macroeconomics puts emphasis on policy making and the necessity of occasional government intervention in the economy. Macroeconomics (in its both Marxian and Keynesian versions) has never been well received by (neo)classical economists because of their faith in the notion of *laissez faire* economy. Even Milton Friedman's (often known as responsible for the ascendancy of neo-liberalism and neoclassical economics in the current era) view on general acceptance of the pragmatic marriage of Keynesian macroeconomics and microeconomics (what Paul Samuelson proudly proclaimed as ‘neoclassical synthesis’) has remained odd (Stilwell 2002, p. 291).

The problem-solving framework entirely captures the premises of modern macroeconomics. Under this framework, the involvement of government (as well as other independent enforcement organisations) is considered as the most important part of the process of emergence of efficient markets (that is, markets with minimum transaction costs). However, once such a market has been well established and becomes an informal institution, this framework suggests minimal government involvement. This is when such a market works as a well-defused “mental model” to solve certain problems (for example, by exchanging certain goods, services, ideas, and so on) which have been known as an “old problem”. Nonetheless, the problem-solving framework appreciates that there is always a possibility of failure for such a market. It is such moments that the problem-solving framework – analogous to Marxian or Keynesian economics – suggests for government intervention. Such interventions will begin as political processes (in the first stage) and end when a better exchange process has emerged (a new market structure). Use of the terms “begin” and “end” are lexical constraints here, because there is no well-defined beginning or end. This is essentially because the above-explained chain of two-stage process of “tentative-solution-and-error-elimination” is happening constantly. However, these terms can still be used because, through a careful historical review, one can pinpoint certain years, when new social problems of the Hobbesian nature emerged. This is identifiable because the extents of enforcement organisations’ activities to address such new social problems increases. The process ends, when these activities are minimised (minimum government interventions) – in modern societies, perhaps when one cannot hear any more about that issue in the media. This is when there is adequately efficient exchange process to address that particular problem. In Chapter 2, such beginnings and ends were described with regards to issues related to the electricity industry. A fuller discussion will be provided in section 3.3.

While traditional economics (micro- and macro-) is captured by the problem-solving framework, the problem-solving framework provides a more satisfactory explanation for the Hobbesian problem of social order. In classical economics (Smith 2002), for example, the explanation for this problem is simply evaded by a faith-like idea of the *invisible hand* and *laissez faire* economy. Under the guidance of problem-solving framework, the Hobbesian problem is addressed by explaining how institutions emerge or decay through a dynamic process of organisational learning. This process, in turn, prompts institutional changes in human knowledge and its associated institutional environment, where shared "mental models" (that is, institutions) are externally stored.

On the basis of the analysis in this section, the problem-solving framework calls for a *political economy* approach to provide clearer reasons behind institutional phenomena. The prime rationale behind this call is that a political economy approach captures both the static and dynamic dimensions of individual and organisational learning. This seeks a better explanation about institutional phenomena through lines of arguments in both political and economic processes. These two processes cause the emergence of institutions in a chain of two-stage process of "tentative-solutions-and-error-eliminations".

3.3 Analysis of Electricity Reforms – a Political Economy Perspective

This section provides a description of electricity reforms in Australia using a political economy approach introduced in Section 3.2. This description is about constructing a logical story about the history of the Australian electricity industry, with a view to providing a fuller explanation for the reasons behind these reforms and validating the theoretical contentions stated in Section 3.2 (particularly, with regards to the dynamic dimension of human actions in the electricity industry). In this description, however, as North (1990) nicely stated, 'we do not recreate the past; we construct stories about the past' (p. 131). The main part of this story has, in fact, already been presented in Chapter 2. Table 3.1 contains a concise summary of the story. In this section, in addition to the analysis of Chapter 2, a clearer distinction is drawn between the ends and means of the electricity industry. This is followed by a fuller discussion on how institutional phenomena (that is, the interplay between the ends and means) have taken place through political and economic processes in Australia (that is, through the Australian political economy).

3.3.1 *Electricity Industry: Collective Ends*

The Australian electricity industry is an active socio-economic sub-system. At the present time, it employs over 30,000 people nationwide (ESAA 2003b). The industry's prime objective is to provide safe and reliable electricity services in order to meet the society's needs (lighting, cooking, heating, cooling, and so on). This overall objective consists of four functional sub-objectives corresponding to industry's generation, transmission, distribution, and retail sub-organisations for generating, transmitting, distributing, and retailing electricity, respectively. There are also other related objectives in the industry that are identified with other sub-organisations of the industry, such as system operators, electricity markets and industry regulators. All these objectives represent industry's collective "ends". The structure of the industry shows the arrangements into which industry has been organised to achieve these collective ends. Table 3.1 shows how the organisational structure of the Australian electricity industry has evolved as a result of the actions of the industry to achieve these ends. As the demand for electricity has kept growing, the institutional environment has continued changing, and as natural resources have continued to be exploited over time.

3.3.2 *Electricity Industry: Social Means*

To satisfy the above-discussed collective "ends", the Australian electricity industry has been confronted with a wide range of technological, natural resource, economic, and social constraints. These constraints also include institutions that have been restraining – in various ways – the organisational actions of the industry over time. These constraints also reflect the frontiers of knowledge (stock of mental models) regarding various aspects of life, in general, and the electricity industry in particular. Hence, they reflect the feasible "means" (as available routine procedures regarding well-known challenges – old problems) for achieving the "ends". Salient aspects of these institutions include technology, rules, regulations, exchange processes (market institutions), ownership arrangements, and the social beliefs that are indicated in Table 3.1.

For example, with regard to the "exchange process", the "free market" rules were applied in the electricity industry during the early years. The "exchange process", in general terms, represents a market institution that provides economic balancing of electricity demand and supply. As can be seen from Table 3.1, this institution changed

Table 3.1 Evolution of Organisational Structure and Institutional Environments of the Australian Electricity Industry (1888 – 2004)

	Early Years	War and Depression	Consolidation Era	Internal Reforms	Market Reform
Nodes of Time – ***decades*** ...	**1888** *1890s* *1900s* *1910s*	**1914** *1920s* *1930s* *1940s*	**1945** *1950s* *1960s* *1970s* *1980s*	**1986** *1990s*	**1994** *2000s* **2002** Present
Electricity Demand	virtually no demand / low demand (electricity as a luxury)	potential demand suppressed by recession (electricity more as necessity)	high rate of growth in electricity demand (ambitious demand forecoasts) less than expected increase in demand (excess capacity)		growing electricity demand
Organisational Structure	no specific structure fragmented generators attached to consumer terminals almost no transmission no interconnections no national approach due to tyranny of distance	initial signs for monopoly (private & public) formation of distribution formation of transmission interconnections enhances vertical integration no national approach due to tyranny of distance	more coherent vertical integrated structure across all States "Central Statutory Authorities" horizontal integrations because of IRS at generation, transmission, and distribution sub-sectors no national approach - except Snowy Mountains Scheme that became the first Inter-State approach	same structure internal productivity improvements	functionally unbundling of generation, transmission, and distribution introduction of new sub-sector of retail and electricity service providores, which formerly was part of distribution function mergers and acquisitions
Institutional Environment Technology	AC/DC debate lack of standards frequency voltage disparity high Increasing Return to Scale (IRS)	AC is adopted due to its longer transmissibility more state-wide stabilised standardisation Lack of standardisation across States growing transmission technology high IRS	tendencies towards giant scales due to IRS yet high IRS large hydros possibility of longer transmissions possibility of efficient interconnections energy efficient appliances CCGT technology brought some doubts on IRS in generation segment of the industry therefore, growing distributed generators Internet and telecommunication revolutions		renewable electricity
Rules & Regulations	competition, but fierce no specific regulation British origin of the industry	less competition mergers and acquisitions	no competition / command & control all State monopolies / rate of return regulation golden ages for electricity industry up until the end of 1960s	more command and control commercialisation corporatisation & incentive base regulations	competition (NEM) mergers and acquisitions Pressures for privatisation
Exchange Process	free market rules	controled market (rationing in shortages)	metrit-base dispatching (command & control market)	same	wholesale & retail free market (NEMMCO)
Ownership Arrangement	dominantly privately owned	mix of public and private public: NSW, VIC, QLD, and TAS private: SA and WA	predominantly publicly owned negligible privately owned plants	dominantly publicly-owned negligible privately owned plants	mix of public and private public: NSW, QLD, TAS, and WA private: VIC, and SA
Mainstream Social Beliefs	classical school of thought capitalism laissez-faire private ownership inherent forces for monopolisation of industry due to IRS	revival of Marxian criticism on capitalism / Marxism failure of laissez-faire doctrine debates for and against private ownership	broadly accepted argument of "Natural Monopoly" emergence of Keynesian School of thoughts in post-war era failure of Keynesianism in the aftermath of collapse of Bretton Woods agreement and stagflation phenomenon emergence of neoclassical school of thought under the new neoliberalism in early 1980s and the revival of "market ideology" under private ownership	concerns for accountability and productivity doubts about "Natural Monopoly", especially for generation segment	politicisation of "market ideology" debates on benefits of competition and "free choice" doubts on efficiency of NEM
Major Events	independence of Australia, 1901	World War One Great Depression World War Two	post-war economic boom Marshall plan and European rehabilitation establishment of Bretton woods system 1944-1971 (stabilised world trade) establishment of World Bank and IMF (1944) beginning of Cold War, peaking over 1980s nationalisation of major industries (world-wide) two oil shocks in 1973 and 1979 environmental movements ambitious energy plans (aluminium) stagflation phenomenon over 1970s and fall of Keynesianism	globalisation program (largely led by the US & UK) privatisation of British infrastructure industries removal of Berlin Wall & collapse of Soviet Union World Bank's uniform prescription for liberalisation and privatisation deregulation policies in the US	COAG's review

Note: this table is developed on the basis of the discussions provided in Chapter 2 into some sort of command-and-control market in the subsequent periods until the early 1990s. Then, in the mid-1990s the free market rules were re-established in this industry. This institution, during the War and Depression period (1914–1944), due to difficult social and economic conditions, was in charge of rationing the supply of electricity according to the priorities and concerns of those days.

During the Consolidation Era (1945–1985) and Internal Reform period (1986–1993), except on certain occasions described in the previous chapter, this institution worked efficiently under the central (statutory) authorities in each state. The institution worked in a way that the price and cost of electricity were matched most of the time. It is interesting to note that during the market reform period, there has been a general tendency to revive the "free market". In order to understand the reasons behind these changes, in Table 3.1, the evolution of mainstream "social beliefs" as another important institution is also presented.

3.3.3 Electricity Reform: Interplay between Ends and Means

Using the problem-solving framework, the electricity industry – as a socio-economic sub-system – can be re-defined as a specialised problem-solver. In other words, electricity industry is set up to solve particular problems relating to electricity generation, transmission, distribution, retailing, and other related issues. Every moment that an electric light is being switched on somewhere in the economy, the electricity industry receives certain signals in a form of a complex problem. Normally no end-user even notices how such a complex problem is being solved, simply because the industry is well set up to solve problems of this kind. Most of the time, such problems are simply solved by certain routine procedures in the industry. However, many complex problems continuously challenge the industry. For example, during peak time if the demand reached its full capacity, a small amount of additional demand may cause a system failure or blackout which would be very harmful. For example, the incident in Queensland on 13 August 2003, when 250,000 households were blacked out (Wardill 2004).

As the industry and economy develop, and social life becomes more and more dependent on goods and services provided by the electricity industry, even a small interruption in electricity supply could cause a lot of damage to the economy and the social well-being of the society. Therefore, industry must be well specialised to undertake routine actions (solving old problems) and well-prepared to confront unexpected situations (solving new problems). There are certain routine actions as a part of industry's preparation to avoid any crisis. For example, careful prediction of demand and peak-load is one such routine action to keep industry's supply flow smooth. Therefore, complex decisions about industry's day-to-day actions as well as its future development must be constantly made. Adequate new capital or replacement investments are continuously required.

Solutions for these old problems are provided by various formal and informal institutions such as technology, procedures, rules, regulations, codes, and market processes. Such formal and informal institutions – while changing continuously – do not change significantly on a day-to-day basis. However, it is always possible that a critical situation emerges for which there is no a routine solution (that is, when a new problem emerges). In such situation, current institutions or mental models can not solve the problem. The industry, then, requires to change some of the current institutions significantly. This is when reform takes place.

Figure 3.3 shows how a socio-economic sub-system acts over time. This Figure is presented in a generalised form in order to present this thesis' theoretical contention for explaining the reform of electricity industry. Two sets of new problems[35] and corresponding actions occur over time. The first kind of new problems are those which are often being solved by the industry's static actions by individuals in the industry. Vertical solid arrows (in Figure 3.3) represent the interactions of the industry in response to these new problems given the social constraints as invariable institutions (see Figure 3.4). The industry strives to solve these problems given all constraints as constant. Hence, for these problems, the industry and its sub-organisations normally respect conventions, follow moral rules, adopt social norms, and obey formal laws,

[35] As discussed in Section 3.3, there are also "old problems", but the focus of learning is on "new problems", which there is no routine procedure as a solution. Further, It should be remembered that the terms "problem" and "solution", in the context of this chapter, were adopted only because Popper (1978, 1979, 1982) and Mantzavinos (2001) use this terminology for their problem-solving frameworks. However, this terminology, in the context of reform of socio-economic sub-systems, conveys the notion of "challenge" and "resolution", respectively.

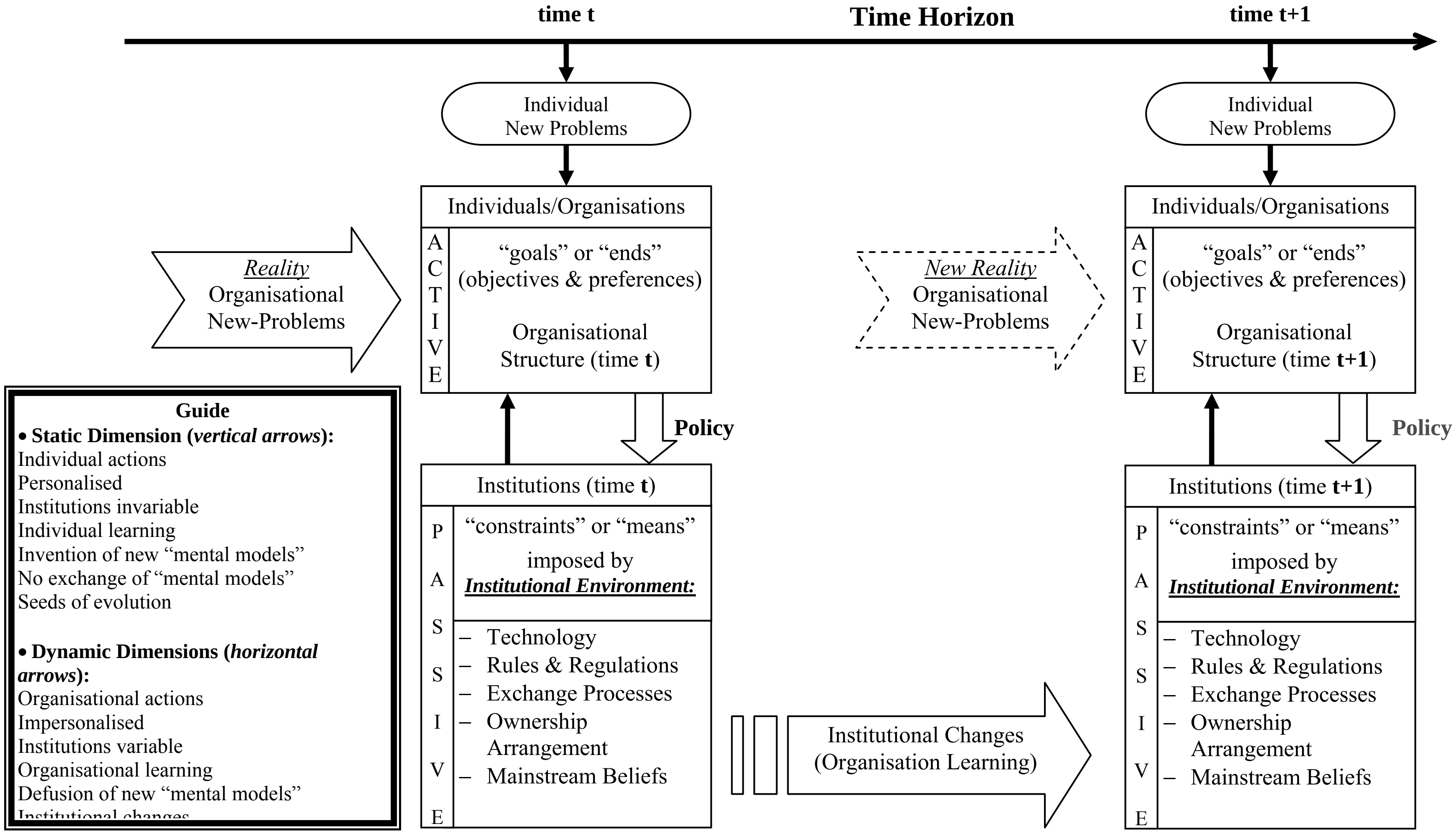

Figure 3.3 Static and Dynamic Dimensions of the Actions of Socio-economic Sub-systems

otherwise they will be faced with external enforcement, especially against any violation from the formal institutions – the law, in general, and industry regulations particularly. The static actions against these problems are made through day-to-day decisions.

The second kind of new organisational problems are related to dynamic actions of the industry. These problems are shown with wide horizontal arrows in Figure 3.4. For these problems there are enough time and reciprocal interests between the beneficiary parties to actively exchange information and mental models, which may lead to the emergence of new institutions. The actions, this thesis contends, work through a chain of two-stage processes. In the first stage, a new policy is imposed which contains certain changes in the current institutions. However, wide acceptance of a new institution highly depends upon the success of the new policy over time as to whether a mutually beneficial exchange process is established. A natural evolutionary process of "tentative-solution-and-error-elimination" is observable in the path of history of the electricity industry as the industry learns from its past experiences. In other words, the review of the history of the Australian electricity industry supports this natural process of static and dynamic motion on the basis of organisational learning.

In order to validate this theoretical contention, the institutional phenomena in the Australian electricity industry are examined. As noted earlier, the evolution of the industry is divided into five periods: early years (1888–1913), between two wars (1914–1944), the consolidation era (1945–1985), internal reforms (1986–1993), and market reform (1994–present). The following discussion is essentially focused on the dynamic actions of the industry. Therefore, actions of particular individuals are not captured. However, it is believed that if more in-depth information is added to the analysis (more detailed historical review) one can make another story and another political economy of the industry, fully consistent with the one provided in this chapter. The following headings analyse the organisational actions of the industry during each time-period, as introduced in Chapter 2. This analysis ultimately elaborates why reforms of the electricity industry have taken place in various periods.

Early Years Concerns

In the early years, several concerns emerged as new problems in the industry. Being at its infant stage, one apparent concern was the nature of technology in those days. In other words, the industry naturally started to suffer from the lack of any technological standards. For example, AC/DC debate was going on as the main engineering challenge in the industry (see Table 3.1). This can be explained in a way that the technology of those days was not institutionalised. As noted in Chapter 2, during those days, the industry used both DC and AC electricity and there was no particular standard regarding voltage and frequency.

Another concern, which soon became an acute social problem, was that the industry was recognised – due to its Increasing-Returns-to-Scale (IRS) – as a “natural monopoly”. Further, another (closely related) concern was this fact that the survival of privately-owned electric utilities became highly dependent on government support. Furthermore, these issues raised the problem of ownership-type in a sense that the industry or the society as a whole became concerned about whether the industry should be run under public or private ownership.

In Australia, no significant interplay between ends and means of the industry can be observed during this period. Hence, as indicated in Table 3.1, no particular regulation was introduced. Further, the essence of culture, social beliefs and economic ideologies remained almost unchanged. Being a British colony, all Australian states were influenced by capitalism and free market ideology. This issue remained unchanged despite the independence movement (which succeeded in 1901). The Australian new constitution did not change the existing social constraints on the electricity industry at all. Influenced by the doctrines of laissez-faire and capitalism, during this period, competition existed among numerous privately-owned utilities (mostly British) in a highly fragmented industry around the centres of populations in major towns and cities (see Table 3.1).

Technology Standardisation

As industry started to develop and demand for electricity increased, the above-mentioned concerns or social problems were becoming more acute. Some organisational actions were expected to be undertaken by the industry and government. During the War and Depression years, the most apparent organisational actions which took place were regarding technological standardisations. These, however, were state-wide actions and nothing much was made at inter-state levels. These organisational actions changed the organisational structure and institutional environment of the electricity industry for the years to come.

The process of standardisation under the premises of problem solving framework resembles the process of emergence of conventions as informal institutions. Once a convention emerges, it stabilises itself with no need for any third-party agency to reinforce it. The *raison d'état* of convention would be that they provide workable solutions to social problems of coordination. For example, AC/DC, voltage, and frequency standard in electricity systems. Once adopted by the industry or the society as a whole, it will work efficiently as long as there is no significant interaction with another external (sub-)system (another state or country) with a different convention. In Chapter 2, the process of technological standardisation was described throughout the industry's history. The first steps was taken during the War and Depression period.

During this period, more critical challenges emerged for the industry as the world went through devastating turmoils. The mainstream social belief (capitalism, free market, and free competition – all under private ownership) were under serious political and intellectual criticisms. Some analysts argued that such turmoils were occurring largely because of the wrong socio-economic model and social beliefs. The World was seeking an alternative socio-economic model. Marxian criticisms, as Schumpeter also pointed out, were true that the answer to the question of 'Can capitalism survive?' was certainly 'No' (Schumpeter 1950, p. 61).

The situation can also be explained using the problem-solving framework. It was obvious that the capitalistic model had significantly contributed to these social problems at national and international levels. Mass unemployment, the gap between rich and poor, and unequal ground between nations in international trade were new social problems for most of the countries. However, the solutions proposed by some intellectuals (particularly, by Marxists) were very harsh (that was, a proletarian revolution and the death of capitalism). This could have been very damaging for the socio-economic fabric of the western civilisation. Soviet Union already adopted an alternative socio-economic model (that is, communism). Germany's national socialist party had also another alternative model (that is, fascism). All these events contributed to the fact that social order was significantly replaced by aggressions at national and international levels. Despite the emergence of communism and fascism in global context, no significant institutional change took place in the western societies (including in Australia). Classical economists called upon the society for calm and argued that these turmoils are temporarily and every thing will be all right soon – just have faith in laissez-faire. During this period, pressures for changing the existing social means (the institutions) reached its maximum.

At the industry level, in Australia, some changes took place as the industry grew slowly. For example, as indicated in Table 3.1, because of War conditions the electricity market was a controlled market and the supply (due to shortages) was under rationing. Public participation became more apparent and, due to development of transmission and distribution technologies, mergers and acquisition (due to the economies-of-scale) were noticeable.

Economies-of-Scale

By the end of World War Two, some critical social issues associated with capitalism, competition, laissez-faire, and private ownership were recognised as new social problems for the industry that required organisational action. Stalinist and Maoist models of Marxism were rapidly spreading at the international level (particular among developing nations in Asia, Africa, and Latin America). Large scale nationalisation of infrastructure industries during those years should substantiate this argument.

An important interplay between social ends and means in the West was the emergence of Keynesianism. Keynesian policy solutions, which were more reformist (as compared to the Marxian revolutionary solutions), soon found political acceptance and were widely implemented in the Western world, including Australia. Under the influence of Keynesianism, organisational and institutional changes took place in the electricity industry. This ushered in the 'golden age' for the industry that persisted until the early

1970s. Establishments of the Bretton Woods agreement, World Bank, and IMF also stabilised the world trade system at least until the late 1960s. These institutions created reciprocal benefits between countries across the world. Ironically, evidence soon emerged that these institutions could not survive, because one country, the USA, was losing in this game. The Bretton Woods agreement had required huge commitments from the USA. Therefore, the sustainability of the institutional environment was compromised and new problems emerged, namely, the collapse of Bretton Woods, and the two oil shocks (see Table 3.1). It was these world-wide turmoils that gave neoclassical economists a chance to blame Keynesian economics.

In Australia (like in other western countries), this era is recognised as the golden age for the electricity industry. Keynesian model helped to address natural monopoly, market, and ownership issues all at once. However, as mentioned earlier, towards the end of this period, electricity industry was also faced with new problems. Unemployment and inflation (stagflation) prevalent in these times attracted the attention of politicians and the public. Further, as noted in Chapter 2, in the early 1980s, for the first time after World War Two, real electricity prices started to increase. Not knowing that much of this was due to imported inflation in the wake of oil shocks, the electricity industry was blamed as being unproductive. This reasoning took the industry into another period, namely, period of internal reform, where new organisational actions were expected to be undertaken by the industry and government.

Productivity

From the mid-1980s to the early-1990s, new organisational concerns emerged in the Australian electricity industry. These included excess capacities, overstaffing, inflexible pricing, and lack of accountability. As noted in Chapter 2, this situation arose due to the ambitious energy plans on one hand, and the drastic reduction of electricity demand (achieved by energy conservation policies in the wake of oil crises) on the other hand. The industry was considered to be performing inefficiently, while almost all through oil crises, the Australian electricity prices, in real terms, were among the lowest in the OECD countries, indicating the industry's relative efficiency. The industry's response to these concerns was to initiate a series of productivity reforms, employing a set of command and control policies. As a result of these organisational actions, which were supported by both industry and governments in the Australian states, significant efficiency gains were achieved (see Table 3.1).

It is important to note that those improvements in productivity were accompanied by only minor changes to the institutional framework of the industry. Overall social means at the societal level also remained unchanged. This substantiates the claim in this research that there is no one-to-one correspondence between institutions and performance of organisations. As other researchers (for example, Johnson and Rix (1991)) have also pointed out, the improvement of productivity during internal reform years was because of managerial and organisational actions. These actions included a firmer command-and-control, imposed by state electricity authorities. Fuller discussion on productivity of state electricity industries will be provided in Chapter 4.

National Competition

In the mid-1990s, in spite of the productivity gains achieved due to internal reforms of the 1980s, the Australian policy makers and planners embarked on a radical reform program under the title of market reform (see Table 3.1). This was due mainly to some significant institutional changes in the global context, especially after the collapse of the Soviet Union, and the launch of the UK- and USA-led globalisation program. It is interesting to note the correspondence between the institutional environments (typified by free competition, free mobility of capital, and the domination of private ownership) of the early years of electrification (the late 1880s) and the recent reform (the market reform of the 1990s). This correspondence, as discussed in Chapter 2, suggests that policy direction of reform of the 1990s has been largely ideological, underpinned by emerging faith in neo-liberalism and neoclassical economics. In broader terms, the cause of reform has been institutional.

It is interesting to note that electricity reform was initiated when significant productivity gains had already been achieved in the early 1990s and, according to several productivity analyses, the Australian electricity industry was performing very well both at domestic and international levels (this will be further discussed in Chapter 4). This, according to the problem-solving framework, implies that despite arguments made by the proponents of reform that reform was to further improve the productivity of the industry, the main reason for reform was rooted in the dynamic dimensions of human actions at organisational and societal levels. In other words, the problem during this period emerged from the society as a whole and also from the institutional environment in international context in the wake of globalisation. This has been the main reason behind the fact that electricity reform during this period became an integral element of the wider economy-wide reform program.

In addition, one should not forget that it was widely believed by many technocrats in the electricity industry that the industry – since its inception – has been disadvantaged because of lack of a national approach towards it. This is while such a national approach – at least since the end of the World War Two – had proven to be economically sound for the same reason that caused the industry's vertical integration at state levels. However, state governments' preferences and determinations were focused on keeping their full sovereignty over their electricity industries. This was indeed fully institutionalised by the Australian constitution. Therefore, while a need for a national approach was already acknowledged by some state electricity authorities, this need was always pushed back because of strong institutional constraints (the institution that electricity is a state matter). In other words, the problem of having a national approach has always been with the industry, but it was being treated as an 'old problem' because there had been an institutionalised solution for that (that was, no inter-state electricity trade). The solution was influenced by strong inter-state and Federal-States politics. As mentioned in Section 3.2, every 'old problem' can become a 'new problem' at any time (see Figure 3.2). This was the main reason and incentive behind the fact that electricity authorities during this period warmly embraced the argument for establishing national electricity market. However, it is not surprising to see that efforts to solve this new problem has created a series of political challenges and 'new problems' in the Australian Federal-State politics, because of the complexity of political processes.

The interplay between ends and means of the electricity industry during this period can be seen in Table 3.1. Changes in institutions are vast during this period. A new regulatory framework has been introduced. Technological improvements in the 1980s and early 1990s allowed the foundations of the natural monopoly debate to be questioned – at least in the generation segment of the industry. Technological improvements (particularly emergence of distributed generation and improvements in information technology and telecommunication) allowed for a functional unbundling of the industry (see Table 3.1). The ownership of the industry, which remained under public domain for a long period of time, started to move towards private domain. Pressures to privatise the industry have been considerable, but due to public opposition this has not occurred in the same manner across the states (see Table 3.1).

Further, the most important institutional change has been a change in the structure of the electricity market. This market has been changed from a command-and-control market (at state levels) to a free market (at national level) with a similar structure as stock exchange market. Although due to electricity's special characteristics, the newly structured electricity market has been a new institutional innovation, one should remember (see Chapter 2) that the traditional command-and-control market had well proven its efficiency in terms of equating electricity costs with electricity prices (this will be further discussed in Chapter 4).

The Australian electricity market structure is similar to the one adopted by UK electricity industry. This market structure later brought a series of new problems in the electricity industry (both in the UK and Australia). By 2002, the COAG (2002) energy market review identified some of these problems as critical, and suggest that they should be addressed in the years to come. Since the beginning of reform, the industry is struggling to find lasting solutions for these problems. The ideological influence of neoclassical economics on the structure of electricity market in Australia, this thesis contends, is a significant aspect of the Australian market reform. In this respect, the application of problem-solving framework provides some interesting insights. Technological advancements, particularly in the information technology, internet, and telecommunication, made it possible to structure a new electricity market similar to stock exchange market. However, due to ideological influences in this restructuring process (influence of free market and neoclassical ideologies), the reform program ignored many peculiarities of electricity – as a commodity as well as valuable knowledge and experiences stocked in the human knowledge throughout the history of the industry. In other words, there were alternative solutions to the national approach for electricity industry in Australia that were ignored by the architects of the reform program. A more focused analysis on alternatives will be carried out in Chapter 5.

3.4 Summary and Conclusions

This chapter provided a fuller explanation for the fundamental reasons behind the Australian electricity reform, by employing a 'problem-solving framework' that emphasised the human element (particularly, human motivations and cognitions) associated with electricity reform. The nature of problems during various phases of the evolution of the industry were discussed using this framework. Main organisational actions (by the electricity industry or government) and institutional changes were also described in this chapter. The main points are summarised below:

- The early years (1888–1913) witnessed the early stages of diffusion of technology. Many problems emerged in those days, highlighting the peculiarities of electricity as a commodity/service and as an industry. These problems related to technological standards, natural monopoly, and ownership of the industry. Motivated by hope and ambition and influenced by institutional environment of those days (typified by the beliefs in the principles of democracy, capitalism, colonialism, and free market), entrepreneurs in the electricity industry started to develop this industry, initially around major cities and towns across the Australian states.

- The War and Depression period (1914–1944) can be best described as the era of 'technological standardisation.' Despite the Wars and the Great Depression, scientific and technological achievements were significant. While the nature of problems in the industry remained the same, the organisational learning process and organisational actions led to substantial improvements in the standardisation for current, voltage, and frequency of electricity. The emergence of technological standards took place as a result of industry's organisational learning and actions. New standards worked as new conventions – self-stabilised informal institutions. This however took place more at the state levels and less at the national level. However, global turmoils – mainly associated with capitalism and laissez-faire ideology – created some problems for the industry. The organisational action in response to these problems included regulations and indirect control in some states and public ownership and direct control in others. Therefore, there were divergent approaches towards regulation and ownership arrangement of the industry across the states.

- The Consolidation period (1945–1985) – also known as the golden age of the electricity industry – can be best described as having been influenced by the economies-of-scale argument, implying that the solution of the problem of natural monopoly and shortcomings of capitalism and free markets, were addressed by a vertical integration of the industry. During this period, it can be observed that the main argument had been that the larger the scale the better would be the solution. Organisational actions in the industry, hence, included developing large-scale plants, as well as large-scale transmission and distribution networks in order to meet the fast growing electricity demand, which was boosted by post-war economic boom. The problems associated with the shortcomings of capitalism and free market ideology were addressed by Keynesianism. Keynesianism provided a politically acceptable and economically workable justification for government regulation and public ownership in the Western world. While society generally believed in capitalism, electricity industry was treated as an exception, requiring central control. Under the influence of Keynesianism, a unanimous change in industry's structure and ownership-type took place during this period. The ownership almost entirely moved towards public and the structure of the industry became vertically integrated under central (statutory) electricity authorities.

- The Internal Reform period (1986–1993) can be best associated with the debates on 'productivity.' The golden age of the industry was accompanied by some serious (new) problems in the early 1980s. The industry started to be blamed as being inefficient and unaccountable, largely because of the rapid rise in real electricity prices. These price rises, however, were mainly due to imported inflation (in the aftermath of the oil shocks of the 1970s), federal government's tight monetary policy, ambitious over-inflated demand forecasts (ignoring significant efficiency improvement of electric appliances as a result of conservation policies of the 1970s), and massive investment in new infrastructures (see Chapter 2). Stagflation was considered as a new phenomenon and a new problem under Keynesian models, as it was theoretically unexplainable by Keynesian theories. While no significant institutional change can be observed with regard to industry's structure, ownership arrangement and regulation; organisational actions of the state industries – characterised by firmer command-and-control, commercialisation, and corporatisation – brought about significant productivity gains during this period. This substantiated the claim in this research that there is no one-to-one correspondence between institutions and the performance of organisations.

- The Market Reform period (1994–present) can be best associated with national economic reform. While productivity of the industry was apparently in good shape prior to reform, yet it was the stated rationale for reform! However, according to the problem-solving framework, the true cause of reform was institutional. In other words, reform was driven by some very strong external institutional pressures in the wake of the USA- and UK-led globalisation and the emergence of market ideology. Further, the initiation of a 'national approach' in the electricity industry (for the first time, while it was noted as economically beneficial approach, since at least 1920s) became an incentive for (some) state electricity authorities to embrace the idea of reforming the electricity industry. From the state industries' point of view (at least, views of many technocrats), a 'national approach' was, in fact, an 'old problem', for which actions were long delayed because of inter-state and federal-states politics. This politics acted as a social constraint (that is, the electricity viewed as a state matter, which was well institutionalised in the Australian constitution). Due to technological advancements (especially in the information technology, internet, and telecommunication), it became possible to establish a new market structure similar to a stock exchange market. This market structure has however brought several new problems that industry has never experienced before.

The analysis of this chapter validated the theoretical contentions developed in this chapter (using problem-solving framework) that 'electricity reforms' is an 'institutional phenomenon'. A 'political economy' approach is suggested by this thesis for explaining this phenomena. This approach examines the reasons behind electricity reforms through political and economic processes in the industry and society. In this approach, electricity industry is looked upon as a socio-economic sub-system that learns by trial and error. The industry keeps a stock of electricity-related human knowledge in various forms of shared 'mental models' as solutions for industry's problems that have been experienced in the past. The followings are some of the most important findings of this chapter:

- Every institutional phenomenon occurs as a result of a dynamic organisational learning process. Through a historical review (presented in Chapter 2 and summarised in Table 3.1), it was revealed how human knowledge about electricity evolved. For example, evolution of technology reflects main constituent of such electricity-related human knowledge. In certain years, it was shown that the speed of technological changes were accelerated and caused significant change (reform). In general, electricity industry has been a technology-driven industry, implying that most of the past reforms were initiated by some technological innovations. Economic factors (costs of technologies) have also contributed to the time of occurrence of reforms. This has not been limited to the recent (market) reform as argued by the proponents of current reform. This has indeed been a case for all periods in which reforms took place. Further, political factors created the environment for reforms to happen.

- Such an organisational learning process prompts emergence of new institutions through a two-stage process of trial and error or "tentative-solution-and-error-elimination" using the faculty of human imagination and creativity. In this process, what is important is the effectiveness and workability of the emerged institutions for addressing the goals and needs of the industry and society. For example, in the early years, it was understood that free competition and private ownership are not good models for the organisational structure of the electricity industry. Public ownership and command-and-control promised a better solution. However, not every model for introducing public ownership and regulation was acceptable in the Western countries. Marxism was also calling for similar change. Keynesianism ultimately provided an acceptable and workable solution in Australia – just like many other Western countries. Therefore, while a tentative-solution is constrained by some broader institutions in society such as ideological beliefs, in error-elimination indeed more alternatives solutions would be debated, even if they challenge institutions of higher hierarchy in society (for example, ideological beliefs). This also implies that the choice of a reform model would be absolutely free from rationalistic behaviour of human beings, but always constrained by some conventions, moral rules, social norms, and formal laws that carry elements of human rationalities.

- Changes in institutions may (or may not) improve economic performance of organisations. This largely depends upon the type of institutions which emerges and the stage of its diffusion. The historical review (in Chapter 2) showed that institutional changes have brought about overall improvement in economic performance of the Australian electricity industry. For example, establishment of standards (AC/DC, voltage, and frequency) as new social conventions during the early years and War and Depression years, and vertical-integration of the industry during the consolidation era brought about significant productivity improvements. However, the analysis of this chapter clearly confirmed that one should not conclude that there is a one-to-one correspondence between institutional settings and performance of organisations. For example, while institutional settings of the Australian electricity industry remained almost the same during the 1980s (the internal reform period), some organisational actions (namely, firmer command-and-control and managerial actions) substantially improved the economic performance of the state electricity industry. In other words, in the long run (when institutions are well disseminated) improvements in economic performance can be associated with institutional changes. However, it is always organisational actions, which contribute to improvement of economic performance through learning process.

- The emergence of a formal institutions (formal laws, rules and regulations), especially in the early stages, may significantly increase the transaction costs and cause inefficiencies. This refers to early stages of reform, when direct intervention of regulatory organisations and government increases. Any transaction of information increases at this stage. Such transaction costs are not limited to economic markets and are often even more in political markets, where negotiations are ongoing to establish new formal rules and regulations. This has been observed in the early stage of reform of the Australian electricity industry in the past, until a time, when (due to wider acceptability) the established formal institutions started to work as informal institutions (conventions, moral rules, or social norms). The political and economic markets – for certain times – then start working with minimum transaction costs and hence minimum direct intervention by regulatory organisations and government. However, there are always a possibilities of market failure due to internal and external institutional factors. For example, during the oil shocks of the 1970s, the energy markets were distracted world-wide. In Australia, despite cheap coal, electricity industry got affected (increase in transaction costs in electricity market and other related political markets) in the early 1980s. Aluminium smelters moved to Australia with the hope of benefiting from Australia's cheap electricity prices, while the industry faced imported inflation. As a result of that, a significant rise (for the first time) in the real electricity prices occurred. Failing to understand this fact, the industry was accused for being inefficient (whereas, the Australian electricity prices were still among the lowest in OECD).

- The emergence of informal institutions (for example, 'conventions' as for well-disseminated technology and 'social norms' as for a well-accepted market structure) may improve economic performance of organisations because of lower transaction costs (compared to formal institutions) and provide a mutually beneficial environment (that is, an environment which is widely acceptable to various beneficiary organisations, again due to its lower transaction costs). For example, a guiding principle of the electricity market for more than five decades was order-of-merit. This principle was working efficiently in pricing electricity so as the price was as close as possible to cost of electricity supply (this will be elaborated in details in Chapter 4).

- Dynamic transformation of 'formal institutions' to 'informal institutions', this thesis contends, is possible through a chain of two-stage process of "tentative-solutions-and-error-elimination". This process, in the first stage works through political processes (negotiation, lobbying, rule making) and secondly get tested (verified) through economic processes (market exchange processes). This process continues over and over again, but there are certain periods in which a relatively efficient market emerges. Therefore, in contrast with the view of the architects of the market reform, this thesis argues that an appropriate electricity market structure (as an informal institution) only emerges through such a process, instead of being designed at once. This process often takes a long time. Apparently, according to historical evidence, the structure of electricity market in Australian state electricity industries prior to the current reform (except during the early 1980s, which the market was distorted by some external shocks) was very efficient.

4 IMPACTS OF ELECTRICITY REFORMS

4.1 Introduction

In Chapters 2 and 3, it was argued that electricity reform is an institutional phenomenon, underpinned by ever evolving human knowledge. Guided by this knowledge, humans create organisations, which through a two-stage process of 'tentative-solutions-and-error-elimination' create new institutions – both formal and informal. And the process continues. By this logic, improvements in the performance of the electricity industry should be a natural outcome of the growth of human knowledge and, in a practical sense, organisational learning. Further, human knowledge grows as a result of human imagination, discovery, innovation, and experience, which, in turn, are driven by human motivations. The human motivations at societal level, the argument continues, are shaped by the all-encompassing social essence of human beings. This essence embodies various social dimensions of interest to humans, for example, political, economic, technical, environmental and other.

However, a review of studies on electricity industry performance reveals that these studies portray humans as 'economic' beings, motivated solely by their economic interests, namely cost minimisation and profit maximisation (human beings as *Homo oeconomicus*). Further, a society, in such studies, is portrayed solely in terms of its 'economic' dimension, for example, gross domestic product and price levels. Such portrayals of human society are also reflected in the selection of various methodologies for assessing industry's performance. The assessment of industry performance based on these methodologies, this research contends, reflects a limited (that is, economic only) aspect of industry performance, and ignores institutional aspects (interplay between ends and means of the industry). This therefore provides rather limited insights for developing policy measures that could be taken to improve industry performance. This also explains why there is significant disparity between expectations from electricity reform and its actual outcomes.

The foregoing arguments reinforce the need to develop a more comprehensive approach for assessing industry performance, and for assessing the impact of electricity reforms on performance of the electricity industry and the wider economy. This chapter is devoted to that need.

Section 4.2 reviews various studies conducted in Australia to analyse the performance of the electricity industry and, in particular, the impacts of electricity reforms on the performance of the electricity industry and the wider economy. The shortcomings identified in this review would provide a basis for the selection of an alternative approach to assessing industry performance in this research. Section 4.3 proposes alternative approaches for assessing the impacts of electricity reform. Section 4.4 applies these approaches in the Australian context. Section 4.5 presents the results of such applications. Section 4.6 summaries the findings of this chapter and presents major conclusions.

4.2 Impacts of Electricity Reforms: A Review of Existing Studies

Several studies have been undertaken by various research groups to assess the impacts of Australian electricity reforms on the productivity of the electricity industry and the wider economy. These studies include Industry Commission (IC 1991), Bureau of Industry Economics (BIE 1992; 1994), Lawrence, Swan and Zeitsch (1990; 1991), London Economics (1993), Industry Commission (IC 1995), Quiggin (1997), and Whiteman (1999). Appendix 4.1 provides a more expanded list of these studies. This section presents the key features of some of these studies. This would help to identify the methodological limitations of these approaches. The first part of this section (4.2.1) presents the key features of each reviewed study, in particular its objective/background, scope, methodology and major findings. These features are then, in Section 4.2.2, analysed with the objective of identifying major limitations.

4.2.1 Key Features of Existing Studies

a) Lawrence et al. (1990)

This study was the first in a series of studies conducted by the same authors (Lawrence et al 1991; Zeitsch et al 1992) with the objective of benchmarking the performance of the Australian electricity industry. This analysed the performance of the Australian state electricity industries for the period 1976–1988.

The main methodology of the study was a multilateral TFP method, which was first developed by Caves, Christensen, and Diewert (1982b). The use of this method was justified by the authors on the argument that traditional TFP analyses (for example, Tornqvist (1936)) only enable comparisons to be made of the rate of productivity changes between electric utilities, and that they often do not enable comparisons of the differences in absolute levels of productivities. Further, traditional TFP analyses, the arguments continued, do not provide any insights for identifying those factors that might help to improve TFPs. Multilateral TFPs, it was argued by the authors of the study, enable such comparison and provide such policy insights.

Together with multilateral TFP, this study also used some regression analysis and Partial Factor Productivity (PFP) measures to explain the causality of productivity changes with what this study referred to as 'choice' and 'non-choice' variables. 'Choice' variables were defined as those variables that can be controlled to some extent through management (for example, size and output composition, which is influenced by pricing policy). 'Non-choice' variables were defined as those that are beyond the control of electricity authorities, for example, geography. This study argued however that there are some interpretational or judgmental difficulties about which variables should be regarded as 'non-choice' variables. With those interpretational issues in the background, the study tried various regression specifications to analyse industry performance. Further, a scenario analysis was used for quantifying overall potential economic benefits of electricity reform at the national level.

The following are the key findings of this study about the influence of various variables (choice/non-choice) on the level of TFP:

i) There was a small positive relationship between scale and TFP.

ii) The proportion of residential sales was significantly negatively related to TFP.

iii) Centralisation of the state was expected to be positively related to TFP.

iv) There was a negative link between length of transmission and TFP.

v) An increased reliance on gas-generation increased TFP.

In view of the above findings and with a view to better compare the TFP levels across various Australian states, various sets of TFP indices were adjusted by the authors for scale, geography, and fuel quality variables. The following were the key findings of the study:

i) South Australia achieved the highest TFP levels for the decade starting with 1976. Its productivity however declined rapidly thereafter. It had the second lowest TFP level in 1989.

ii) Since 1986, Queensland had the highest improvement in TFP.

iii) Western Australia had similar TFP levels to Queensland in the 1970s but had lagged behind from the early 1980s.

iv) Victoria had consistently been the worst performer in terms of TFP levels.

v) By the end of the 14 year period (that is, 1976–1989), the spread of TFP levels between the five states had narrowed considerably.

Further, by examining partial factor productivities, the causes of poor performance of each state electricity industry were explained in terms of: (i) very poor fuel and capital productivity levels, in Victoria; (ii) relatively poor capital productivity levels, in Queensland; (iii) relatively poor other inputs productivity levels, in NSW; and (iv) poor labour and other inputs productivity levels, in Western Australia (WA). Furthermore, the study showed that South Australia achieved mid-to-high rankings in all partial productivities, with the exception of capital in the late 1980s.

Finally, using scenario analysis, this study argued that substantial cost savings were possible if four states (namely, NSW, Victoria, SA, and WA) could achieve the TFP level of Queensland in 1989. These savings, if all inputs were reduced in equal proportions, would approximately be $851 million. This included $351 million in New South Wales, $339 million in Victoria, $96 million in South Australia, and $65 million in Western Australia.

b) Swan Consultants (1991)

This study was an update of the previous study. It had the same objective as the previous study. Its scope was however international; it benchmarked the performance of the Australian state electricity industries with the USA investor-owned utilities, for the period 1983–1990. This study used the same methodology as the above-discussed study. The study showed that substantial productivity improvements had been achieved during the late-1980s. Despite these improvements, this study also suggested that the Australian electricity industries had been operating at only 70% of the productivity levels of privately-owned electric utilities in the USA. It argued therefore that significant potential for more productivity improvements exists. This study did not explain however how such gains would be achievable. It only implicitly referred to privatisation as a possible way of realising this potential. This argument for privatisation was criticised by some researchers, for example, Rix and Johnson (1991) and Quiggin (1997).

c) Zeith et al. (1992)

This study, another version of the above-discussed studies, was undertaken with a similar objective. Its scope was the same as Lawrence et al. (1990). From a methodological point of view, however, this study further elaborated the importance of the application of multilateral TFP indices and adjustment of TFP levels. The study revealed that the Queensland electricity industry was 20% more productive than its NSW counterpart when adjustments were made to TFP levels, and only 13% more productive than NSW industry when no adjustments were made.

d) Bureau of Industry Economics (BIE 1992)

The objective of this study was to benchmark the performance of the Australian state electricity industries. The scope of the study was international and hence the performance of the state electricity industries was benchmarked against their international counterparts (around 40 electric utilities), for the period 1982–1989. The scope – compared with earlier studies – was further broken down into industry's functional segments (that is, generation, transmission, distribution, and customer services). The methodology used conventional PFP and TFP modellings. This study also applied some trend and cross section analyses.

This study revealed that substantial improvements had been achieved in the productivities of the state electricity industries, especially in terms of electricity price, outage time and reserve plant margin. It suggested that productivity was significantly below world best practice in terms of capacity factor, plant availability and labour productivity. The Canadian TransAlta and Japanese utilities were identified as the world best practice industries.

e) Electricity Supply Association of Australia (1992)

The objective of this study was to provide various productivity measures, for the period 1988–91, grouped by three major interest groups, namely: (i) customers – residential, commercial and industrial; (ii) businesses – staff and management, government analysts, investors, other utilities and groups interested in utilities' business performance; and (iii) community – the public at large, which is interested in the performance of the utility from the view point of its value to community, and its environmental impacts.

The scope of this study was national, focusing on state electricity industries, segregated in terms of their functional segments (generation, transmission, and distribution) for the period 1988-1991. This study used conventional PFP modelling. However, the study provided a broader range of PFPs (technical and financial) than previous studies. While this study provided no detailed analysis in support of its major conclusions, it contended that substantial productivity improvements had been made in the Australian electricity industry over the period 1988–91.

f) Steering Committee on National Performance Monitoring of Government Trading Enterprises (SCNPMGTE 1992)

The objective of this study was to measure the TFP of generation and transmission segments of Pacific Power (NSW) for the period 1984–1992. This study used conventional methods for measuring TFP and provided a trend analysis. The study showed that TFP of Pacific Power did not improve over the period 1979–1988, but improved substantially (about 12 percent per annum) over the period 1988–1990. TFP remained almost unchanged during 1990–1991. The overall TFP improvements were due to improvements in: (i) labour productivity – a total decrease in the labour force of over 40% – from 1984 to 1992, (ii) utilisation of capital, particularly regarding availability and capacity factors – by over 50% and 25%, respectively – from 1979 to 1991, and (iii) internal funding of Pacific Power, particularly regarding capital expenditure – a 20% reduction in debt since its peak in 1988.

g) London Economics (1993)

This was yet another study that benchmarked the productivity of the Australian electricity industry. This study was more comprehensive than other studies, focusing on all functional segments of the industry (generation, transmission, distribution, and customer service) at national and state levels for the period 1982–1992. A Frontier Approach (Data Envelope Analysis (DEA)) was proposed in this study for the first time, for decomposing the sources of productivity changes (that is, changes due to scale, technical, allocative, and cost efficiencies). The main reasons behind this proposal were arguments that inefficiency (that is, below production possibility frontier) is possible and that introduction of competition (market reform) would lead to substantial improvements in allocative efficiency as well as technical efficiency. These arguments, generally ignored in previous studies, placed ‘economic and market considerations on an equal footing with engineering excellence’ (COAG 2002, p. 63). Notwithstanding this intent, this study focused largely on measuring conventional PFPs and TFPs. The results of the study, after implementation of its methodological proposal, were later published separately by ESAA (1994) as Part Two of this study (see item h, below).

This study – like preceding studies – suggested that substantial productivity improvements occurred in the Australian electricity industry in the late 1980s and the early 1990s. It showed that the TFP in the entire electricity industry grew by 32% over the period 1982–1992 (3.1% average annually). However, majority of this growth had occurred in the most recent five years (4.5% average annually). The study also showed that the average annual growth of TFP in generation, transmission, and distribution segments of the industry was 2.9%, 5.1%, and 3.7%, respectively, over the period 1982–1992.

With regards to the PFPs in the Australian electricity industry over 1982–1992, most important improvements at the national level included: 24% in capital productivity;

11% in fuel efficiency; 93% in labour productivity; and 22% in other factors' productivity.

h) ESSA (1994)

This study became Part Two of the above-discussed study. As mentioned above, in Part One of the study, the application of a Frontier Approach was suggested to measure technical, allocative, and cost efficiencies of the Australian electricity industry, using DEA. This study benchmarked the Australian electricity industry with its international counterparts. Efficiency measures were presented for generation, transmission, and distribution segments of the industry. The following were its main findings:

i) The average level of technical efficiency in generation (with a score of 0.93) was above that of international utilities (with an average score of 0.91).

ii) The generation segment of Queensland electricity industry was close to the frontier with a score of 0.999.

iii) The average level of cost and allocative efficiency in generation nearly matched the overall average of the international sample.

iv) Given that Australian fuel costs were competitive, and that labour costs only accounted for 15 percent of generation costs, it was asserted that the relative costs of capital per MW installed might be a constraint to Australia's competitive performance.

v) In contrast to generation, the average level of technical efficiency in transmission (with a score of 0.75) was significantly below the overall average of the international sample (with a score of 0.78).

vi) While initial DEA analysis showed that the average level of technical efficiency in distribution segment (0.73) was below the overall average of the international sample (0.78), an extended DEA analysis (by making some adjustments in dataset) showed that this indicator (0.83) was above the average of the international sample (0.81) and one state (WA) was even located on the frontier. Hence, in the distribution segment, no consistent conclusion was made.

i) Bureau of Industry Economics (BIE 1994)

This study was an update of the BIE (1992), with the same objective, scope and methodology. The time period for analysis in this study was 1982–1991, compared with 1982–1989 for BIE (1992). The study showed that electricity prices in Australia (particularly in the industry sector) were among the lowest in the world. Also, the study showed that system reliability improved over the period 1982–1991. For example, reserve plant margin (RPM) reduced from 35% in 1991 to 33% in 1992, and the TFP gap between the Australian electricity industry and the USA's investor-owned utilities was narrowed.

j) Industry Commission (1995)

This study was undertaken by the Industry Commission at the behest of the Council of Australian Governments (COAG). Its objective was to comprehensively assess the economy-wide benefits of implementing the entire package of microeconomic reforms in Australia. The scope of this study was the Australian national economy and not just the electricity industry.

Essentially the methodology used in this study followed a two-stage approach. In the first stage, the study focused on benchmarking the productivity of various industries and government businesses (including the electricity industry) with their international counterparts, using conventional productivity analysis methods (PFP and TFP). In the second stage, using scenario analysis, the study measured expected economic growth assuming that implementation of microeconomic reforms would improve the productivity of the industries and government businesses to the world's best practice levels, as measured in the first stage. The scenario analysis in this study therefore assumed that microeconomic reforms would definitely improve the productivity of selected industries to world's best practice. In other words, this study, somewhat subjectively, equated the gap from the world's best practice frontier with the benefits that would inevitably follow from microeconomic reforms. No convincing explanation was provided in this study about the basis for this assumption.

In the second stage, a Computable General Equilibrium (CGE) model – called HILORANI CGE model – was used. This model assumed that current returns to labour and capital represent opportunity costs, implying that the economy could use its resources to full capacity at all times. Any sectoral displacement of resources in the electricity industry, it was assumed, would be re-allocated to other sectors. This might be a plausible assumption for assessing longer-term impacts, but appears untenable for assessing short-term impacts (SAIIR 2002). These assumptions imply that estimates were maximum achievable productivity gains, rather than most likely outcomes. Further discussion on the foundations of this methodology and its assumptions will be provided in Section 4.2.2.

The first stage analysis suggested that, as a result of the implementation of microeconomic reform, productivity of the Australian electricity industry would be improved as follow: (i) 4% reduction in capital requirements; (ii) 50% reduction in labour requirements; (iii) 20% fall in construction cost of the industry capital; and (iv) a steady growth in TFP (3–4% per year).

The second stage analysis – with the above-noted productivity gains as inputs into the CGE model – suggested that there would be overall economic benefits at the national level – 1.39% per year additional GDP growth and 1.07% per year additional growth in consumption.

k) Quiggin (1997)

Quiggin (1997) provided a critical review of IC (1995). The scope of the study remained the same. Quiggin, while employing the same methodology (as in IC(1995)), also provided a critical commentary on the weaknesses of this methodology.

This study argued that IC’s estimates were inflated due to several reasons including unrealistic: a) best-practice productivity benchmark, b) “base-case” scenario, c) connection between reform and productivity gains, d) assumptions regarding re-employment of the displaced labour force, and e) choice of the CGE model for the Australian economy (SAIIR 2002). According to Quiggin:

> … the assessment in IC (1995) typically begins with a comparison that is clearly untenable. For example, labour productivity (in GW/employee) in the Australian

> electricity industry is compared to that of a Canadian company serving a few large industrial customers. Of course, the small number of customers greatly reduces the need for line workers and service technicians (Quiggin 1996, pp. 2–3).

Also, according to Quiggin, although the best-practice labour productivity in Australia was less than that of the best Canadian utilities, it was better than US and Japanese utilities, many of which had a substantial hydro and nuclear component. Quiggin then suggested the application of a lower bound benchmark that identifies specific deviations from the world's best practice. In this regard, Quiggin also added:

> … a comprehensive program of micro-economic reform is unlikely to yield welfare gains that would be detectable over the noise generated by macro-economic fluctuations in the economy. The direct gains from the entire program are likely to be less than 1 percent of GDP and these will be offset by the consequences in terms of higher unemployment … the notion that micro-economic reform is a process that must be pursued regardless of the short-term costs should be recognized as a mistake. Reform should be assessed on a case-by-case basis with careful attention to the consequences for consumers, employees and the public as a whole (Quiggin 1997, p. 270).

By adjusting the assumptions made by IC (1995), Quiggin then developed new estimates for overall economic benefits of microeconomic reforms. He argued that TFP of the electricity industry would likely improve by only 1% per year in short term. Quiggin argued that additional GDP growth would be only 0.08% per year, compared with a figure of 1.39% suggested by IC (1995). Quiggin provided no estimates of the overall consumption growth associated with microeconomic reform.

l) Coelli (1998)

The main motivation for this study was Quiggin's criticism of the appropriateness of the methodologies used in the previous studies. The main objective of Coelli (1998) was 'to compare and contrast three alternative approaches to the calculation of TFP indices' (ibid). This study focused on coal-fired electricity generation over the period 1982–1991.

Coelli (1998) applied Stochastic Frontier Approach (SFA) and Malmquist TFP index, besides DEA and conventional TFP analysis. Application of SFA was justified by Coelli on the argument that this approach can address one of the most important issues raised by Quiggin (1997), namely, upper/lower bounds of estimations and the issue of detectability of the noise generated by macroeconomic fluctuations. Further, the use of Malmquist TFP index was justified on the grounds that this method allows the decomposition of TFP changes into two components, namely, those arising from changes in efficiency (moving towards or away from a given production possibility frontier), and those arising from changes in technology (shifts in production possibility frontiers). These issues will be discussed in more details in Sections 4.2.2.

Although this study provided a new methodological basis for measuring productivity and efficiency using advanced approaches and also provided justification for the appropriateness of each method, the study generally lacked serious policy analysis about the impacts of electricity reform on the productivity of the electricity industry.

m) Whiteman (1999)

Whiteman (1999) followed up on Quiggin's criticism of the methodological weaknesses of IC (1995) and aimed to present more realistic estimations of the world's best-practice productivity benchmark and, hence, more realistic estimation of the economy-wide impacts of electricity reform. This study – as Quiggin suggested – focused on determining the impacts of electricity reform on the economy (instead of assessing the impacts of the entire microeconomic reform program). Further, this study focused only on the generation segment of the electricity industry, and benchmarked it with its international counterparts.

The methodology of this study – just like IC (1995) – consisted of two stages. In the first stage, DEA and SFA were employed to measure the degree of shortfall in the productivity of the electricity industry as compared with the world's best-practice benchmark. This shortfall, in this study, was referred to as *X-inefficiency*. The concept of *X-efficiency* – developed by Leibenstein (1966) – arose from a belief that 'there is nothing technical about the most substantial sources of non-allocative inefficiencies in organizations' (Leibenstein 1998). This concept therefore includes various social and cultural – or, in general, *institutional* – aspects, which could influence efficiency. Despite this claim, Whiteman (1999) actually measured only technical inefficiency, as measured by similar studies before and after his study. The application of SFA was justified by Whiteman on the basis that it allows the examination of Quiggin's comments on lower/upper bounds for the world's best practice benchmark. Finally, in the second stage, the overall economic benefits of electricity reform were estimated on the basis of Monash CGE model.

Whiteman's estimates of technical inefficiencies in generation segment of the Australian electricity industry (that is, its shortfall as compared with the world's best practice) were 17% and 30%, as measured by DEA and SFA approaches, respectively. This was, however, contrary to expectations. In this respect, the theory on this subject suggests (as emphasised by Quiggin (1997), Coelli (1998) and SAIIR (2002)) that the application of SFA should lead to a lower estimation of inefficiency. In response to this contradiction, Whiteman recommended the use of results obtained with the application of the DEA method (17%), with this argument that the SFA method has not shown evidence of any significant stochastic error. Therefore, it appears that Whiteman conservatively – not methodologically (as the lack of stochastic error might be due to modelling issues (see SAIR 2002)) – sets this assumption for the second stage of his analysis that the removal of 17% inefficiency would be the outcome of electricity reform. Whiteman – like IC (1995) – however provided no convincing reasoning in support of this assumption.

On the basis of this assumption, the results of the CGE model in the second stage of analysis suggested an additional GDP growth of 0.22% and consumption growth of 0.22% per year. These were more modest estimates than those of IC (1995).

n) Productivity Commission (1999)

This study, to some extent, was a continuation of IC (1995). The study took the results of the first stage of the IC (1995) as given. Thus, in terms of productivity gains at the industry level, there were no differences between these two studies. The major difference was that whereas PC (1999) focused on assessing the impacts of microeconomic reforms at the level of Australian regions, IC (1995) focused on these impacts at the level of national economy. PC (1999) accordingly did not make any new contribution towards addressing the methodological weaknesses of IC (1995). PC (1999) employed a top-down approach, and was unable to explain the linkages between productivity gains at the industry level and the overall economic benefits at national level.

This study suggested that microeconomic reforms would result in additional GDP growth of 1.09% per year, and consumption growth of 1.02% per year.

o) Short et al. (2001)

The objective of this study was similar to Whiteman (1999). In the first stage of analysis, this study – like Whiteman (1999) – focused on the generation segment of the industry only for the period 1991–1999. It – unlike Whiteman (1999) – however did not seek the world's best-practice benchmark; rather it aimed to establish the Australian best-practice benchmark. The methodology of productivity benchmarking (in the first stage of its analysis) was very simple and consisted of some conventional PFP analysis. In the second stage of analysis, the results of such PFP analysis were fed into a CGE model to estimate overall economic benefits of reform. A dynamic CGE model, called the Global Trade and Environment Model (GTEM), was used for this purpose. Although this study followed the same two-stage methodological framework as used by IC (1995), Quiggin (1997), Whiteman (1999), and PC (1999), there was an important difference. While all previous studies used *ex-ante* scenario analyses to measure *potential* economic benefits of electricity reform (or the whole package of microeconomic reforms), this study used an *ex-post* scenario analysis to measure *actual* benefits of reform. This was in recognition of the relative maturity of electricity reform at the time of the study. However, as will be discussed later in Sections 4.2.2 and 4.3.1, such maturity would allow for the use of more appropriate, alternative, methodology (instead of scenario analysis), which have been ignored by previous studies.

This study – like most of the previous studies – confirmed that significant productivity improvements took place in the Australian electricity industry during the 1990s. The study ascribed these improvements to the electricity reform of the 1990s. The study also estimated that 0.26% additional annual GDP growth resulted from electricity reform. It, however, provided no estimation on the overall growth in consumption.

On the basis of the above review, one can divide these studies, and associated analyses, into two broad groups. The first group includes analyses of the impacts of electricity reform on the performance of the electricity industry. These analyses, in the context of this thesis, are called *micro-impact analyses*. The impacts measured on the bases of these analyses are, in turn, called *micro-impacts*. The second group of analyses – relying largely on the results of the first group of analyses (either as exogenously given or carried out independently) – focused on assessing the impacts of electricity reform on the wider economy (expressed essentially in terms of overall economic growth). These analyses typically employed a variant of the CGE model. These analyses, in the context of this thesis, are called *macro-impact analyses* and the corresponding impacts, *macro-impacts*. Tables 4.1 and 4.2 summarise the key features of the reviewed studies, grouped into micro- and macro-impact analyses, respectively.

4.2.2 Major Limitations of Existing Studies

This section provides a discussion about major limitations/weaknesses of the existing studies. This discussion is organized in terms of the key features discussed in Section 4.2.1, namely, objectives, scope and methodology.

i) Objectives

The present review suggests that the main objectives of the existing studies have been to assess the micro- and macro-impacts. Their motivations were the introduction of electricity market reform in the early 1990s. As noted in Chapter 1, the main ideas behind this reform were that the introduction of competition in the electricity industry (and other government businesses) and its privatisation would improve the performance of the electricity industry and provide wider economic benefits that would

Table 4.1 Micro-impact Analyses: Key Features

	Background/Objective	Scope	Methodology[1]	Assumptions	Major Results
Lawrence et al.. (1990)	• first study in a series of studies conducted by the same authors • benchmarking the performance of the Australian electricity industry	• Domestic Benchmark • Period 1976–88	*Measurement:* Index Approach: • Sophisticated PFPs • Sophisticated TFPs *Assessment:* Trend Analysis	• introducing some environmental variables (called 'choice' and 'non-choice' variables) • judgmental and interpretational difficulties regarding these variables • certain assumption on these variable to provide adjusted TFP levels – see Section 4.2.1	With regards to uncontrollable factors, the study concludes: • A small positive relationship between scale and TFP • A negative correlation between scale and TFP • A negative link between length of Transmission and TFP • An increased reliance on gas-generation increase TFP With regards to state TFPs, the study concludes: • QLD has the highest TFP level • If other states try to achieve same productivity as QLD, the whole Australian ESI will benefit by $851 million savings. • The benefit of microeconomic reforms would be even larger if Australian ESIs try to reach international best practice
Swan Consultants (1991)	• Updating and improving the above two studies • providing an international benchmarking	• International benchmark • USA investor-owned utilities • Period 1983–1990	*Measurement* Index Approach: • Sophisticated PFPs • Sophisticated TFPs *Assessment:* Trend Analysis	• Same as Lawrence et al. (1990)	• Substantial productivity improvements in recent years • Despite these gains, Australian utilities were operating at 70% of levels achieved by privately-owned electric utilities in the United States.
Zeith et al (1992)	• Developed version of Lawrence et al. works	• Same as Lawrence (1990)	*Measurement* Index Approach: • Sophisticated TFPs *Assessment:* Trend Analysis	• Same as Swan Consultant (1991)	• After adjustment, QLD is 20% more efficient than NSW in terms of TFP score. • Before adjustment this is just 13%
BIE (1992)	• Provide an international benchmarks for Australian electricity industry	• International benchmark • 30–40 utilities	*Measurement* Index Approach: • PFPs • Sophisticated PFPs • TFPs *Assessment:* Trend Analysis	Performances according to • Reliability • Prices • Productivity	• Prices, Outage Time and Reserve Plant Margin (RPM) are higher than world best practice • Capacity Factor, Plant Availability, Labour Productivity, were lower than world best practice, often significantly so • Substantial improvement has occurred in recent years • TransAlta (Canada) and Japanese utilities are identified as world best practice
ESAA (1992)	• Estimation of technical and financial indicators considering three interest groups: • customers • businesses • general public	• Domestic benchmark • Three interest groups – customers, businesses, and community • Period 1988–1991	*Measurement* Index Approach: • PFPs • Sophisticated PFPs *Assessment:* Trend Analysis	• Based on publicly available data sources	• The report contains no overall conclusion, but studying the provided PFPs indicates extensive improvements in state PFPs in recent years, ending in 1991.

Table 4.1 Micro-impact Analyses: Key Features (Continued)

	Background/Objective	Scope	Methodology[1]	Assumptions	Major Results
SCNPNGTE (1992)	• Estimation of TFP of Pacific Power, NSW	• Generation and transmission of Pacific Power • Period 1984–1992	*Measurement* Index Approach: • TFPs *Assessment:* Trend Analysis	• Certain assumptions for the capital series, which the study says need to be comprehensively scrutinised	• Significant rationalisation of employee numbers from 1984 to 1992, a total fall of over 40%) • Closure of economically inefficient generation plant • Improved utilisation of capital (availability & capacity factor up by over 50% and 25% respectively from 1979 to 1991) • Internal funding of Electricity Commission's capital expenditure program • 20% reduction in Electricity Commission's debt since it peaked in 1988
London Economics (1993) – Part 1	• Extending the views of previous productivity studies, using comprehensive Index Analysis	• Domestic benchmark • Functional levels of state industries – generation, transmission, distribution • Period 1982–91	*Measurement* Index Approach: • PFPs • Sophisticated PFPs • TFPs *Assessment:* Trend Analysis	• No adjustments were made for differences in operating environments	Substantial productivity improvements in recent years • Overall TFP of Australian ESI grew by a total 32% (3.1% average annual) • The majority of growth occurred in the most recent five years (4.5% average annual) • Generation TFP: 2.9% average annual growth • Transmission TFP: 5.1% average annual growth • Distribution TFP: 3.7% average annual growth Overall increase in PFPs over 1982–1991 period are: • 24% in capital productivity • 11% in fuel efficiency • 93% in labour productivity • 22% in other factors' productivity
ESAA (1994) – L.E., Part 2	• International Performance Benchmarking	• International Benchmark • Functional levels of state industries – generation, transmission, distribution • Period 1982–91	*Measurement* Frontier Approach: • DEA *Assessment:* Trend Analysis	• No adjustments were made for differences in operating environments	
BIE (1994)	• An update of BIE, 1992	• International Benchmark • Functional levels of state industries – generation, transmission, distribution • Period 1982–91	*Measurement* Index Approach: • PFPs • Sophisticated PFPs • TFPs Frontier Approach: • DEA *Assessment:* Trend Analysis	• No adjustments were made for differences in operating environments	• Australian ESIs continue to be relatively cheap electricity country from industry customers' perspective • Improvement in system reliability • Australian RPM was 35% in 1991 and 33% in 1992, well above US's 26% in 1991 • Narrowing the gap of Australian ESI TFP and US investor-owned TFP: a steady improvement

Table 4.1 Micro-impact Analyses: Key Features (Continued)

	Background/Objective	Scope	Methodology[1]	Assumptions	Major Results
IC (1995)	• Concerns focused on the micro- as well as macro-impacts of the microeconomic reforms • The first work to assess links between such impacts	• International Benchmark	*Measurement* Index Approach: • PFPs • TFPs *Assessment:* Scenario Analysis	• World's best practice benchmark is achieved by the market reform – without proving any convincing reason • Economy is in full equilibrium – fill employment of labour and capital	• 4% reduction in capital requirement • 50% reduction in labour requirements • 20% fall in construction cost of ESI capital • Steady growth in TFP, 3-4% annually for many years
Coelli (1998)	• Comparison of the robustness of various productivity approaches	• Domestic benchmark • Australian base-load, coal-fired generation • Period 1982–1991	*Measurement* Frontier Approach: • Distance Function • TFP (Malmquist) • DEA • SFA *Assessment:* Trend Analysis	• Some assumptions about weak vs. strong disposability of distance function	• Some comments on advantages and disadvantages of different applied approaches. Also: • Depreciation monetary measures of capital stock might be misleading • Using weight when aggregate firm-level results
Whiteman (1999)	• Follow on Quiggin's (1997) criticism on IC (1995) – see Table 4.2 • Assess the micro- and macro-impacts of the market reform on overall economic growth	• International benchmark • Generation • National economy	*Measurement* Frontier Approach: • DEA • SFA *Assessment:* Scenario Analysis	• Same as IC (1995), with minor adjustments	• On average, the DEA estimates of x-inefficiency (17%) are about half the size of SFA (30%) • The study errs on the conservative side and adopts DEA results to be used for the estimation of macro-impacts; however, it suffers from contradictory results (theoretically it is supposed that SFA estimations would be less than DEA)
Short et al (2001)	• Same as White man (1999)	• Domestic benchmark • Generation • National economy	*Measurement* • PFP *Assessment:* Scenario Analysis	• No allowance for fuel-mix • No-reform scenario assumes labour productivity increases by 2% per annum	• Significant labour and capital productivity gains

Note: Further details about methodological frameworks are summarised in Table 4.3.

[1] A distinction is made between measurement and assessment methodologies in this research (see part (iii) in Section 4.2.2)

Table 4.2 Macro-impact Analyses: Key Features

Study	Background/Objective	Scope	Methodology	Assumption	Key Results
IC (1995)	Following the release of Hilmer report, the IC was assigned by COAG to estimate the economy-wide impacts of the microeconomic reforms	• Economy-wide impacts	**Micro-Impacts** • Index Analysis (TFP/PFP) **Macro-Impacts** • HILORAI CGE model	**Micro-Impacts** • As a result of ESI reform, productive efficiency of the ESI will be improved to international best practice **Macro-Impacts** • Directly displaced labour force in ESI will be re-employed by the rest of the economy	**Micro-Impacts** • 4% reduction in capital requirements • 50% reduction in labour requirements • 20% fall in construction cost of ESI capital • steady growth in TFP, 3–4% annually for many years **Macro-Impacts** GDP growth +1.30% Consumption growth +1.07%
Quiggin (1997)	Critical review of the IC (1995)	• Same as IC (1995)	Same as IC (1995)	**Micro-Impacts** • As a result of ESI reform, productive efficiency of ESI will rather be improved into most likely outcome **Macro-Impacts** • 25% of labour shed in the adjustment process permanently leave the workforce	**Micro-Impacts** Extra TFP gain at a rate of 1% per year continues for 4 years. **Macro-Impacts** GDP growth +0.08% Consumption effects – not analysed
Whiteman (1999)	Following on Quiggin's criticism regarding IC (1995)	• Micro-impacts of electricity reform in generation segment • Economy-wide consequences	**Micro-Impacts** • Direct impacts measured by best world benchmark • DEA and SFA approaches applied to evaluate best available benchmark **Macro-Impacts** • Monash CGE	**Micro-Impacts** • As a result of ESI reform, productive efficiency of the ESI will be removed into international best practise • Simplistic production function • No allowance for fuel-mix **Macro-Impacts** • Same as IC, 1995	**Micro-Impacts** • On average, the DEA estimates of x-inefficiency (17%) are about half of the size of SFA (30%) • The study errs on the conservative side and adopts DEA results to be used for 2nd stage. **Macro-Impacts** GDP growth +0.22% Consumption growth +0.22%
PC (1999)	Assessment conducted by PC about the regional impacts of the microeconomic reforms (commenced by COAG)	• Same as IC (1995) but specifically focused on regional impacts of the microeconomic reforms	**Micro-Impacts** • Same as IC (1995) **Macro-Impacts** • Top-down CGE model • Tailored Monash CGE for regional disaggregation, Monash-RR	**Micro-Impacts** • Same assumption as IC (1995) for direct impacts **Macro-Impacts** • Not mentioned explicitly but include assumptions that generally apply for top-down CGE models	**Micro-Impacts** Same as IC (1995) **Macro-Impacts** GDP +1.09% Consumption growth +1.02%
Short et al (2001)	similar objectives as Whiteman (1999)	• Micro-impacts of electricity reform in generation segment • Economy-wide consequences	**Micro-Impacts** • Direct impacts measured by best Australian benchmark • Index Analysis (TFP/RFP) **Macro-Impacts** • GTEM/MEGABARE CGE model	**Micro-Impacts** • No allowance for fuel-mix • No reform scenario assumes labour productivity increases by 2% per annum **Macro-Impacts** • Not mentioned explicitly	**Micro-Impacts** Significant labour and capital productivity gains **Macro-Impacts** GDP +1.30% Consumption effects – not analysed

Note: Further details about methodological frameworks are summarised in Table 4.3.

enhance the social well being of all Australians.

These studies, therefore, focused on developing empirical estimates of micro- and macro-impacts. Such estimates were needed at the time by governments (and other interests) to secure public acceptance for reform. While this need only became explicit during the COAG enquiry (IC 1995), it was still implicit even in the early studies, for example IAC (1989a; 1989b), IC (1991), and Lawrence et al. (1990;1991).

There is however a significant difference between the overall objectives as enunciated in earlier debates on reform and the specific objectives set in various empirical studies. The former are marked by a general lack of clarity about performance indicators and methodology of analysis, whereas the latter are very precise in these respects. For example, in terms of methodologies, each study describes which approach (for example, PFP, TFP, DEA, or SFA) is used for micro-impact analyses, and which for macro-impact analysis. Further, in terms of performance indicators, each study explains which productivity indicators (for example, PFP, TFP, and efficiency) are measured for micro-impact analysis, and which economic indicators (for example, GDP and aggregate consumption) are measured in macro-impact analysis.

For example, BIE (1992; 1994) focused particularly on international benchmarking for the realisation of the relative position of various PFP and TFP measures. Coelli (1998) emphasised comparison of the robustness of three widely-used productivity approaches, namely TFP, DEA and SFA for analysing changes in Malmquist TFP index (see Table 4.1). Whiteman (2000) focused on measuring the impacts of market reform on the growth of national product, and PC (1999) focused on assessing such impacts on sectoral products of various Australian regions (see Table 4.2). Despite these differences in specific objectives, all studies provide insights into overall aspects of 'performance' and 'social well being' as raised in the underlying debates.

Such boundaries for specifying objectives are indeed useful. This aspect is broadly accepted by social scientists engaged in empirical analyses. However, the above review suggests that from various dimensions of human actions that could influence 'performance' and 'social well being', the main focus in these studies is on narrowly defined economic dimension. This, this thesis argues, is mainly because the theoretical foundation of the reviewed studies has been informed by microeconomics. These studies have therefore tried to portray humans merely as ‘economic’ beings, motivated solely by their economic interests, namely cost minimisation or profit maximisation. Although this is useful (because economic dimension is important), the previous studies have ignored consideration of other dimensions of humans actions and behaviour including social, political, and environmental. This, indeed, is unhelpful.

ii) Scope

The reviewed studies were different from each other in terms of scope, as defined by the segments of the electricity industry (for example, generation, transmission, distribution), the levels at which studies are set (that is, industry, state, national, or international), and the time period for analyses. One of the most important features about the scope of the previous studies is related to the level of benchmarking, that is, whether it is domestic or international. For example, Lawrence et al. (1990) are based on domestic benchmarking, whereas London Economics (1993) is based on international benchmarking.

While limiting the scope is useful in empirical analysis, it could prove to be a limiting factor when one is aiming to analyse an all-encompassing objective, for example, economy-wide impacts of electricity reforms. This is – this research argues – a significant limitation of the previous studies.

iii) Methodology

Methodology is an important component of any empirical analysis. It should be defensible from conceptual, theoretical and analytical perspectives.

Traditional microeconomics has provided much of the conceptual foundation for past studies. This has resulted in an implicit imposition of the behavioural assumptions of microeconomics on these studies, namely, the ‘rationality’ of human behaviour (that is, humans as utility maximisers) and of organisations (that is, organisations as cost minimisers or profit maximisers).

Two methodological frameworks can be discerned in past studies: (i) a framework for measuring economic performances, and (ii) a framework for assessing to what extent change in performance is due to reform and to what extent, to other factors. These frameworks, in the context of this thesis, are called *measurement-frameworks* and *assessment-frameworks*, respectively. This distinction has, however, not been made explicit in the reviewed studies, perhaps because these frameworks are often tightly intertwined with each other. Some analysts, may argue that such a distinction is unnecessary and that measurement-frameworks are assessment-frameworks as well. Such argument, to some extent, may be true, because the concept of performance is a relative concept and the measurement of 'performance' always includes some kind of assessment as well. This can be seen in simple comparisons over time or across the same counterparts.

This thesis contends that this distinction is useful because it allows a more comprehensive approach for assessing industry performance, and for ascertaining the impact of electricity reform on industry performance and on wider economy (see also, Fathollahzadeh 2005; Fathollahzadeh & Sharma 2004).

A tabular classification of the methodological frameworks employed in past studies is presented in Table 4.1 and Table 4.2. In Table 4.3, further details of these methodological frameworks are presented to highlight their classification. The following discussions – under three headings – reveal the weaknesses of these frameworks.

(I) Framework for measuring micro-impacts

The frameworks for measuring micro-impacts involve some kind of productivity analyses. Such analyses typically employ two main approaches: *Index Approach* (IA) or *Frontier Approach* (FA), which measure productivity in terms of various partial or overall productivity indices (see Table 4.3). However, there are some variations, across various studies, in the selection of specific measurement-frameworks. For example, Lawrence et al (1990) apply IA for measuring PFP and TFP; Whiteman (2000) uses FA with more advanced DEA and SFA; Short et al. (2001) – simple PFPs; Lawrence et al. (1990) – a sophisticated multilateral TFP; and Coelli (1998) – a distance

Table 4.3 Classification of existing studies in terms of their measuring frameworks and benchmarking-scope

Benchmarking Scope	Measurement-frameworks					
	Partial Index Number		Overall Index Number		Behavioural Framework	Axiomatic Framework
	PFP	Sophisticated PFP	TFP	Sophisticated TFP	e.g. Cost Minimisation	Distance Function
	e.g. Labour/Capital Productivity	*e.g. Financial/Managerial Index*	*e.g. Fisher/Tornqvist Index*	*e.g. Multilateral Index*	*e.g. Technical, Allocative, Economic Efficiency*	*e.g. Technical Efficiency, Malmquist TFP Index*
	Index Approach (IA)				Frontier Approach (FA)	
	Partial Index		Overall Index			
Domestic	Lawrence et al. (1991) ESAA (1992)	Lawrence et al. (1990) ESAA (1992)	Lawrence et al. (1991) SCNPNGTE (1992)	Lawrence et al. (1990) Zeitch et al. (1992)	Coelli (1998) Murtough et al. (2001)	Coelli (1998) Murtough et al. (2001)
International	BIE (1992) London Economics (1993) Part 1	Swan Constultant (1991) BIE (1992) London Economics (1993) Part 1	BIE (1992) London Economics (1993) Part 1	Swan Constultant (1991)	ESAA (1994), London Economics Part 2	
Domestic	Short et al. (2001) **This Thesis** (Non-Scenario Analysis)					**This Thesis** (Non-Scenario Analysis)
International	IC (1995)		IC (1995)		Whiteman (1999)	

function framework. The following presentation and classification of various measurement-frameworks is a concise one, focusing on those used in existing studies only.

Although measurement frameworks can be classified in different ways, they have one thing in common. They are all based on one conceptual principle, essentially an input/output (I/O) model. On the basis of this I/O model, every process of production uses some inputs (for example, labour, capital, fuel, and material) to produce some outputs (for example, electricity). A typical I/O model is shown in Figure 4.1. In this measurement framework, the concept of productivity, in broad terms, is defined as a ratio of outputs over inputs. This definition is, however, not accurate because there is no single mathematical basis to calculate this ratio. If the production process was merely involved with a single-input/single-output process, the whole concept of productivity analysis could have been limited to this basic I/O model. However, in reality, there is often more than one input and output involved in the production process. Therefore, one cannot simply calculate the ratio of inputs over outputs. This issue is known as the *index number problem* (Coelli, Prasada & Battese 1998, p. 71) and implies that in order to apply the I/O framework there is a need for more complicated formulations for measuring productivity.

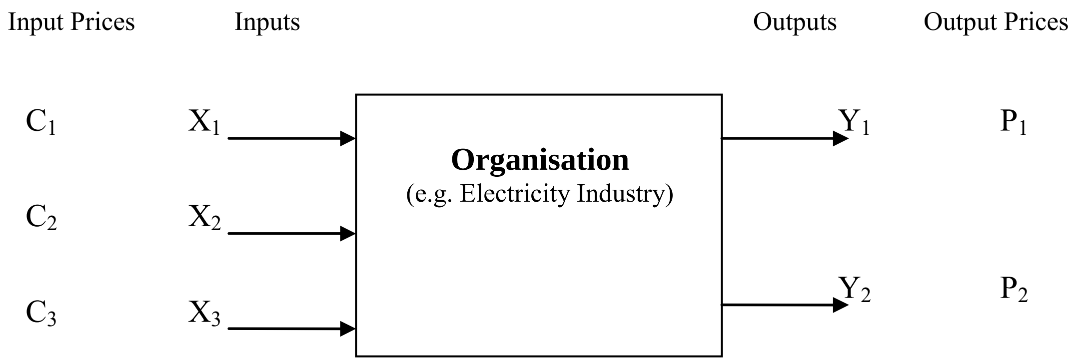

Figure 4.1 Basic Input/Output (I/O) Model

The simplest proposition for overcoming the index number problem is that one can measure several PFPs. For example, one can calculate labour, fuel, and capital productivities and analyse them. This is what has often been practised. However, this issue arises that measuring PFPs always involves the omission of some important information about the process of production and that this might therefore lead to misleading conclusions. For example, a high improvement in labour productivity might be due to a heavy capital investment, which is usually more difficult to judge with regard to its opportunity costs.

Another proposition is that it is better to calculate a broad range of PFPs and analyse them in association with each other. Such a suggestion is useful and has led to a wide range of sophisticated formulations for PFP frameworks, such as financial and managerial ratios. All simple and sophisticated PFPs, in the context of this thesis, are called partial index number frameworks (see Table 4.3).

As another pragmatic way for solving the index number problem, it has been suggested by research economists that the overall index number be used by calculating weighted averages for inputs and outputs and then defining TFP as the ratio of such weighted averages. Endeavours to conquer the so-called index number problem are continuing and more advanced measurement-frameworks have been suggested. For example, Laspeyres, Paasche, Fisher (1922) and Tornqvist (1936) have proposed various TFP index frameworks – now known by the same names as their proposers – that are among the most popular overall index number frameworks. Caves, Christensen, and Diewert (1982b) have also proposed a more sophisticated TFP index framework, which has been used in a number of previous studies, as noted in the foregoing discussion. As a result of these endeavours, index numbers have found broad applications in economics (for more details see Coelli, Prasada & Battese 1998, pp. 69–131). The frameworks of both partial and overall index numbers are usually called Index Approaches (IA). Table 4.3 shows the position of those previous studies that are based on IA. For example, London Economics (1993) has measured a wide range of PFPs and TFPs.

In response to the index number problem, over recent decades, another methodological improvement has been made under the class of Frontier Approaches (FA). In the FA, the basic I/O model is essentially enhanced to define the concepts of efficiency, Production Possibility Frontier (PPF), and ultimately – in an alternative way, compared with IA – productivity. The conceptual framework of the FA can be classified into two categories: (i) behavioural framework, and (ii) axiomatic framework.

(i) Behavioural framework

The behavioural framework is based on the traditional *theory of firm* in microeconomics, in which organisations are assumed to be cost minimisers or profit/revenue maximisers (that is, entrepreneurs are Homo oeconomicus). A pragmatic application of the behavioural framework was initially developed by Farrell (1957), 'who drew upon the works of Debreu (1951) and Koopman (1951)' (cited in Coelli, Prasada & Battese 1998, p. 134). Figure 4.2 presents the conceptual framework of Farrell's work, which is an input-oriented presentation.[36]

For the purpose of simplicity of presentation, it is assumed that organisations employ only two inputs (fuel and labour) and produce only one output (electricity). In Figure 4.2, the cross-section of data for seven hypothetical organisations (points A to G) is shown. Each point represents a combination of inputs for producing the same unit of output. In Figure 4.2, the PPF is typically a concave curve or a piece-wise kinked line that represents the best-practice unit isoquant. The PPF can be used as a benchmark to assess whether a specific organisation is relatively efficient or not, and to measure various relative efficiencies. For instance, organisations represented by points A, C and D are all technically efficient as they are posited on the PPF. The organisations C and D, while technically efficient, are not *allocative efficient*, because at given input prices, these organisations can reduce their production costs by partially substituting fuel for labour or vice versa (assuming such substitution is possible). The organisation A is both technical and allocative efficient. The organisations B, E, F, and G are neither technical efficient nor allocative efficient, and hence are inefficient.

One way of measuring various types of efficiencies – firstly proposed by Farrell (1957) – is to assign a radial index to them, which is simple and consistent. On the basis of one such radial index, the technical efficiency for the typical organisation B is equal to OQ/OB and the allocative efficiency is equal to OR/OQ (see Figure 4.2). Another measure is *economic efficiency*, which is equal to OR/OB. Economic efficiency is equal to the multiplication of technical and allocative efficiencies. Economic efficiency is thus

[36] In an input-oriented presentation of the FA, the framework focuses on the possibility of proportional reduction of inputs, given a certain level of outputs. An output-oriented presentation of this framework, on the contrary, focuses on the possible proportional increase of outputs, given a certain level of inputs.

an *overall efficiency*[37] measure, which is decomposable into technical and allocative efficiencies. Taking into account the concepts of 'returns to scale' and 'congestion', Färe et al. (1985) further argue about the importance and possibility of the decomposition of overall efficiency into another three efficiency components: (i) pure-technical efficiency, (ii) congestion efficiency, and (iii) scale efficiency. Pure-technical, congestion, scale, technical, allocative, and economic efficiency measures are usually collectively called *productive efficiency*.

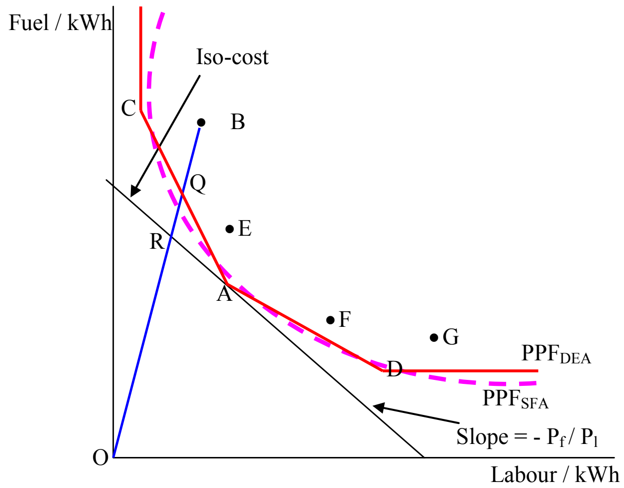

Figure 4.2 Conceptual Framework of the Behavioural Frontier Approach

(ii) Axiomatic framework

The axiomatic approach is based on a set of axioms. The axioms consist of some intuitive properties that ascertain inter-relationships between inputs and outputs of the I/O framework. In the axiomatic approach, a production technology mathematically can be defined as an output-set[38], P(x), which represents the set of all output vectors, y, which can be produced using the input vector, x.

[37] In fact, Farrell (1957) uses the term *overall efficiency* for *economic efficiency*, and the term *price efficiency* for *allocative efficiency* (pp. 254-5), which seems to be a more appropriate terminology, because in both cases the terms mean a *ceteris paribus* demand-side efficiency. The terms allocative and economic efficiency are macroeconomic concepts and include both demand- and supply-side efficiency (see also Stoft 2002, p. 53). They refer to the broader concept in economics usually known as the *Pareto Optimality*. However, these terms these days are almost universally used in the demand-side-only context. In this chapter also, for keeping terminological consistency with other studies, this convention is followed. Therefore, wherever necessary, the term *economy-wide economic efficiency* is also used.

[38] One can similarly define the production technology as an input-set, L(y) (see Coelli, Prasada & Battese 1998, p. 64).

$$P(x) = \{y : x \quad can \quad produce \quad y\} \tag{1}$$

It is assumed that the technology satisfies the following axioms (see Coelli, Prasada & Battese 1998, p. 62; also Shepard 1970, p. 14) as follows:

i) $0 \in P(x)$: nothing can be produced out of a given set of inputs (that is, inaction is possible)

ii) non-zero output levels cannot be produced from a zero level of inputs

iii) $P(x)$ satisfies strong disposability of outputs: if $y \in P(x)$ and $y^* \leq y$ then $y^* \in P(x)$

iv) $P(x)$ satisfies a strong disposability of inputs: if y can be produced from x, then y can be produced from any $x^* \geq x$

v) $P(x)$ is closed

vi) $P(x)$ is bounded

vii) $P(x)$ is convex.

As can be seen, these axioms are free from any behavioural assumptions. This is useful because, in reality, not every organisation is a cost-minimiser or profit-maximiser (see also Coelli 1998). Relaxation of behavioural assumptions in the axiomatic framework makes this framework consistent with the premises of the problem-solving framework developed in Chapter 3. In the axiomatic approach, efficiency is measured by the distance function. The output distance function[39] is defined on the output-set, P(x), as:

$$d_o(x, y) = \min\{\delta : (y/\delta) \in P(x)\} \tag{2}$$

Where the distance, $d_o(x, y)$, characterises the distance of the output vector of a particular organisation from the PPF, meaning from the maximal proportional

[39] One can similarly define the input distance function on the set of input-set, L(y) (see Coelli, Prasada & Battese 1998, p. 64).

expansion of the output vector, given an identical input vector for all organisations in the sample dataset.[40]

The distance, $d_o(x, y)$ will take a value between 0 and 1 if the output vector, y, is an element of the feasible production set, $P(x)$. It will take a value of unity if y is located on the outer boundary of the feasible production set or PPF. In these cases (that is, $0 \leq d_o(x, y) \leq 1$), the $d_o(x,y)$ represents technical efficiency. Finally, the distance will take a value greater than one if y is located outside the feasible production set. The distance measure for a typical organisation B is shown by OQ/OB in Figure 4.2, which represents the technical efficiency of the organisation B, when only physical inputs and outputs are used to calculate the output distance function.

In FA, the concept of productivity or TFP is defined as the ratio of efficiency/distance measure of a particular organisation in two different times with regard to the PPF of a particular time (either the present or past) as the base-time PPF (Coelli 1998). Therefore, while the efficiency/distance measure always takes a value between 0 and 1, the TFP measure can take any value, as also noticed in its earlier-provided definition on the basis of IA (that is, the ratio of weighted-averaged indices of output over input). The TFP measure larger than 1 implies productivity improvement, while the TFP less than 1 implies a reduction of productivity. However, TFP improvement on the basis of FA may occur while the organisation is inefficient. This is essentially because the PPF may shift from time to time. A shift (over time) in the PPF is known as *technological change*.

In an empirical analysis, it is important to be consistent in selection of the base-time, orientation of calculation, and the type of relative efficiency measures (that is, pure-technical, congestion, scale, technical, allocative, and overall efficiency). The Malmquist TFP index, introduced by Malmquist (1953), is one useful way of ensuing a consistent selection of these aspects (Caves, Christensen & Diewert 1982a). The Malmquist TFP index is an application of distance functions using a dynamic I/O

[40] Similarly, an input-oriented distance considers the minimal proportional contraction of the input vector of a particular organisation, given an identical output vector for all organisations in the sample dataset (see Figure 4.2). In the FA, the numeric measured productivity may vary depending upon the selection of the base-time PPF and orientation of calculation (that is, whether it is input- or output-oriented).

framework. The Malmquist TFP index measures TFP change between two data points as the geometric mean of two TFP measures for a particular organisation in the dataset with regard to common PPF: respectively to the past PPF and the present PPF (for details see Coelli, Prasada & Battese 1998, pp. 221–6).

As has been noted in the above discussion, there is a sharp distinction between the concepts of efficiency and productivity in FA, compared with IA (that is, in the Fisher and Tornqvist TFP indices). While IA assumes all organisations are efficient (being on the PPF), the FA allows for inefficiency. Recent developments in FA have further emphasised the importance of such distinction for empirical studies, which one could evidently also observe in the directions and contributions of recent productivity analyses in the above reviewed literature. While, in general terms, productivity improvements are important, the sources of change in TFP are even more important. For example, an organisation may be inefficient while showing TFP growth. Hence, one can state that being an inefficient organisation is not good at all, however, being efficient may also not be good enough. There is a range of inefficiencies (for example, congestion, scale, allocative efficiencies) that their removal – if possible – may contribute to improvement of TFP. Further, in dynamic analyses, shifts in the PPF, which indicates technological changes, could be another source of TFP change that is not simply identifiable in the IA. Table 4.3 shows the position of the previous studies in terms of whether they have used IA or FA.

Various quantitative methods have been developed for the FA. These methods are classified in different ways: deterministic vs. stochastic methods or parametric vs. non-parametric. For example, DEA is a deterministic and non-parametric method, whereas SFA, as is apparent from its name, is a stochastic and parametric method (for details see Coelli, Prasada & Battese 1998). Stochastic methods make allowance for errors due to the sample and dataset, which, as noted, had its importance pointed out by Quiggin (1997) in the reviewed literature. In Figure 4.2, two hypothetical PPFs are illustrated. The PPF_{DEA} represents a PPF which is estimated by DEA, and the PPF_{SFA} represents a PPF which is estimated by SFA.

(II) Framework for Measuring Macro-impacts

As noted in Section 4.2.1, estimates of micro-impacts have typically employed a variant of CGE model. For example, IC (1995) uses a version of the Monash CGE model called ORANI, whereas PC (1999) uses another version of the Monash CGE model, called Monash-RR, for a top-down regional disaggregation of macro-impacts (see Table 4.2).

Figure 4.3 presents the simplified conceptual framework used by various CGE models for measuring macro-impacts. For simplicity, the economy is represented by only two commodities – food and electricity. The concept can, however, be generalised to a multi-commodity economy. Given the total amount of inputs in an economy as constant (for example, labour and fuel) in a given time, the overall economy-wide PPF shows the combination of food and electricity that can be produced using the most efficient available production processes. Every point on the PPF indicates that supply-side productive efficiencies have been achieved in all production processes (that is, food and electricity, in the present case). Every point under the PPF is defined as an inefficient choice, because it is possible to produce more commodities (i.e. food/electricity), given the same amount of inputs.

However not every point on the PPF in Figure 4.3 is economically efficient. The assessment of the economically efficient combination of food and electricity requires information about consumer preferences. Such preferences are shown by the indifference curves (IC) in Figure 4.3. The farther the IC from the origin, the higher the consumer satisfaction and the greater the social welfare. Economic efficiency, in this framework, is denoted by the point of tangency between the PPF and the IC – point Y in Figure 4.3. Any departure from Y will imply the worsening-off of at least one person without anybody else becoming better off (that is, moving away from *Pareto optimality*). In order to find the economically efficient equilibrium, the price and quantity of all commodities and services, as endogenous variables, should be solved in a system of simultaneous equations. The slope of the tangent line through point Y represents the relative prices for food and electricity ($-P_f/P_e$). Any line parallel to the tangent line and closer to the origin, while having the same relative prices ($-P_f/P_e$), represents lower levels of total expenditure.

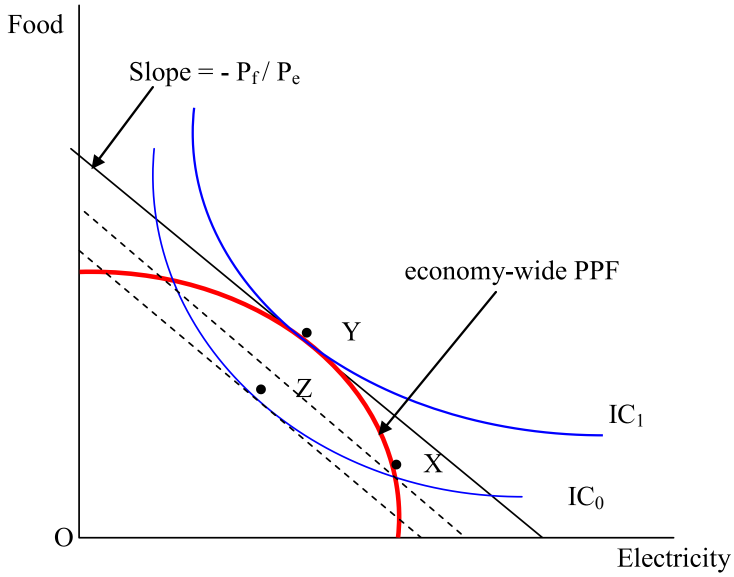

Figure 4.3 Conceptual Framework of Macro-impact Studies (source: SAIIR 2002)

Point X, though productively efficient (from a supply-side point of view – located on the PPF), is not economically efficient (from a demand-side point of view) because, given the relative prices ($-P_f/P_e$), consumers would prefer point Z, which indicates a lower level of expenditure to attain the same level of satisfaction as point X. But Z is inefficient because it is located inside the PPF. The concept of economy-wide "economic efficiency" is clearly less "tangible" than productive efficiencies, but its implications are not less real. This conceptual framework provides the theoretical foundations for most of the CGE models. In other words, CGE models help to operationalise such conceptual frameworks to calculate the location of the equilibrium point (point Y in Figure 4.3) in an economy.

(III) Framework for Assessing Micro- and Macro-impacts

Scenario analysis was used by all reviewed studies as the framework for assessing micro- and macro-impacts. The macro-impact analyses, in general, provided estimations for economic benefits of market reform in terms of additional GDP growth on the basis of the comparison between the GDP growth rates in two scenarios, namely *reform* and *no-reform* (see Table 4.2). The distinction between these measurement-frameworks and assessment-frameworks is like the distinction between the means and ends of these analyses. In this context, the main objective of every performance analysis is to assess the impacts of a policy decision on performances, rather than merely to measure the performances.

The distinction – though mainly implicit – is clearly identifiable in the reviewed studies. As noted regarding measurement-frameworks, productivity provides relative measures which enable comparisons to be made about the rate of productivity changes between organisations/economies (the micro-/macro- impacts at industry/national levels) or across time. These measures have been used in some of the reviewed studies for analysing the causality between productivity and a set of factors that may influence these measures. Such a set of factors, according to Coelli et al. (1998, p. 166), are called *environmental variables*, and such analyses, this thesis argues, have been conducted through the assessment-frameworks of the previous studies.

These above-noted environmental variables are neither inputs nor outputs in the measurement-framework. Geographical characteristics, fuel quality, managerial factors, regulatory aspects, and ownership type are some typical examples of environmental variables that have been introduced in some of the previous studies. Appropriate environmental variables are those that can quantify the institutional environment of socio-economic sub-systems such as those discussed in Chapters 2 and 3. Therefore, any systematic analytical framework that, alongside a measurement-framework, could provide an explanation for the causality between performance measures (usually productivities) and environmental variables is assessment-framework, which allows for inferential hypothesis testing. For example, one can test the causality between ownership type and performance of organisations. Färe et al. (1985), Atkinson and Harvelson (1986), and Pollitt (1995) have, for instance, developed various assessment-frameworks for testing hypotheses about the role of ownership on industry performance. Hattori and Tsutsui (2004) and Steiner (2000) have also developed useful assessment-frameworks for testing various hypotheses on the significance of broader institutional differences (for example, regulatory frameworks) on electricity prices in OECD countries. Further, Coelli et al. (1998), in a generic discussion, provide four types of such assessment-frameworks (for details see ibid, pp. 166–71).

One should, however, note that all these assessment-frameworks are only applicable for ex-post analyses, that is, they assess the impact of environmental variables on industry performance based on historical data. Ex-post analyses – if one recalls the problem-solving framework of the previous chapter – are an essential part of the process of organisational learning and assist with the diffusion of knowledge and natural institutional changes at the societal level. However, the generalisation of the results of ex-post analysis for ex-ante predictions (for instance, assessing the outcome of a policy decision), according to the problem-solving framework, are subject to failure. In other words, the success or failure of every ex-ante policy action will only be known after the implementation of such policy action. This is because the organisational learning, as analysed in Chapter 3, after all, follows the "tentative-solution-and error-elimination" process.

Significant distinctions between the assessment and measurement frameworks can be observed in past studies. For example, studies in the early 1990s have reflected their concerns about the assessment-framework, without giving it a name. Some of these past studies, in addition to measuring productivities, apply regression analyses to carry out various managerial and policy assessments (see, Lawrence et al. 1990). Some of the environmental variables used in these studies include fuel quality, output composition, centralisation, and scale. The assessment-frameworks of the early studies (1990–1994) were a kind of cross-section or trend analysis. In fact, cross-section or trend analysis is a built-in assessment-framework in every productivity analysis, although most of the studies have not even mentioned it as a distinct methodological framework and rather referred to it as their scope. Table 4.3 shows those previous studies that have used cross-section or trend analysis to assess the impacts of electricity reform.

The review of previous studies shows that scenario analysis is the dominant and explicitly mentioned assessment-framework, especially after IC (1995). This framework has largely been used to assess the productivity gains of electricity reform. SAIIR (2002) also points this out and mentions that 'the most common approach to estimate benefits of reform has been to estimate a best practice outcome for the electricity sector, and then assume that reform will achieve that outcome' (p. 32). This implies that impacts of electricity reform have been assessed by the gap between two scenarios, namely no-reform and reform. The no-reform scenario consists of the continuation of the pre-reform trends of productivities, whereas the reform scenario assumes that these productivities will be improved to the best-practice benchmark. In fact, since 1995, the main focus of performance analyses has explicitly moved towards the assessment of impacts – mostly productivity gains – whereas the main focus of studies before that year was to provide more robust measures for productivity. Table 4.3 shows the position of previous studies in terms of their assessment-frameworks.

The appropriateness of scenario analysis as a methodological framework has however been the subject of intense debate, since 1995, when the IC report was released. It is argued by critics that scenario analysis suffers from a methodological weakness in assessing micro- and macro-impacts of electricity reform. Such a weakness, according to the critics, relates mainly to the fact that this framework is not able to specify 'what changes in practice need to take place, that reform will induce the Australian … *electricity industry* … to emulate the performance of the benchmark enterprise' (Quiggin 1996, p. 258, italics added; see also SAIIR 2002). While the assessment-framework should be able to address this issue, the scenario analysis assumes these gains as somewhat granted as a result of reform. This assumption, critics argue, 'involves a substantial leap of faith' (SAIIR 2002, p. 32) that has inflated the estimated benefits of the market–reform (see also Johnson & Rix 1991, pp. 130–4; Quiggin 1997).

Although the methodological weaknesses of scenario analysis are revealed by some of the critics, the recommendations provided by these critics have not given any significant guidance. Essentially, this is because the recommendations have focused on highlighting the weakness in the measurement-frameworks of the previous studies and the sensitivity of the measured productivity gains to the assumptions of reform/no-reform scenarios. For example, with regard to (IC 1995), Quiggin argues that the 'estimated productivity gains are overoptimistic, representing upper bounds to possible achievement rather than likely outcomes' (1997, p. 256). Consequently, for instance, Quiggin urges 'the choice of an appropriate benchmark' (ibid, p. 258) and SAIIR similarly recommends the adoption of 'more reliable estimates of a best practice benchmark' (2002, p. 32).

Clearly, these recommendations do not adequately reflect the methodological weaknesses of scenario analysis as a distinct assessment-framework. As a result, responses to the criticisms have all focused on the adoption of an alternative measurement-framework, but almost all of the studies continued using scenario analysis as their assessment-framework. For example, Whiteman (2000), in responding to Quiggin's criticism, carried out another study applying two alternative measurement-frameworks (that is, DEA and SFA), but using the same assessment-framework (that is, scenario analysis). Although Whiteman's use of SFA was due to its advantage in making allowances for errors, the results became even more paradoxical. In fact, theoretically the inefficiency measured by SFA is supposed to be less than that from DEA (SAIIR 2002, p. 21), whereas the results from SFA in Whiteman's study, in contrast, were almost double the results from DEA (see Table 4.2). Further, even Short et al's (2001) analysis – undertaken about seven years after the introduction of market reform – uses the same methodological assessment-framework as Whiteman. In fact, despite Quiggin's criticism, none of the studies have adopted any alternative assessment-framework. Alternative assessment-frameworks should indeed allow for hypothesis-testing on the basis of ex-post analysis.

To sum up the discussion on methodology: it is important to note that attention has been paid to conceptual and methodological weaknesses of conventional performance analyses, triggering improvements in measurement- and assessment-frameworks. However, these improvements, in the context of empirical studies on the Australian electricity industry, appear to be highly imbalanced, inadequate and skewed towards measurement-frameworks. Their theoretical underpinnings – intertwined with economic rationalism and market ideology – render most of these studies normative rather than positive. Although CGE models for measuring macro-impacts have also improved, no alternative framework has been tried for this purpose. Finally, with regard to assessment-frameworks, not much improvement has been made.

Against the backdrop of the limitations/weaknesses of previous studies, it is not surprising that one notices there has been a disparity between expectations from electricity reform and its actual outcomes. These studies have provided inadequate and biased analyses about the impacts of reform and hence insufficient insights for policy purposes. This has become more evident in recent years, as the actual outcomes of reform created new challenges. In 2002, COAG launched a comprehensive investigation into the reasons behind the disparities and challenges. A more focused discussion on these topics would be provided in Chapter 5.

4.3 Proposed Frameworks for Assessing the Impacts of Electricity Reform

The foregoing analysis revealed methodological weaknesses of the previous studies and identified a research gap. Two sets of methodological proposals have been developed in this thesis in order to fill this gap. These proposals are related to the measurement- and assessment-frameworks, respectively. These proposals are outlined in sub-sections 4.3.1 and 4.3.2.

4.3.1 Framework for Assessing Micro-impacts

Measurement-framework

This thesis proposes a framework for measuring micro-impacts of reform that is based on some modifications to the basic I/O model. These modifications, although simple, make significant improvement in the quality of productivity analyses. Figure 4.4 illustrates a typical multi-input/multi-output framework proposed by this thesis. In this illustration, the organisation represents a state electricity industry. Such organisation could be any functional segment of the electricity industry, for example, thermal generation, all generation, transmission, or distribution. The inputs and outputs shown in Figure 4.4 are not inclusive, and may be different depending on various model configurations. In this thesis, various model configurations are applied instead of building one single model and analysing its results (as was the case in most of the previous studies).

Under this proposal, the following criteria are adopted for assigning factors of production to the input or output sides of the model:

(i) An input is a factor for which, if other factors remain constant, using less of it would be more desirable for the organisation or society[41]

(ii) An output is a factor for which, if other factors remain constant, making more of it would be more desirable for the organisation or society.

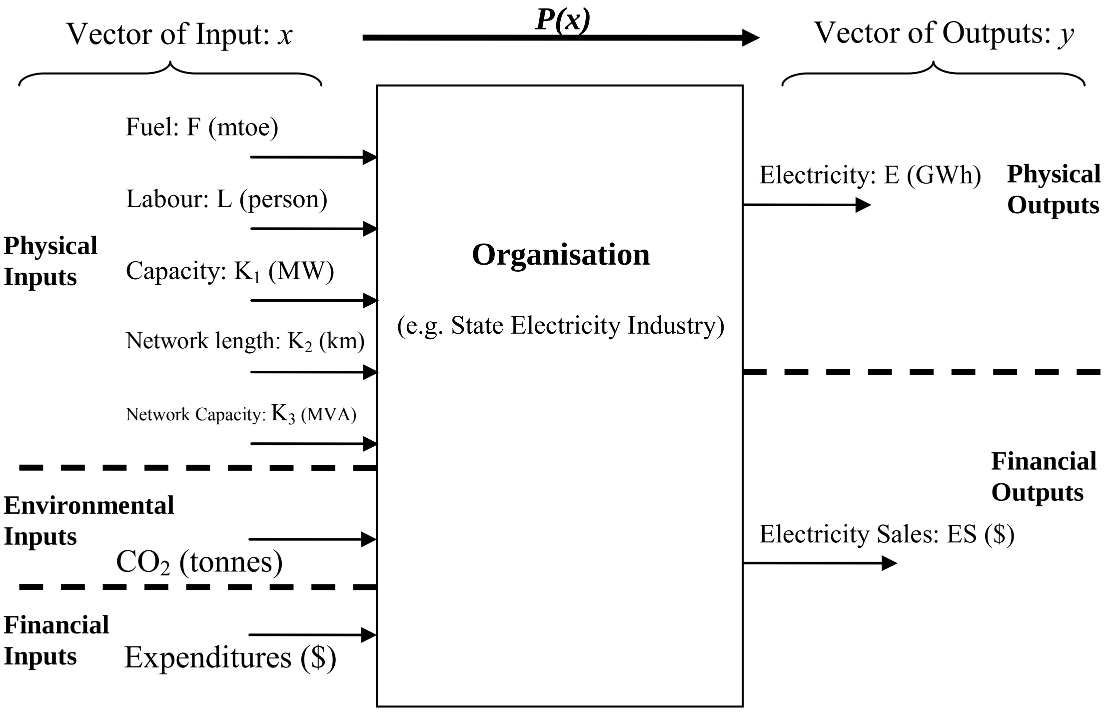

Figure 4.4 Proposed Input/Output Framework

There may be some ambiguous and judgmental cases to which modellers may find it difficult to assign a particular factor on the input or output side. However, in such cases, the situation can be resolved by either interpreting the results of both alternative possibilities or by introducing a compound factor with a clearer situation regarding the input/output nature of that factor. For example, some may argue that in a larger geographical area, a larger network length is more desirable and hence suggest the network length as an output. In such a case, one can use a compound factor for network length, for example, network length per customers, and assign it to the input side. Industry knowledge would be extremely useful for modellers at this fundamental stage of modelling.

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41 In these criteria, society is also mentioned for those factors that contain social considerations (for example, environmental factors).

The interesting point about these criteria is that they classify inputs and outputs in a way that is consistent with the axioms of any feasible output set, *P(x)*, discussed above. On the basis of these criteria, physical inputs and outputs (for example, labour, capital, and generated electricity) are assigned as they have traditionally been assigned in most studies of this nature (see Figure 4.4).

The financial factors (for example, expenditures or revenues), in this research, are assigned differently from the way they have traditionally been assigned. Such factors are traditionally applied in the form of information that contains unit prices of physical inputs and outputs. These factors, following the above-mentioned proposal, appear directly as inputs as well as outputs (see Figure 4.4). This precludes the need to make any behavioural assumption about organisations (that is, cost minimiser or profit maximiser) as is the practice in traditional microeconomics. Thus, the proposed measurement-framework is in the class of axiomatic frameworks. Further, this framework is more flexible with regards to the availability of data. However, whenever more data are available, they will be easily accommodable in this framework.

Environmental externalities such as CO_2 emissions have been assigned differently in this research from how they have traditionally been assigned. In the literature of this nature, CO_2 emissions, as a non-marketed undesirable physical output, are usually assigned on the output side (see, for example, Murtough et al. 2001). This, however, violates the strong disposability axiom of the feasible output set, *P(x)* (see axioms iii and iv in Section 4.2.2). This is usually handled by assuming that undesirable outputs are weakly disposable. Such a weaker axiom requires a different formulation for measuring efficiency, incorporating shadow prices of CO_2 emissions (see Färe, Grosskopf & Logan 1985). In the framework proposed by this research, it is simply assumed that lower CO_2 emissions are more desirable for society. Therefore, on the basis of the above-mentioned criteria, CO_2 emissions are assigned on the input side.

As noted above, the traditional axiomatic framework only measures technical efficiency. However, the proposed framework can measure a wider range of efficiencies (for example, scale, congestion, technical, and cost) by including various model configurations. This is possible because, in this framework, the interpretation of PPFs varies depending on the model configuration. For example, if there are only physical inputs and outputs, the interpretation of PPF would be, as traditionally, the best-practice technology. If, however, financial expenditures are also included on the input side, the interpretation of PPF would be the lowest-cost practised technology. Further, if financial revenue is also included on the output side, the interpretation of PPF would be the most-profitable practised technology. Finally, if CO_2 emissions are also added to the model, the interpretation of PPF would be the cleanest practice technology. The term 'clean', in the context of this chapter, refers to the best practised technology (with lowest CO_2 emissions).

Being classified as an axiomatic framework, efficiency in the proposed framework, therefore, is simply computable as the distance from the best practice PPF. Thus, corresponding to the interpretation of PPF in each model, the interpretation of efficiency also varies from model to model. For example, for physical inputs/outputs, the PPF would represent the best practice technology, and the measured efficiency would be technical efficiency. If PPF represents the lowest-cost technology, the corresponding efficiency would be cost-efficiency. Similarly, "clean-cost-efficiency" is measurable from the distance function of a model in which CO_2 emission is assigned on the input side.

Another interesting property of the proposed framework is that sometimes adding a new input/output to a model will not make any difference in the measured efficiencies (at least, for a large number of data points). In such cases, the interpretation of PPF and efficiency are referred to the original model (that is, the model before adding the additional input/output). This is simply because additional input/output has not brought a true constraint for the model (being a redundant constraint to the LP) and consequently the interpretation of PPF and distance function remain the same. Therefore, one should be aware of the fact that the real interpretation of PPFs and efficiencies will be revealed only after the estimations are made. This demonstrates the objective nature of the proposed framework for empirical studies. For example, if by adding a financial factor as an input to a model that only contains physical inputs/outputs, before estimation, as mentioned earlier, the interpretation of efficiency is aimed to be cost efficiency. However, if after estimation, it is revealed that the new input has only brought a redundant constraint to the LP (see Appendix 4.2), one should realise that cost efficiency would be equal to technical efficiency. This is while in the traditional behavioural framework, as can be seen in Figure 4.2, the above-mentioned property of the proposed framework will never happen in the behavioural framework and there will always be a difference between the measured cost and technical efficiencies. This is firstly because, in the traditional framework, the relative prices of inputs are assumed to be the same across organisations, while usually different organisations pay different unit prices for factors of production. This directly reflects the normative character of the traditional behavioural framework, which emphasises a general equilibrium at aggregate level at a given time (that is, equilibrium prices are given for individual organisations).

Assessment-framework

With regard to the framework for assessing micro- and macro-impacts, this research proposes hypothesis-testing for reform-induced institutional changes. These institutional changes are quantified in this research in terms of organisational structure, and industry’s ownership.

The organisational structure of the Australian electricity industries, for a long period of time, used to be – and in some states still is – vertically integrated (VI). The generation, transmission, distribution, and retail functions of the industry, in a vertically integrated structure, were under a monopoly authority (called a statutory authority). This organisational structure has been functionally unbundled (FU) in the course of the current reform. This change has been captured by this research using a dummy variable as follows:

$$D - S_{i,t} = \begin{cases} 0 & if \quad VI \\ 1 & if \quad FU \end{cases} \quad \forall \quad i,t \tag{3}$$

Where: $D\text{-}S_{i,t}$ is the dummy variable for structure, and i and t represent state, and time, respectively.

This structural change (in those states that have undergone reform), as indicated in Table 3.1 in Chapter 3, concurrently occurred with other institutional changes, such as the introduction of new regulatory frameworks and a wholesale/retail electricity market. However, due to a strong correlation between the time of occurrence of organisational and institutional changes, they are all captured under the same environmental variable, represented by $D\text{-}S_{i,t}$.

Although the separation of organisational and institutional changes in the form of dummy variables is challenging, it would however considerably enhance the effectiveness of assessment-frameworks of this type. In this thesis, wherever possible, additional facts and evidence – largely on the basis of the analyses of Chapters 2 and 3 – are used to distinguish the impacts of organisational and institutional changes on economic performance.

With regard to the changes in industry ownership, the Australian states have had different approaches. Whilst the electricity industry has remained in the public domain in most of the states, it has been privatised in Victoria and South Australia. Public corporatisation is also observed in some states where the electricity industry is still in the public domain (for example, New South Wales). Therefore, three observations are made regarding the ownership of the Australian electricity industry. These are public (Pu), public corporate (PC), and private (Pr). The following dummy variable is defined to capture this change:

$$D-O_{i,t} = \begin{cases} 0 & if \quad Pu \\ 1 & if \quad PC \qquad \forall \quad i,t \\ 2 & if \quad \Pr \end{cases} \tag{4}$$

Where: $D\text{-}O_{i,t}$ is the dummy variable for ownership.

Using these dummy variables, the measured efficiencies (symbolised by η) are classified in different groups over time and space. Then, three hypotheses are tested using the Analysis of Variances (ANOVA). These three hypotheses are as follows.

Test (1) for assessing the impacts of restructuring on efficiencies:

$$H_0 : \overline{\eta}_{VI} = \overline{\eta}_{FU}$$
$$H_1 : \overline{\eta}_{VI} \neq \overline{\eta}_{FU} \tag{5}$$

Test (2) for assessing overall impacts of ownership change on efficiencies:

$$H_0 : \overline{\eta}_{Pu} = \overline{\eta}_{PC} = \overline{\eta}_{\mathrm{Pr}}$$
$$H_1 : \overline{\eta}_{Pu} \neq \overline{\eta}_{PC} \neq \overline{\eta}_{\mathrm{Pr}} \tag{6}$$

Test (3) for assessing specific impacts of ownership change on the efficiencies of those states that have experienced PC or Pr ownership:

$$H_0 : \overline{\eta}_{PC} = \overline{\eta}_{\mathrm{Pr}}$$
$$H_1 : \overline{\eta}_{PC} \neq \overline{\eta}_{\mathrm{Pr}} \tag{7}$$

where, for example, $\overline{\eta}_{VI}$ represents the mean of efficiencies among state electricity industries with vertically integrated structure. Null hypotheses (H_0) state "no significant reform-induced impacts", whereas alternative hypotheses (H_1) state "significant reform-induced impacts".

These hypotheses are generally set as two-tailed tests. They merely identify the significance of a change in the mean of productivity measures as a result of a change in reform variables. These are regardless of the direction of changes (increase or decrease). However, in the following analysis – wherever required – one-tailed tests are also applied to test the significance of improvements in productivity measures.

4.3.2 Framework for Assessing Macro-impacts of Electricity Reform

Analysis of macro-impacts has a more complex nature than micro-impact analysis. This is about capturing the inter-relationships between the macro-economic variables, and between the micro- and macro-impacts. This is complex also because it is difficult to decompose the impacts of electricity reform from the impacts of all other simultaneously occurring reforms (for example, gas and water) on overall performance of the economy. To deal with such complex is a time consuming task. This is beyond the scop of this research.

A simple – some might say, simplistic – econometric model is adopted in this research in order to develop broad assessment of the impacts of the reform on the wider economy. Econometrics enables one to analyse the causality between micro- and macro-impacts. Further, in contrast with CGE models in which economic gains from reform are estimated on the basis of various counterfactuals, econometric models allow for hypothesis testing (that is, statistical significance of any possible gain) on the basis of ex-post analysis of the historical data. Therefore, despite its simplicity, this model have some advantages in terms of overcoming some of the limitations of CGE models, for example, sensitivity to a large number of judgmental assumptions in counterfactuals and data-smoothing. Econometric approach is free from prior counterfactuals and rather allows for hypothesis-testing by developing appropriate structural equations and collecting a suitable historical panel dataset.

4.4 Model Specifications and Data/Software Considerations

Two set of models are required for assessing the impacts of electricity reform on the economic performance of the electricity industry and economy. This section briefly describes these models and provides some details about data/software considerations. Additional details are included in Appendix 4.2 and Appendix 4.4.

4.4.1 Analysis of Micro-impacts

Model specifications

This thesis has developed two groups of models for measuring the impacts of electricity reform on productivity of electricity industry, namely Partial-Index models for PFP, and Overall-Index models for efficiency and TFP. Tables 4.4 and 4.5 show the input-output configurations of these two groups of models. With regards to the Overall-Index Models, the Malmquist TFP index is adopted as the measurement-framework, as suggested by Coelli (1998). The Malmquist framework holds a number of properties that makes it especially useful for the analysis of this research. More specifically, this framework is: (i) capable of analysing the dynamism of changes in productivity, using a suitable panel dataset; (ii) calculable based on the axiomatic approach and distance functions and thus free from behavioural assumptions; and (iii) decomposable into efficiency change and technological change.

Table 4.4 Input-Output Configuration of Partial-index Models: Partial Factor Productivity

Factor	PFP	variable name	Unit	Configuration Numerator	Denominator
Labour	Labour productivity in whole ESI	L-P-ESI	GWh/person	Total final electricity supply	Total labour in ESI
Capital	System Capacity Factor	SCF	%	Total final electricity supply	Total installed generation capacity multiplied by 8,760 hours
	System Load Factor	SLF	%	Total final electricity supply	System peak load multied by 8,760 hours
	Excess Capacity	Excess-C	%	Total installed generation capacity minus system peak load (idle capacity)	Total installed generation capacity
	Productivity of Network Length	T&D-NL	GWh/Km	Total final electricity supply	Length of network
	Productivity of Network Capacity	T&D-NC	GWh/MVA	Total final electricity supply	Capacity of network
Energy	Thermal efficiency of T&D	T&D-eff	%	Total energy loss of T&D (i.e. entropy as energy consumed by T&D)	Energy content of total electricity available for transmission and distribution
	Thermal efficiency of generation	Therm-eff	%	Energy content of total electricity gererated by thermal genearators	Energy content of total fossil fuel consumed by thermal generators
Environment	CO_2 emmission of thermal generation	CO2-TG	MWh/Tonnes CO2	Total electricity generated by thermal generators	CO2 emissions from thermal generators
	Percentage of Hydro-Capacity	Hydro-C	%	Total installed hydro capacity	Total installed generation capacity
Financial	Average cost	A-R-Cost	cent/KWh	Total operational costs (1990 prices)	Total final electricity supply
	Average residential price	R-R-Price	cent/KWh	Total residential sale revenue (1990 prices)	Total final electricity supply
	Average business price	B-R-Price	cent/KWh	Total business sale revenue (1990 prices)	Total final electricity supply

Notes: PFP – Partial Factor Productivity; ESI – electricity industry; T&D – transmission and distribution.

Table 4.5 Input-Output Configuration of Overall-index Models: Efficiency and Total Factor Productivity

Model	Time period	Number of Cross sections (states)	Level of Aggregation	Interpretation of Efficiency	No. Inputs	Inputs	No. Outputs	Outputs
1	1980–2001	7	ESI	Pure-technical-	5	Fuel (TJ), Labour (Person), Generation Capacity (KW), Network Legnth (KM), and Network Capacity (MVA)	1	Total final electricity supply (GWh)
2	1980–1995	7	ESI	Cost-	6	Fuel (TJ), Labour (Person), Generation Capacity (KW), Network Length (KM), Network Capacity (MVA), and Total expenditure (m$)	1	Total final electricity supply (GWh)
3	1980–1995	7	ESI	Clean-cost-	7	Fuel (TJ), Labour (Person), Generation Capacity (KW), Network Length (KM), Network Capacity (MVA), and CO2 emission (tonnes)	1	Total final electricity supply (GWh)
4	1980–2001	6	TG	Pure-technical-	3	Fuel (TJ), Labour (Person), and Generation Capacity (KW)	1	Total thermal electricity generation (GWh)
5	1980–2001	6	TG	Cost-	4	Fuel (TJ), Labour (Person), Generation Capacity (KW), and CO_2 emission (tonnes)	1	Total thermal electricity generation (GWh)
6	1997–2001	5	T&D	Pure-technical-	4	Labour (Person), Network Length (KM), Network Capacity (MVA), and Electricity input (GWh)	1	Total final electricity supply (GWh)

Notes: ESI – the electricity industry; TG – the thermal generation segment; T&D – the transmission and distribution.

The third property of the Malmquist TFP index (that is, decomposability) is especially useful for the purpose of policy analysis. It allows for decomposing TFP growth into those components that are due to efficiency gains (moving towards the frontier) and those that are due to technological improvements (shifts in PPF). The former can be interpreted as the possible impact of introduction of competition (that is, an increase in the degree of competitiveness among firms), whereas the latter is related to technological improvements (that is, increase in the degree of diffusion of technology). Mathematical specifications of these models are provided in Appendix 4.2.

Data/Software

A panel dataset for eight states/territories over the period 1955–2001 has been developed. In order to reduce the volume of computation, the time series data for Partial-Index models is collected for the period 1955–2001, and the time series data for Overall-Index models have been limited to the period 1980–2001. This period for overall-Index models adequately includes data from before and after the recent electricity reform and captures the impact of the ongoing market reform. In some cases, due to lack of data or the change in structure of datasets, this period has been further limited (see Table 4.5).

The data for inputs and outputs for various state electricity industries, corresponding to those listed in Tables 4.4 and 4.5, are obtained mostly from the Electricity Supply Association of Australia (ESAA) publications in various years. The inputs and outputs of the Snowy Mountain Scheme – for simplicity and on the basis of EANSW (1986) and also on the basis of the assumption made by Whiteman (1999) – are divided between the two states (NSW and Victoria) in the ratios 2/3 and 1/3, respectively. The Australian Capital Territory (ACT) is merged with NSW. Therefore, the largest cross-section observation of the panel data includes: New South Wales and the Australian Capital Territory (NSW&ACT), Victoria (VIC), Queensland (QLD), South Australia (SA), Western Australia (WA), Tasmania (TAS), and the Northern Territory (NT).

Although a large number of observations are available for labour force, the reliability of the time series at functional levels (that is, generation, transmission and distribution) has been questioned by this research. This is essentially due to the recent organisational changes in the industry. The longest reliable time series at functional levels has been limited to the 1997–2001 period. The former statutory authorities used to provide lump-sum employment figures for the whole of the industry rather than by its functional segments. Therefore, a longer time series comparison for labour productivity is only possible at the overall industry level (see Table 4.5).The time series of total expenditure in VIC and SA only covers 1980–1995 and 1980–1997, respectively. The unavailability of detailed financial data is the natural outcome of the privatisation of electricity industries in these states (see Johnson & Rix 1991, pp. 109-13). This issue has caused unbalanced estimations for some models in this thesis. For example, as shown in Table 4.5, the time periods for Models 2, 3, and 4 are limited to 1980–1995. The real values of financial data are calculated by dividing the nominal values by the Consumer Price Index (CPI) of each state.

CO_2 emissions are estimated on the basis of emission-factors for fuels consumed in electricity generation, as provided by the National Greenhouse Gas Inventory Committee (NGGIC 1994). Comparison of emission-related productivities at the state level, however, is problematic, particularly when Tasmania is included. This is because of the different compositions of fossil-fuel and non-fossil-fuel-based electricity in various states. Therefore, comparison of emission-related productivities is only made for thermal generation (and with the exclusion of Tasmania, in which, the bulk of electricity supply is based on hydro plants).

Finally, dummy variables ($D\text{-}S_{i,t}$ and $D\text{-}O_{i,t}$) are based on various sources and this author's personal communications with several institutions and industry professionals.

With regard to software packages, all computations for micro-impact models are performed using Microsoft Excel software package. The mathematical models (Linear Programming (LP)) are solved using the built-in solver facility of this package and a macro-program developed by this thesis (see Appendix 4.3). The results of the models have been double-checked using the DEAP program developed by Coelli (1996).

4.4.2 Analysis of Macro-impacts

Model specifications

The econometric model used in this research for assessing macro-impacts is a purpose-specific (*ad-hoc*) panel-data model. The structural form of this model is designed to capture inter-relationships, on one hand, between macro-economic variables and, on the other hand, between the micro- and macro-impacts. In this model, emphasis is given on elaborating the inter-relationship between economic growth and electricity demand. There are thus two main equations, which makeup a system of simultaneous equations through energy balance identity. Mathematical specification of these equations and their justification is provided in Appendix 4.4.

Data/Software

A panel dataset for eight states over the period 1980–2002 has been developed for macro-impact model. The main macro-economic data are obtained from official publications of the Australian Bureau of Statistics (ABS 2001, 2004a, 2004b, 2004c, 2004d). These data include current value and chain volume of gross domestic products (GDP), gross state products (GSP), gross fixed capital formation, end-year net capital stocks, and consumption of fixed capital. The dataset also includes state and national data for consumer price indices (CPI), population, labour force, total primary energy supply (TPES), and total final energy consumption (TFEC). Due to some structural changes in ABS's state-based statistics, the longest reliable time series used in this research has been the 1990–2002 period.

Finally, all econometric modellings have been run using Eviews 4.1 software package (Lilien et al. 2002). This package contains powerful features regarding panel-data modelling.

4.5 Empirical Results

This section presents the empirical results of the models discussed in the foregoing sections. The discussion is divided into two sub-sections presenting micro- and macro-impacts, respectively. The analysis of micro-impacts is divided into three parts, namely, impacts of electricity reform on various PFPs, efficiencies, and TFPs. The volume of measured productivities is large, thus Appendix 4.4 is allocated for presenting these measures.

4.5.1 *Micro-Impacts*

Partial Factor Productivities

Table 4.6 shows a summary of the descriptive statistics of various PFPs for the sample, aggregated over electric utilities with different types of structures (that is, vertically integrated (VI) and functionally unbundled (FU) structures) and ownership (that is, public, public-corporate, and private ownership). The number of observations, means, and standard deviations of PFPs are also presented in this Table. Further, the results of the three hypotheses tests – discussed in Section 4.3 – are summarised in this Table. The area under F distribution and greater than estimated F-value are also indicated. The following sub-headings divide the discussion into five groups of PFPs corresponding to labour, capital, fuel, environmental, and financial, respectively.

a) Labour Productivity

The analysis shows that the labour productivity of the Australian electricity industry (at national and state levels) has significantly improved as a result of changes captured by the above-introduced dummy variables. More specifically, the result of Test 1 affirms that the restructuring of the electricity industry has significantly improved labour productivity in the whole electricity industry. The results of Test 2 confirm, overall, that there is a relationship between labour productivity and industry ownership. Further, the results of Test 3 show that privatisation has resulted in a more labour-productive electricity industry. However, one should be aware of the nature of these results. The following observations help to better understand this.

As discussed in Section 4.4, a consistent panel dataset for labour productivity at functional levels (that is, generation and T&D segments of the industry) has only been available for the years after 1997, and thus the following results are divided on the basis of the calculations from 1997 onwards. The labour productivity of the generation segment at the national level has increased from 11.9 GWh per person in 1997 to 22.8 GWh per person in 2001, showing a 16.3% growth rate per year. This is while the growth rate of labour productivity in transmission-and-distribution over 1997–2001 at

Table 4.6 Summary of Descriptive Statistics of Partial Factor Productivities and the Results of Hypotheses Tests

Factor	Labour	Capital					Energy		Environmrnt		Financial		
Variable Name	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Therm-eff*	*T&D-eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-Price*	*B-R-Price*
Unit	GWh/person	%	%	%	GWh/Km	GWh/MVA	%	%	MWh/tonnes	%	cent/KWh	cent/KWh	cent/KWh
Number of Observations													
Total	376	376	85	85	264	264	376	376	376	284	360	376	376
Vertically Integrated	334	334	52	52	222	222	334	334	334	247	334	334	334
Functionally Unbundled	42	42	33	33	42	42	42	42	42	37	26	42	42
Total	376	376	85	85	264	264	376	376	376	284	360	376	376
Public Ownership	349	349	67	67	237	237	349	349	349	264	349	349	349
Public-Corporate	12	12	9	9	12	12	12	12	12	8	11	12	12
Private Ownership	15	15	9	9	15	15	15	15	15	12	na	15	15
Means													
Total	1.6	41.6	65.6	27.6	161.2	745.3	30.1	96.2	1.0	28.5	11.2	11.5	10.8
Vertically Integrated	1.3	40.6	65.6	31.1	153.7	730.9	29.5	96.7	1.0	29.1	11.6	11.8	11.4
Functionally Unbundled	4.6	49.8	65.5	22.1	201.0	821.2	34.8	92.0	1.1	24.7	6.5	9.2	6.3
Total	1.6	41.6	65.6	27.6	161.2	745.3	30.1	96.2	1.0	28.5	11.2	11.5	10.8
Public Ownership	1.4	41.1	67.8	31.4	158.2	745.6	29.8	96.5	1.0	29.2	11.4	11.6	11.1
Public-Corporate	4.0	45.3	53.7	13.8	176.9	690.5	35.3	92.5	1.2	20.1	7.4	9.7	7.0
Private Ownership	5.1	51.6	61.3	13.0	196.2	784.5	33.9	92.4	1.1	18.9	na	10.0	6.6
Standard Deviation													
Total	1.4	7.4	12.2	12.6	74.2	276.0	4.9	0.3	0.2	29.8	4.9	3.5	5.1
Vertically Integrated	1.0	6.7	11.6	12.8	74.9	284.3	4.8	0.3	0.3	30.6	4.9	3.6	5.1
Functionally Unbundled	0.9	7.4	13.4	10.3	56.5	214.5	2.6	0.0	0.1	23.6	1.6	1.2	1.1
Total	1.4	7.4	12.2	12.6	74.2	276.0	4.9	0.3	0.2	29.8	4.9	3.5	5.1
Public Ownership	1.2	7.0	10.3	10.6	75.8	285.0	4.9	0.3	0.3	30.8	4.9	3.6	5.1
Public-Corporate	0.8	6.2	14.5	10.4	54.3	57.6	2.4	0.0	0.2	1.0	1.7	1.1	0.7
Private Ownership	0.7	8.6	16.4	8.0	50.9	235.7	1.5	0.0	0.1	0.8	na	0.9	0.6
Test1: (H0: No significant difference between mean of efficiencies within State-ESIs with different structure)													
F-Value	462.16	69.06	0.00	11.55	15.11	3.82	49.13	1.32	5.50	0.70	28.02	21.37	41.92
(Prob>F)	0.0000	0.0000	0.9713	0.0010	0.0001	0.0517	0.0000	0.2515	0.0196	0.4020	0.0000	0.0000	0.0000
Test2: (H0: No significant difference between mean of efficiencies within State-ESIs with different ownership)													
F-Value	99.94	17.49	6.64	21.54	2.15	0.39	12.67	0.32	2.09	1.02	na	3.14	9.54
(Prob>F)	0.0000	0.0000	0.0021	0.0000	0.1188	0.6802	0.0000	0.7249	0.1255	0.3625	na	0.0443	0.0001
Test3: (H0: No significant difference between mean of efficiencies within State-ESIs with PC and Pr ownership)													
F-Value	14.55	4.50	1.68	0.03	0.90	1.81	3.83	0.05	2.20	9.92	na	0.61	2.27
(Prob>F)	0.0008	0.0440	0.2066	0.8655	0.3513	0.1909	0.0615	0.8192	0.1504	0.0055	na	0.4432	0.1449

Note: Further details are provided in Appendix 4.6 in page the national level (also at state levels) has remained steady, with only a relatively flat rate of growth of 1.2% per year. Labour productivity of the transmission-and-distribution segment was equal to 6.8 and 7.1 GWh per person in 1997 and 2001, respectively (see Appendix 4.4). The large difference between the average growth rates of labour productivity in the generation and transmission-and-distribution segments over 1997–2001, compared with the average growth rate of labour productivity in the entire electricity industry, which is a weighted average of these, indicates that most of the labour productivity improvement has largely occurred as a result of redundancies in the generation segment.

It should also be kept in mind that the generation technology has moved away from its relatively more labour-intensive form to a relatively more capital-intensive form in recent years. Considerable doubts will therefore remain regarding the comparability of labour productivities before and after the recent reform on the basis of the publicly available datasets. This, as mentioned earlier, is essentially because of the broad changes that have taken place in the structure of labour statistics. Personal communications with industry experts suggest that there are ambiguities in the publicly available labour-force data. For example, while in the current structure of the industry, many labour services are provided by contract workers which are not included in the current dataset (and these data are not available); the same labour services were included as the labour input in the traditional vertically integrated structure of the industry. Further, the impact on labour-force of the mergers between energy utilities (for example, electricity and gas) remains unclear in the current dataset. The lack of detailed data on labour-force and existing data-inconsistencies are general issues observed in the literature (see also Johnson & Rix 1991, p. 132).

b) Capital Productivity

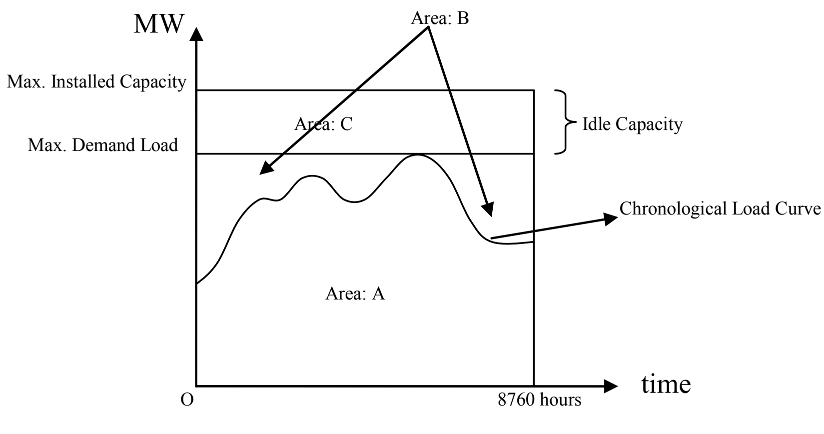
Assessing the productivity of capital is not as straightforward as labour productivity, essentially because capital is a stock variable and very difficult to measure. Such difficulties mainly stem from accounting conventions that vary from time to time, from organisation to organisation, from industry to industry, and from state to state.[42] In this

[42] This issue is even more critical for international benchmarking purposes.

research, five PFPs are calculated as proxies for capital productivity. These include System Capacity Factor (SCF), System Load Factor (SLF), Excess Capacity (Excess-C), Network Length (T&D-NL), and Network Capacity (T&D-NC) (see Table 4.4). The first three measures are related to the capital-productivity of the generation segment, and the last two, to the productivity of the transmission-and-distribution segment.

The first three measures (that is, SCF, SLF, and Excess-C) are inter-related and should be assessed together, otherwise the assessment may lead to incorrect judgments. Figure 4.5 demonstrates such inter-relationships. In this Figure, the Chronological Load Curve, Maximum Installed Capacity (MIC), Maximum Demand Load (MDL), and the gap between MIC and MDL – known as Idle Capacity – are shown for a typical one-year period (that is, 8,760 hours). The definitions of SCF, SLF are geometrically demonstrated by the ratios of the areas shown in Figure 4.5.

Figure 4.5 shows that in order to improve the capital productivity of generation, area “A” should be maximised and/or areas “B” and “C” should be minimised. This means that improvement of capital involves the so-called demand- and supply-side management as well as issues related to idle capacity. The followings are the two guiding “rules of thumb” extracted from Figure 4.5: (i) given a constant Excess-C (constant idle capacity), any improvement in SCF requires an improvement in SLF, and vice versa; (ii) given a constant SLF, any improvement in SCF tends to require lower Excess-C, and vice versa.



$$SCF = \frac{A}{A+B+C} \qquad SLF = \frac{A}{A+B} \qquad Excess - C = \frac{Idle \quad Capacity}{Max. \quad Installed \quad Capacity}$$

Figure 4.5 The Inter-relationship between SCF, SLF, and Excess-C

As discussed in Chapter 1, electricity, as a commodity, is not storable and not separable from its transportation. Hence, the existence of idle capacities – although always having an inverse relationship with the productivity of capital – is a crucial aspect for the electricity industry in order to minimise the risk of power failures and for sustaining service reliability. Electricity authorities can only directly improve SCF by reducing Excess-C, which may, however, increase the risk of blackouts. They cannot directly control SLF. This means that they cannot dictate the demand, which fluctuates with the needs of consumers. However, it is possible – through certain policy tools – to create enough incentives among consumers to changes their preferences in a way that improves SLF. Such policy tools are called Demand Side Management (DSM) and these days they are becoming a major area of focus for the policy-makers. For instance, authorities may create incentives for off-peak usage.

The measured PFPs show that the lowest SCF is observed for the Northern Territory's ESI in 1968, which was 23.5% – corresponding to a vertically integrated and publicly-owned industry. The highest SCF is observed for Victoria's ESI in 2000 (a record), which was 63.4% – corresponding to a functionally unbundled and privately-owned industry. The observed record in Victoria's SCF is even higher than the best international benchmark, measured by Whiteman (1999), which was for Ontario Hydro in 1995, with an SCF equal to 55.8% (p. 21). However, recalling the inter-relationships between SCF, SFL, and Excess-C, one must question whether the SCF, per se, is an adequate measure for benchmarking the productivity of capital.

As shown in Table 4.6, the result of Test 1, with a high level of significance, confirms that restructuring of the ESI has improved the SCF. The results of Test 2 also show that, in general, the mean of the SCF in state electricity industries under public-corporate and private ownership is significantly higher than those with public ownership. The result of Test 3, however, indicates that the difference between the mean of the SCF in industries with the industry under public-corporate and private ownership is acceptable with only about 4.4% level of significance.

In other words, one might come to the conclusion – only on the basis of improvements in SCF – that capital productivity has improved as a result of market reform.

Fluctuations in SCF, however, depend upon many factors and must, therefore, not simply be credited to reform. Besides SCF improvement, the measurements show that the trend of SLF has been steady in all states, except in the case of South Australia[43], in which the trend of SLF has been negative. Further, the results of the hypothesis tests for SLF also confirm that reform has had no impacts on SLF (see Table 4.6).

Further, with regard to Excess-C, Test 1, with a high level of significance, confirms that the restructuring of the electricity industry has reduced excess capacity (Excess-C). With regard to ownership change, although Test 2 affirms that, in general, excess capacity in electricity industries under public-corporate and private ownership is significantly lower than those under public ownership. The result of Test 3 indicates that the null hypothesis of no difference between the mean excess capacity in the whole of the industry under public-corporate and private ownership cannot be rejected (see Table 4.6). This implies that a reduction in excess capacity cannot be credited to privatisation and that it merely relates to restructuring.

On the basis of the above analysis, the overall inference regarding capital productivity of the generation segment of the Australian electricity industry is that this productivity has improved overall as a result of a reduction of excess capacity. This, in turn, has improved the SCF. However, this research shows that the pattern of electricity demand captured by the SLF has remained unchanged (in the case of South Australia, the SLF has even declined). Therefore, one could infer that the improvement of capital productivity is likely to have occurred as a result of restructuring of the industry – through the creation of inter-connections – that, in turn, has created enough incentives for state electricity authorities to reduce their Excess-C. However, the sustainability of such an improvement will depend upon future actions for improving the SFL. Otherwise, there could be risks of power failure. These risks, the results of this research show, have unexpectedly worsened since the introduction of market reform. This issue, as one of the emerging challenges in the industry, will be discussed in the next chapter.

[43] Details of calculations by states are available in Appendix 4.4.

With regard to the transmission-and-distribution segment, the productivity of network length (T&D-NL) and network capacity (T&D-NC) – as proxy variables – are measured to capture the capital productivity of the transmission-and-distribution segment of the electricity industry (see Table 4.6). The result of Test 1 confirms that the restructuring of the electricity industry has significantly improved the capital productivity in the transmission-and-distribution segment. This is while this test, with only a 5% level of significance, supports such an improvement for the productivity of network capacity.

Furthermore, according to Tests 2 and 3, ownership change has had no impact either on the productivity of network length or on the productivity of network capacity (see Table 4.6). These, however, are not surprising results because the network segment of the electricity industry is still a natural monopoly and has largely remained in the public domain.

c) Energy Productivity

Energy productivity is also known as *energy efficiency*, which is generally a technological issue. From an economic point of view, especially regarding the generation segment of the industry, changes in energy efficiency mainly depend upon the selection of fuel composition on the basis of the level of scarcity of the fuels (that is, user costs that reflect the long-term availability of the fuels). From this point of view, the selection of fuel is highly intertwined with capital investment and is a long-term decision. Once the investment has been made, it is not flexible to change the fuel mix, and hence the energy efficiency of electric utilities, unless additional investments are made. Additional investment will lead to a gradual change in fuel mix and hence energy efficiency. Further, energy efficiency is obviously a matter for thermal generators. For renewable energy sources (for example, hydro, wind, and solar), energy efficiency is less important. Instead, what is more important regarding renewable electricity plants is their utilisation rate. This relates to the percentage of time in which, for various reasons, these plants can or cannot supply electricity. For example, a multi-purpose large hydro cannot supply all of the time because, for instance, the water which feeds it must also be used some times for irrigation purposes. In addition a wind turbine or solar panels cannot supply electricity constantly due to meteorological conditions. Moreover, energy efficiency in the transmission-and-distribution segment of the industry is an even more technology-driven matter and mainly relates to energy entropy and energy loss in the wires and transformers of the network.

Keeping these fundamental aspects in mind, in this research, two PFPs are measured to capture the energy efficiency of the electricity industry, namely the energy efficiency of transmission-and-distribution (T&D-eff) and thermal generators (Therm-eff). The results of the hypothesis tests show that the efficiency of thermal generators has improved as a result of the restructuring of the industry. No significant improvement can be confirmed as a result of ownership change for the energy efficiency of both segments. Further, the study shows that energy efficiency of transmission-and-distribution has no relationship to restructuring. These results, however, are not surprising because, as mentioned earlier, energy efficiency is a technological issue. The following discussion better substantiates this observation.

While a conventional Gas Turbines (GT) converts about 20% of the chemical energy content of natural gas into electricity, Combined Cycle Gas Turbines (CCGT) can convert up to 50% (NPPC 2002, p. 1). Additional energy efficiencies are also possible – above 80% – using cogeneration technologies, such as Combined Heat and Power (CHP). Given these technological achievements regarding energy efficiencies, it is obvious that the average thermal efficiency cannot suddenly be improved to these levels (although technologically attainable), and it is only possible through long-term investments. This depends upon the relative prices of these technologies and strategic policy direction on a macro-level.

The trend of the average energy efficiency of the Australian thermal generators supports this idea. Figure 4.6 shows this trend. Four periods are identifiable in this trend. For 15 years (1955–1970) the energy efficiency of thermal plants shows an average rate of growth of 2.28% per year. The energy efficiency increased from 20.97% in 1955 to 29.51% in 1970. From 1970, for 14 years, the efficiency had a very flat rate of growth – 0.18% per year. It reached 30.26% in 1984. Then, for seven years, this efficiency increased at an average growth rate of 1.96% per year, and reached 34.7% in 1991. Finally, from 1991 the growth stops again (only a slight rate of growth, at 0.22% per year) and thermal efficiency remains almost fixed, at around 35% until 2001 (see Appendix 4.4).

Such stepwise improvement of energy efficiency suggests that energy efficiency improvement is a technological issue in the sense that it depends upon the level of diffusion of technologies. The process of improvement is time-consuming because it is largely a matter of replacement investment. The current energy efficiency, which since 1991 has been around 35%, relates to technological achievements during the early 1980s. The coincidence of the last period (1991–2001) with the current reform is not surprising. It was expected as a result of the natural outcome of organisational learning regarding the emergence of the CCGT and co-generation technologies since the early 1980s (see Table 3.2 in Chapter 3). The electricity industry, as it has always been in its 12 decades of history, is a technology-driven industry. Therefore, one of the main drivers behind every reform of the industry has always been technological improvements (see also Boehm 1955; Booth 2003, p. 22; IEA 1999, pp. 23–4).

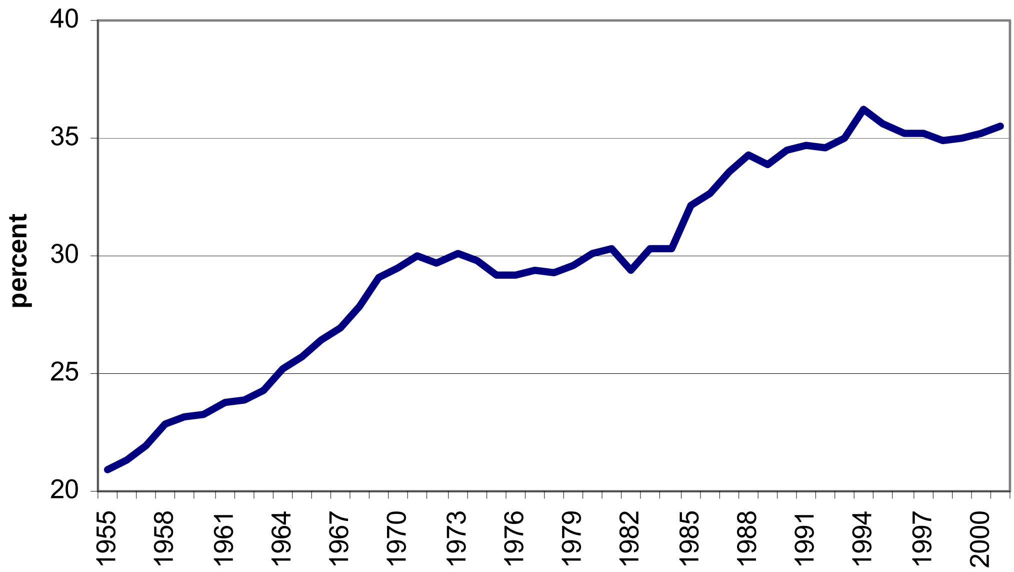


Figure 4.6 Energy efficiency of the Australian thermal plants

d) Environmental Productivity

In this research, two indicators are developed to capture environmental productivity. These include CO_2 emissions in the thermal generation segment (CO_2-TG) and the percentage of hydro-electric capacity (Hydro-C) (see Table 4.4). As can be noted, the

CO_2-TG has, in this research, been unconventionally measured in terms of MWh/tonne-of-CO_2 rather than the conventional tonne-of-CO_2/MWh. This is due to assigning of CO_2 emission as an input, rather than an output. Therefore, in this analysis the higher this variable is, the more environmentally productive the thermal generation segment of the industry is.

According to Test 1, with a 2% level of significance, the CO_2-TG has improved as a result of industry restructuring. Such an improvement, however, is more likely related to the improvement of the thermal efficiency discussed under the previous heading. In other words, this result appears to be a coincidence. This is simply because the thermal efficiency improvement has normally, in terms of energy contents, led to lower fuel consumption and, in turn, to relatively lower CO_2 emissions. The results of Test 1 show no impact on the percentage of hydro-capacity as a result of restructuring, which is consistent with expectations.

Further, the results of Tests 2 and 3, in general, show no relationship between privatisation and these environmental productivities. The only noticeable result relates to Test 3, regarding the percentage of hydro capacity which indicates, with about a 1% level of confidence, that this measure has significantly reduced as a result of industry privatisation. This result, however, is not surprising, because the privatised states (that is, South Australia and Victoria) have had neither any new hydro capacity nor any new potential hydro capacities as such, whereas their installed thermal capacity have increased. Therefore, the average of these two privatised state electricity industries would not be lower than those state industries under public-corporate ownership.

e) Financial Productivity

As discussed in the introduction, the main argument behind electricity reform has basically revolved around financial gains from reform. This research has measured such gains in terms of three financial productivity indicators (see Table 4.4), namely, average real cost (A-R-Cost), residential real price (R-R-Price), and business real price[44] (B-R-Price).

The results of Test 1 confirms (with a high degree of confidence) that restructuring of the electricity industry has generally improved the three indicators. Due to lack of information, Tests 2 and 3 could not be carried out for the A-R-Cost. The results of Tests 2 and 3 on the R-R-Price and B-R-Price show that there is no relationship between these PFPs and the ownership type. One should note that the results of Test 3 take priority over the results of Test 2, which in these cases show some degree of such a relationship. This is essentially because the results of Test 2 may be correlated to the results of Test 1. In the analysis of variance (ANOVA), there are certain techniques to avoid such a problem. However, because of the unbalanced data regarding two dummy variables (that is, *D-S* and *D-O*) such techniques were not applicable to the dataset of this research (for details, see Girden 1992; Spiegel 1988, pp. 310–16). One of the reasons for designing Test 3, was an attempt to overcome this problem.

The results of Test 1 may seem supportive for the proponents of market reform. These results may be interpreted as if the cost/price reductions confirm the initial stated arguments for the benefits of reform. Such an interpretation, however, loses much of its strength when subjected to more rigorous examination. The following analysis sheds more light on this issue.

First of all, as explained in Section 4.2.1, every PFP measure involves omitting valuable information about the performance of the organisations concerned. It is highly recommended that PFPs should be analysed in association with other PFP, efficiency, and TFP measures. As previously noted, labour productivity and energy efficiency have significantly improved as a result of restructuring. However, it was also shown that many of the improvements in both labour and fuel productivities were most likely the result of recent technological achievements rather than of market reform. According to Orchisson and Beardow (1993), labour and fuel expenditures contain about half of the marginal costs (cited in BIE 1994, pp. 19 and 31). Furthermore, it was also shown that

[44] This includes commercial and industrial customers.

the productivity of capital largely improved due to an improvement in the system capacity factor and the reduction of excess capacity, although it was shown that the system load factor, which is the most important factor with respect to capital productivity, has not improved at all as a result of reform. Therefore, the combination of evidence shows that the observed cost/price reductions might have only been the outcome of the internal restructuring of the state electricity industries. Such internal reform, as noted in Chapters 2 and 3, was focused on better management and control of the industry.

This argument becomes more plausible, when one sees that cost/price reductions have also been observed in the cases of WA and NT – states that are outside the National Electricity Market. In addition, the Tasmanian electricity industry has been an exception and there has been no cost/price improvement in this state. This is understandable because of Tasmania electricity industry predominantly consists of hydro plants. The trends of cost/price in Tasmania have remained almost constant over the 1980s and 1990s, averaging between 3 and 5 cents per KWh. These are the lowest costs/prices among the Australian states (see Appendix 4.4). In addition, Tasmania's participation in the NEM is expected to take place after the completion of the basslink high voltage direct current (HVDC) project (Booth 2003, p. 119). Therefore, the overall decline in the costs/prices of electricity in Australia is not related to the establishment of the electricity market. They are to the contrary more likely related to technological improvements as a result of the internal reforms in the mid-to-late 1980s. This argument will be discussed further when the results of the Overall-index productivities are analysed.

It seems that there has been a misconception regarding the use of the term "market" in the arguments stated by the proponents of the most recent reform. These arguments seems to imply that there has never been an electricity market in Australia before the commencement of the market-reform; indeed an electricity market has only been created by this reform (see Booth 2003, pp. 25–7; Hunt & Shuttleworth 1996, pp. 21–9; Stoft 2002, pp. 202–344). This proposition, however, constitutes a total misconception. The trends of the costs and prices of electricity at the national level – illustrated in Figure 4.7 – confirms this fact. As can be seen, the costs and prices have always moved together. Similar trends are observed for individual states, except the NT, which has experienced considerable disparity between costs and prices (a kind of subsidy) and can be interpreted as market distortion. The co-movement of costs/prices has not been accidental. It reflects the fact that there has always been a price mechanism to equate the demand and supply of electricity on the basis of economic factors. Such a mechanism – known as the order-of-merit process – constitutes an electricity "market".

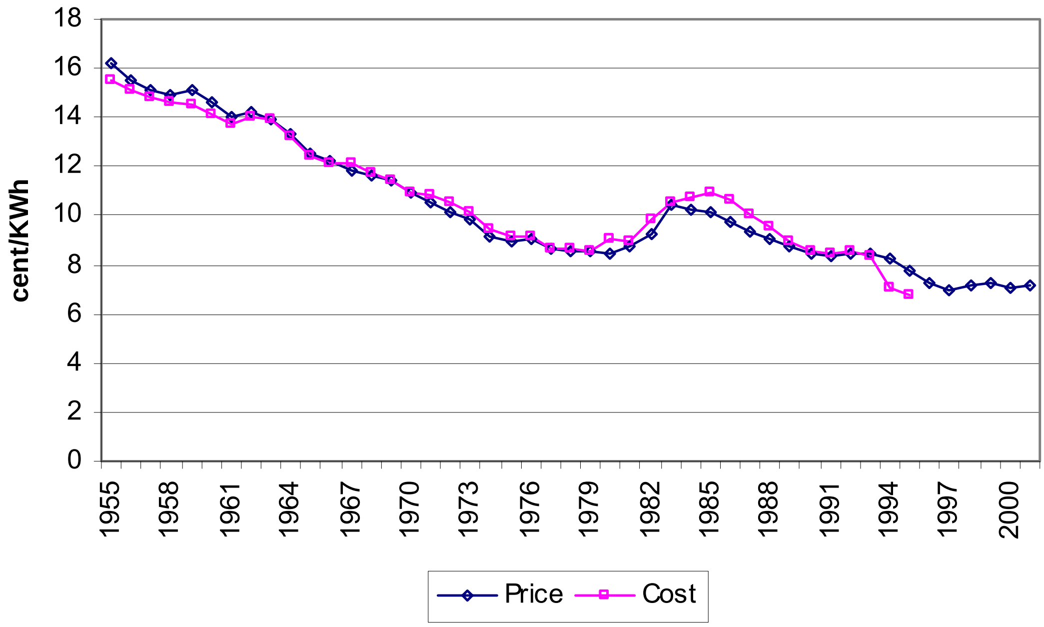


Figure 4.7 Trends of average real cost and price of electricity in Australia

Efficiencies

Table 4.7 shows a summary of statistics for various efficiency measures for the sample, as well as being aggregated over electric utilities with different types of structures and ownership. As elaborated in Section 4.3.1 (see also Table 4.5), the interpretation of efficiency, in the context of the micro-impact models of this thesis varies with the model configurations. The number of observations, means, and standard deviations of the PFPs are presented in Table 4.7. Further, the results of the three hypothesis tests – described in Section 4.3.3 – are summarised in this Table. The following sub-headings divide the discussion into three groups of models corresponding to the level of aggregations on which these models are configured.

Table 4.7 Summary of Descriptive Statistics of Efficiency Measures and the Results of Hypotheses Tests

	Model1	Model2	Model3	Model4	Model5	Model6
Number of Observations						
Total	154	112	112	132	132	25
Vertically Integrated	121	106	106	103	103	5
Functionally Unbundled	33	6	6	29	29	20
Total	154	112	112	132	132	25
Public	136	108	108	114	114	13
Public Corporate	9	4	4	9	9	4
Private	9	0	0	9	9	8
Mean of efficiencies						
Total	0.9417	0.9320	0.9418	0.9443	0.9800	0.9966
Vertically Integrated	0.9263	0.9282	0.9385	0.9328	0.9784	0.9973
Functionally Unbundled	0.9983	1.0000	1.0000	0.9854	0.9858	0.9965
Total	0.9417	0.9320	0.9418	0.9443	0.9800	0.9966
Public	0.9340	0.9295	0.9397	0.9397	0.9788	0.9990
Public Corporate	1.0000	1.0000	1.0000	0.9753	0.9967	0.9858
Private	1.0000	na	na	0.9719	0.9791	0.9983
Standard Deviation						
Total	0.0702	0.0741	0.0708	0.0679	0.0372	0.0088
Vertically Integrated	0.0717	0.0743	0.0714	0.0708	0.0387	0.0060
Functionally Unbundled	0.0097	0.0000	0.0000	0.0324	0.0309	0.0095
Total	0.0702	0.0741	0.0708	0.0679	0.0372	0.0088
Public	0.0712	0.0742	0.0712	0.0703	0.0381	0.0037
Public Corporate	0.0000	0.0000	0.0000	0.0379	0.0098	0.0178
Private	0.0000	na	na	0.0441	0.0412	0.0049
Test1: (H0: No significant difference between mean of efficiencies within State-ESIs with different structure)						
F-Value	33.0045	5.5598	4.4096	15.0486	0.8803	0.0366
(Prob>F)	0.0000	0.0201	0.0380	0.0002	0.3499	0.8500
Test2: (H0: No significant difference between mean of efficiencies within State-ESIs with different ownership)						
F-Value	7.6311	na	na	1.9731	0.9749	4.8562
(Prob>F)	0.0007	na	na	0.1432	0.3800	0.0179
Test3: (H0: No significant difference between mean of efficiencies within State-ESIs with PC and Pr ownership)						
F-Value	6.6623	na	na	0.0306	1.5537	3.7478
(Prob>F)	0.0201	na	na	0.8634	0.2305	0.0816

a) Efficiency of the Entire Electricity Industry

This includes Models 1, 2, and 3 (see Table 4.5). Model 1 measures the technical efficiency of the entire states' electricity industries. The trends of technical efficiencies at state levels show that the Tasmanian electricity industry has obviously always been on the PPF of Model 1. Since 1991, the majority of states have also performed efficiently technically, except for WA and the NT (for details, see Appendix 4.4).

The results of Test 1 on Model 1 confirm that the technical efficiency of the industry has significantly improved as a result of restructuring across the states and at the national level (see Table 4.7). The results of Test 2 on Model 1 show that there is an overall relationship between industry ownership and technical efficiency. Finally, regarding Test 3 on Model 1, the null hypothesis has been rejected at an 0.02 level of significance. This confirms that there is most likely a positive relationship between the improvement in technical efficiency and privatisation. However, the results of Tests 2 and 3 should be viewed with caution. In terms of Test 2, this is because, as mentioned earlier, the results of Test 1 and 2 might be correlated. In terms of Test 3, it is because the value of F is much smaller than its value for Test 1. Further, the means of the technical efficiency for industries under public-corporate and private ownership are the same and equal to one, and the standard deviations of these are almost zero (see Table 4.7). Thus, there has been no variation as such in their respective technical efficiencies. Model 2 is designed to measure the cost-efficiency of the entire states' electricity industry because the variable of total expenditure is added on the input side of Model 1 (see Table 4.5). However, the measured cost efficiencies have been numerically the same as the measured technical efficiencies of Model 1 (except for a few exceptions). Hence, the measured efficiency is still interpreted as technical efficiency. This is interesting if one recalls the methodological difference between the proposed measurement-framework of this research and the traditional frameworks on the basis of behavioural assumptions (see Section 4.3.1). This implies that what really forms the PPF of the industry across the states is the technological constraints and not the financial costs. With regard to the hypothesis tests, it is better to rely on Model 1 because Model 2, due to the lack of financial data, has lost a considerable number of observations (see Table 4.7). For the same reason (that is, losing considerable number of observation and, hence, degree of freedom), the results of Test 1 on Model 2 are inconsistent with the results of the same Test on Model 1. Tests 2 and 3 are not possible for Model 2 due to the lack of financial data.

Finally, Model 3 is designed to measure the clean-cost-efficiency of the state electricity industries because the variable of total CO_2 emissions are added on the input side of the Model 2 (see Table 4.5). However, for the same reason stated for Model 2, the measured efficiency is only clean-technical efficiency. This means that the omission of the variable of total expenditure as an input has no impact on the measured efficiency. One should notice that the variable of total CO_2 emissions is not redundant and the measured efficiencies of Model 3 considerably differ from the measured technical efficiencies of Models 1 and 2. Only Test 1 applies for Model 3. The null hypothesis has been rejected at only 0.04 level of significance (see Table 4.7).

In addition, the results also show that the trends of clean-technical efficiency are highly correlated with pure-technical efficiency. The high correlation of these two variables, which is 0.982, is not surprising and again confirms that the improvements in environmental performance as a result the reform (that is, an improvement in clean-technical efficiency) is a technological issue and obviously related to the energy efficiency of the thermal generators. This issue will be addressed shortly, when the results of Model 5 are presented. Further, this issue should by no means be related to the regulatory changes associated with the electricity market. On the contrary, emerging evidence, especially with regard to VIC and SA shows that the electricity market has created incentives for generators to use more low-cost-high-CO_2-emitting brown coal rather than high-cost-low-CO_2-emitting black coal (see Sharma, Beardow & Sproule 1999).

b) Efficiency in the Thermal Generation Sub-sector

This include Models 4 and 5 (see Table 4.5). Model 4 measures the technical efficiency of the thermal generation segment of the Australian electricity industry at state and national levels. As mentioned in Section 4.4, Tasmania is excluded in Model 4 and Model 5, mainly because the thermal generation capacity of the Tasmanian electricity industry is negligible and mainly relates to remote islands or non-base-load electricity. The trends of technical efficiencies at state levels reveal that QLD, VIC and

NSW&ACT, in most years, have been on the PPF, whereas the NT, followed by WA have always been below the PPF. Not surprisingly, generation segment of the NT electricity industry has been the most inefficient generation (see Appendix 4.4).

The results of Test 1 on Model 4 confirms that the technical efficiency of the thermal generation has significantly improved as a result of restructuring across the states and at a national level (that is, the null hypothesis has been strongly rejected at an 0.0002 level of significance). The results of Test 2 and Test 3 on Model 4, strongly suggest that there has been no relationship between the improvement of technical efficiency and privatisation (see Table 4.7).

Model 5 is designed to measure the clean-efficiency of the thermal generation at state and national levels. The variable of total CO_2 emissions is added on the input side of Model 4 (see Table 4.5). The measured efficiencies in Model 5 differ from those of Model 4. Hence, they represent clean-efficiencies. The results of Tests 1, 2, and 3 interestingly reject any impact from either restructuring or privatisation on the clean-efficiency of the thermal generation (see Table 4.7).

The trend of clean-efficiency for the NT shows that, since 1988, this state's thermal generation segment of the industry has been located on the PPF which represents the cleanest practised generation technology. This is while, as noted regarding Model 4, the NT has always had the most technical-inefficient generation in Australia and until 1987 also had the highest clean-inefficient generation. A careful examination of the details of the dataset reveals that improvement in clean-efficiency is largely related to the change in fuel-mix of thermal generation in this state. Until 1984, the dominant fuels in this state were oil (80%) and diesel-oil (20%). The fuel-mix in 1987 shows that the fuel shares of oil, diesel-oil, and natural gas changed into 47%, 11% and 41%, respectively. Furthermore, since 1988, the dominant fuel in this state has been natural gas with an over 95% share of the whole fuel consumption of this state's thermal generation (ESAA various). This is very interesting with regard to the assessment-framework of this research because the NT is a state that is far away from the mainstream Australian electricity industry reform.

c) Efficiency in Transmission and Distribution

This section analyses the findings of Model 6. This Model measures the technical efficiency of the transmission-and-distribution segments of the Australian electricity industry at the state and national levels. The results of the three Tests on this Model do not support any significant impact on the technical efficiency of the transmission-and-distribution segments from either restructuring or privatisation (see Table 4.7). This is, however, not surprising, because, as discussed earlier in this sub-section, the transmission-and-distribution is more reliant on technological aspects.

Total Factor Productivity and Its Decomposition

The volume of calculations for TFP measured on the basis of the Overall-Index models of this research and the decomposition of these TFPs into efficiency changes and technological changes is very large. The most intriguing result is presented by Figure 4.8, as a demonstrative example. This Figure shows the trend of the average TFP of the Australian electricity industry on the basis of Model 1. The Figure also shows the decomposition of this TFP measure into the changes which have resulted from efficiency (that is, moving relatively closer or away from the PPF over time) and the changes which have resulted from the shifts in the PPF (technological changes). The former (that is, efficiency changes) can be interpreted as the degrees to which states compete with each other or imitate one another to achieve the highest practised technology (that is, the PPF). The latter (that is, technological change) shows how the best practised technology has significantly changed. Such decomposition is very useful for assessing the impacts of reforms on the overall performance of the electricity industry.

As can be seen in Figure 4.8, from the early to mid-1980s, the TFP of the Australian electricity industry declines mainly as a result of inefficiencies (moving away from the PPF). During this period, many states moved away from the PPF. The Tasmanian electricity industry – obviously because of its special characteristics (that is, dominantly being hydro electricity) – has always been located on the PPF. This period, as discussed in detail in Chapters 2 and 3, brought about considerable attentions towards inefficiency of the electricity industry. Such attentions initiated a series of state-based reforms (that is, the internal reforms, as outlined in Chapter 2). Figure 4.8 further shows that as a result of internal reforms, the TFP of the Australian electricity industry has significantly improved, undoubtedly as a result of efficiency improvements indicating inter-state competition to achieve a higher efficiency. These productivity improvements also have been captured by most of the productivity analyses, which were reviewed in Section 4.2. However, what has not been captured by previous studies is that whether these productivity improvements should be really ascribed to market reform and that whether they would be as a result of efficiency changes, or mainly due to technological improvements (shifts in production PPF).

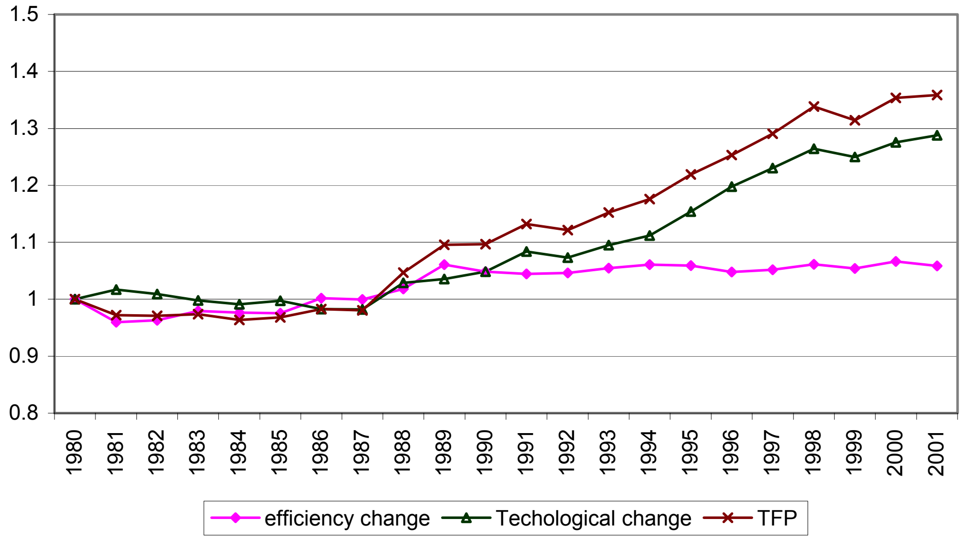


Figure 4.8 Decomposition of Average TFP of the Australian Electricity Industry

Figure 4.8 clearly demonstrates that the improvement of TFP, since the year 1990, has been largely affected by technological changes. It shows that the relative technical efficiency remains constant all through the 1990s. Technological change, these results reveal, stems from internal reform and not necessarily from market reform, which had commenced in 1994. Although the foregoing analysis was based on TFP, averaged on the national level on the basis of the results of Model 1, similar inferences can be drawn from the results of other Models (see Appendix 4.4).

4.5.2 Macro-Impacts

The Australian economy, both at state and national levels, in terms of economic growth, has performed very well over the last decade (that is, 1992–2002). With 3.8% real annual GDP growth, Australia has been one of the world's fastest growing industrialised economies (ABS 2004a; see also EIA-DOE 2003). At state levels, for the same period, QLD, with 4.8% annual growth of gross state product (GSP), has had the highest economic growth. VIC, WA, NT, NSW&ACT, SA, and TAS respectively, with 4.2%, 3.9%, 3.7%, 3.6%, 2.9%, 1.7% annual growth, are ranked after QLD in descending order. In terms of the share of GSPs in GDP[45], NSW&ACT, with about 36%, has had the largest Australian state-economy. VIC, QLD, WA, SA, TAS and NT, each respectively with about 26%, 17%, 11%, 7%, 2%, and 1%, are ranked after NSW&ACT in descending order (ABS 2004a, 2004b).

A question immediately arises as to whether, and to what extent, such impressive economic performance can be attributed to electricity reform? Answering this question requires an analysis, which is much more complicated than the micro-impact analysis presented in the previous sub-section. This is essentially because of the complex nature of the inter-relationship between the macro-economic variables, and between the micro- and macro-impacts. Also, at macro level it is difficult to decompose the impacts of electricity reform from the impacts of other reforms (for example, gas and water), which are on-going simultaneously. The econometric model of this research is designed to capture such inter-relationships, with an emphasis on elaborating the inter-relationships between economic growth and electricity demand. The model is also designed to test the significance of the impacts of electricity reform on overall economic growth.

Table 4.8 summarises the results of estimating the parameters of the structural, reduced, and final forms of the model (see Appendix 4.4 for model specification and Appendix 4.5 for all details of Eviews outputs). While the parameters of the structural form reflect the impulse or immediate inter-relationship between macro variables, the parameters of the reduced and final forms show respectively the short- and long-term inter-relationships between endogenous variables (in this particular model, that is, electricity demand and real GSP) and exogenous variables (for example, electricity price, labour force, and capital stock). Finally, Table 4.9 presents the major elasticity measures of the Australian economy. These elasticities are used, in this analysis, to elaborate on the inter-relationships between major macro-economic variables.

[45] Here, the GDP means the summation of all GSPs.

Table 4.8 Summary of Estimations for Structural, Reduced and Final Forms

	Structural Form		Reduced Form		Final Form	
Variables	ln(E)	ln(Y)	ln(E)	ln(Y)	ln(E)	ln(Y)
ln(E)	1.0000	0.1904	1.0000	0.0000	1.0000	0.0000
ln(Y)	0.0336	1.0000	0.0000	1.0000	0.0000	1.0000
ln(P)	-0.0336	0.0000	-0.0339	-0.0064	-0.3749	-0.2357
ln(K)	0.0000	0.0992	0.0034	0.0998	0.1225	0.4047
ln(L)	0.0000	0.1082	0.0037	0.1089	0.1336	0.4413
R	0.0000	0.2867	0.0097	0.2885	0.3540	1.1695
FU	0.0162	0.0000	0.0163	0.0031	0.1809	0.1138
ln(E(-1))	0.8891	0.0000	0.8949	0.1703	0.0000	0.0000
ln(Y(-1))	0.0000	0.6972	0.0235	0.7017	0.0000	0.0000
Intercept						
NSW	0.8811	-0.5223	0.8691	-0.3569	9.1716	4.0416
VIC	0.8376	-0.4714	0.8271	-0.3140	8.7498	3.9445
QLD	0.8563	-0.4963	0.8450	-0.3354	8.9268	3.9738
SA	0.7576	-0.3697	0.7500	-0.2269	7.9840	3.7990
WA	0.7662	-0.3298	0.7600	-0.1851	8.1292	4.0221
TAS	0.7484	-0.4838	0.7368	-0.3436	7.7400	3.2686
NT	0.6205	-0.8099	0.5971	-0.6962	5.9129	1.0428

Coefficient of Determination and Durban-Watson stat for Structural Forms

	R-squared		**DW**	
State Equation	ln(E)	ln(Y)	ln(E)	ln(Y)
NSW	0.9624	0.9919	1.9490	0.4557
VIC	0.9751	0.9803	1.7405	1.0026
QLD	0.9794	0.9901	2.3038	1.1200
SA	0.9709	0.9618	1.8628	2.2347
WA	0.9605	0.9852	1.1944	2.6918
TAS	0.8919	0.8683	1.7998	1.8877
NT	0.9654	0.9713	1.3565	2.0761

Table 4.9 Major Elasticities of the Australian Economy

		endogenous variables		exogenous variables			
		electricity demand	real GSP	Electricity price	reform dummy	capital	labour
electricity demand	impulse	1.0000	0.0336	-0.0336	0.0162	0.0000	0.0000
	short-term	1.0000	0.0000	-0.0339	0.0163	0.0034	0.0037
	long-term	1.0000	0.0000	-0.3749	0.1809	0.1225	0.1336
real GSP	impulse	0.1904	1.0000	0.0000	0.0000	0.0992	0.1082
	short-term	0.0000	1.0000	-0.0064	0.0031	0.0998	0.1089
	long-term	0.0000	1.0000	-0.2357	0.1138	0.4047	0.4413

* The relationship between the Primary Energy and Electricity Demand is known as energy balance identity. This research shows that, on average, every 1% increase in Electricity Demand requires a 66.4% increase in the Primary Energy Supply (see Appendix 4.4 and 4.5).

One of the features of this model is that it captures the dynamic impacts of a change in an exogenous variable (for example, electricity price) on electricity demand and real GSP through impulse, short- and long-term elasticity measures. For example, the estimated impulse-, short- and long-term price elasticity of electricity demand are equal to -3.36%, -3.39%, and -37.5%, respectively (see Table 4.9). Real GSP is not directly a function of electricity price, while it is affected by electricity price variables through electricity demand in the short- and long-term. The impulse effect (that is, immediate effect within a year) of a 1% increase in electricity prices has no impact on economic growth. In the short-term, when the simultaneity of electricity demand and real GSP is adjusted through the economy (within about a few years), a 1% increase in electricity price will reduce the real GSP by only about 0.64%. In the long-term, when a full adjustment is made through the economy, a 1% increase in the electricity price will reduce the real GSP by about 23.6%. In this particular case, the model suggests that approximately 58% of full adjustments are made within the first five years.

The model also provides a similar elasticity analysis regarding the change in capital stock, labour force, and primary energy supply (see Table 4.9). It is interesting to note that the Australian economy is more responsive to changes in the labour force (or unemployment) than capital stock, all in impulse, short- and long-term. Figure 4.9 shows the responsiveness of real GDP to labour force (unemployment), in the period 1978–2002. In this Figure, inflation rate, unemployment, and annual GDP growth are shown. Any sharp reduction in the labour force (increase in the unemployment rate) causes immediate negative economic growth and any increase in this variable (decrease in the unemployment rate) causes positive economic growth. For example, such situations can be observed in the stagflation period of the early 1980s, which caused the recession of the year 1983 (see Figure 4.9), and also in the recessions of 1991–2. In these recessionary cases, one can observe how a sharp increase of unemployment has caused an intense decrease in economic growth. Further, the Figure shows that whenever unemployment rate has recovered, economic growth has also improved, unless a sharp inflation rate has neutralised this effect through reduction of demand (see, for example, 1987 and 2001). This inter-relationship between GSP and labour is well captured by this model.

The impact of market reform is measured by introducing an exogenous dummy variable (that is, the dummy variable for unbundling the structure of the electricity industry, $D\text{-}S_{i,t}$ – restructuring of the industry). The estimated parameter of this variable in the macro-model implies that one cannot reject the hypothesis of “no impacts from restructuring of the electricity industry" either in the short term or in the long term. In the short term, the result of the model suggests that about 0.31% of the actual growth in the real GSPs during the mid-1990s, has been most likely the result of changes associated with the dummy variable $D\text{-}S_{i,t}$ – the restructuring (see Table 4.9). The model further suggests that the longer term impact of such changes on real GSP growth, if other things remain constant, would be around 12%. It is, however, interesting to note that, with regard to the measured short-term macro-impacts of the reform, this research provides a more modest result than the results of the previous studies using alternative CGE models. The estimates from the previous CGE models ranged between +0.08% and +1.3% GDP growth per annum (see Table 4.2), compared with +0.31% GSP growth per annum from this research's model (see Table 4.9).

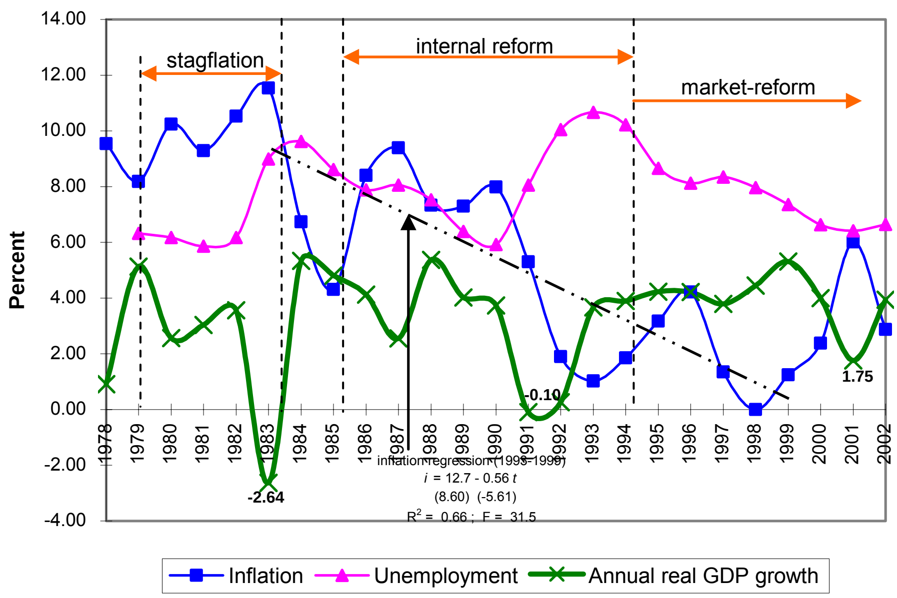


Figure 4.9 Inflation, Unemployment, and Annual GDP Growth (ABS 2004a, 2004c, 2004d)

However, one should notice that the estimated macro-economic gains measured by this research should not be totally attributed to the introduction of new electricity market as the exchange process in the electricity business, which is regarded – by the architects of the NEM – as the main component of market reform. The introduced dummy variable (that is, $D\text{-}S_{i,t}$), as mentioned earlier, mainly captures the restructuring characteristics of market reform rather than emphasising the change occurring in the exchange processes. This is essentially because, as noted in Section 4.5.1, much of the productivity gains at the sectoral level were due to restructuring boosted by recent technological achievements (that is, shifts in the PPF) rather than introducing a new electricity market or changes occurring in the ownership type. Therefore, the flow of micro- to macro-impacts was also largely reflected by such technological and restructuring impacts. This result sharply contrasts with what was argued by the proponents of market reform (IAC 1989a, 1989b; IC 1991, 1995; ICOIICPIA 1993).

Additional information about the Australian macro-economy further suggests that the rather impressive performance of the Australian economy during the 1990s was largely unrelated to changes in the performance of the electricity industry induced by creation of a national electricity market. During the 1980s and 1990s, much of the improved performance of the macro-economy was mainly related to the Australian Government's monetary policy, which successfully reduced inflationary pressures. As shown in Figure 4.9, a simple regression line for the inflation rate over time indicates that the inflation rate has reduced on average by 0.56% per year between 1983 and 1999.

This argument about the disconnection between overall economic performance and reform of the electricity market is further substantiated if one removes the effects of high unemployment caused by the economic depression of the early 1990s (occurring before the market reform), from the average economic growth rate in the time intervals of the internal and market reforms. This can be simply illustrated by averaging Australian economic growth in the three periods of 1978–1983 (stagflation), 1984–1994 (internal reform), and 1995–2002 (market reform) after excluding the recessionary years of 1983, 1991, and 2001 (highlighted in Figure 4.9). The normal averages of economic growth over these three periods indicate that the market reform period has the highest average growth rate, at 4%, compared with the stagflation and internal reform periods – with 2.1% and 3.4%, respectively. However, after the exclusion of the recessionary years, the result of the averaged economic growth for the stagflation, internal-reform, and market-reform periods would be 3%, 4.2%, and 4.2%, respectively. This proves that there has been no difference between the internal-reform and market-reform periods in terms of overall economic performance. This is particularly interesting because it is clear that unemployment in the early 1990s – largely caused by sectoral improvements in (labour) productivity (due to industry-based redundancy programs) in major industries (including the electricity industry) – was not going to be immediately improved (see Figure 4.9). This was the argument that was firstly raised by Quiggin (1996; 1997) and was not captured by the CGE models in the previous studies.

Further analysis of the fiscal and monetary policies of the 1980s and 1990s would better corroborate the disconnection between impressive overall economic performance and the electricity market reform. Governments of modern economies are well-used to employing these kinds of macroeconomic policies, which are the legacy of Keynes (1936) after the Second War Two. As discussed in Chapter 2, these kinds of Keynesian policies were intensely challenged by neoclassical economists in the 1970s and 1980s as being too excessive regarding governmental interventions in the economy. Keynesian economists during the 1970s and early 1980s were also overwhelmed by unknown problems, for which there were no solutions – particularly the problem associated with stagflation. In addition, the whole idea of market reform was supported on the grounds that excessive governmental interventions are unnecessary and had caused poor economic performance. Therefore, it is very interesting when one finds out that much of the impressive economic performance over the 1990s, is not only because of the creation of a new market structure (e.g. mandatory electricity pool), but largely because of successful Keynesian policy-making.

It is not surprising if politicians attribute overall economic gains to some unrelated cause, performance of NEM, for example. What is important from the political point of view is a success, especially in the economic arena. However, from the point of view of academic analysts and economists (neoclassical and non-neoclassical), it is important to appropriately distinguish real causes and effects, which has been the subject matter of this chapter. In fact, the newly created national electricity market, due to several reasons, has been recognised as not being an efficient market. The results of the energy market review by COAG (2002) confirms this fact (see also Sharma 2004a, 2004c). Therefore, according to the problem-solving framework of this thesis, it is more convincing to attribute the impressive economic performance to successful fiscal and monetary policies, rather than crediting it to the newly created electricity market. The economy has performed well simply because there has been a rich stock of knowledge (largely the legacy of Keynes) for confronting various recessionary and inflationary problems at the macro-economic level. The Australian federal and state treasuries are certainly well specialised and equipped to deal with these problems and employ the relevant policy solutions. With regard to the newly emerged problems in energy (electricity and gas) markets, endeavours to address these problems are in process. More analysis of these issues will be undertaken in Chapter 5.

4.6 Conclusions

The main objectives of this chapter were to assess the impacts of electricity reform on the productivity of the Australian electricity industry (micro-impacts) and wider economy (macro-impacts). The major findings are as follow:

Micro-impacts

- The **labour productivity** of the electricity industry (at national and state levels) has shown a significant improvement as a result of industry restructuring and privatisation. For example, overall mean of labour productivity for state electricity industries with vertically integrated structure, over the period 1955–2002, was 1.3 GWh/person. This measure for state industries with functionally unbundled structure (reformed) was 4.6 GWh/person. Care should however be exercised in interpreting these results because of underlying data-related issues and changes in the structure of datasets, for example: lack of detailed data (unavailability of a reliable time-series for labour-force by industry's sub-sectors); lack of data for outsourced and contract workers; and impact on labour-force due to mergers and acquisitions in the electricity and gas industries.
- The **capital productivity**, overall, has shown significant improvements in terms of certain indicators, while in terms of other indicators, no improvement is evident, for example:

  i) The capital productivity of generation (as measured in terms of System Capacity Factor, System Load Factor, and Excess Capacity – three inter-related capital productivity indicators) appears to have improved slightly as a result of reform, specifically in terms of System Capacity Factor and Excess Capacity. These improvements appears to have resulted from industry restructuring and not privatisation. Moreover, much of these productivity gains have come from a reduction in excess generating capacity because the System Load Factor – an important indicator of capital productivity – does not appear to have been affected by industry restructuring or privatisation. This also shows that electricity reform has largely failed to trigger a demand-side response. Moreover, the reductions in excess capacities have caused increase in the risk of power failure.

ii) The capital productivity of transmission and distribution, as measured in terms of productivity of network length per customer, has shown some improvement as a result of industry restructuring. However, the productivity of network capacity – another indicator of capital productivity – shows no evidence of any appreciable improvement.

- The **energy efficiency** of thermal generation has shown some improvement, since the introduction of reform. Overall, mean of thermal efficiency for the vertical integrated electricity industries has improved from 29.5% (for the period 1955–2002) to 34.8% since the introduction of restructuring. This result should however be interpreted cautiously, because much of this efficiency improvements is due to autonomous technological improvements. Further, analysis shows that privatisation has had no impact on energy efficiency of thermal generation. The energy efficiency of transmission and distribution too has not shown any noticeable improvement as a result of industry restructuring and privatisation.

- The technological improvements in thermal generation (as noted above) have contributed to relatively small improvement in **environmental productivity** (as measured in terms of CO_2 emissions per unit of electricity generation) – 1 MWh/tonnes for vertically integrated utilities, to 1.1 MWh/tonnes for functionally unbundled industries. The analysis shows that privatisation has had no significant impact on environmental productivity.

- The **financial productivity** was measured in terms of average real cost of electricity, and real electricity prices for the residential and business sectors.

  i) Average **real cost** has declined significantly as a result of restructuring – from 11.6 cent/KWh for vertically integrated industries, to 6.5 cent/KWh for functionally unbundled industries. Due to the unavailability of data, one cannot comment on the impact of privatisation on real cost (in privatised environment, cost information is confidential).

ii) The **real electricity prices** for both residential and industry sectors have also shown a significant decrease as a result of industry restructuring. For example, real electricity price in businesses and industries have declined from 11.4 cent/KWh for vertically integrated industries to 6.3 cent/KWh for functionally unbundled industries. Industry privatisation, the analysis shows, had had no impact on real electricity prices. Like other results, these results too should be viewed with caution, because much of the declining trend in prices was evident prior to the introduction of electricity reforms. It would therefore be inappropriate to attribute price declines to solely to market reform (see Section 4.5.1 (e)).

iii) Analysis in this research suggests that there is a degree of coincidence between industry restructuring and technological improvements, for example, in information technology and telecommunication. This suggests that care needs to be exercised in attributing cost and price reductions solely to electricity reform. The reasons for declining costs and prices impacts could only be ascertained by separating out the effects of technological improvements from industry reform. This separation is made in this research by developing various Malmquist TFPs (see below for detailed results).

- This research also assessed the impact of industry restructuring and privatisation on various **efficiency** measures. Following points are the main findings:

i) **Pure technical efficiency** of the industry has significantly improved as a result of industry restructuring, from 0.926 to 0.998. This measure has also improved in thermal generation segment of the industry from 0.932 to 0.985. However, privatisation had not impact on pure technical efficiency.

ii) The **technical** and **cost efficiencies** in the industry have been numerically the same. The interpretation of this finding is interesting, especially if one views it in the context of the measurement-framework applied in this research, which used financial data directly as inputs/outputs and relaxed behavioural assumptions. This is in contrast with the conventional measurement-frameworks, which use financial data as unit costs/prices and regard industries as utility/profit optimizers – a behavioural assumption. This implies that what really forms the production possibility frontier (PPF) of the electricity industry is actually a technological constraint rather than financial constraint.

iii) The impact of reform on **clean-efficiency** of the industry has been insignificant. This result is consistent with what was stated above regarding environmental productivity. Further, due to lack of data, this research was not able to determine the impact of privatisation on clean-efficiency.

iv) The impact of reform (both restructuring and privatisation) on **cost efficiency** of thermal generation has been insignificant.

v) **Pure technical efficiency** of transmission and distribution has not been affected at all by restructuring or privatisation.

The above discussed results are summarised in Table 4.10.

The main points relating to the assessment of the impact of industry restructuring and privatisation on **TFP index and its decomposition** are noted below:

- Much of the productivity gains in the electricity industry have been achieved due to technological improvements – more specifically, investment made in the 1980s. The decomposition of changes in TFP index suggests that:
  - from the early-to-mid 1980s, the TFP of the electricity industry declined mainly as a result of inefficiencies that had occurred in that period (moving away from the PPF);
  - from the mid-1980s to early-1990s (the internal reforms period), the TFP of the industry improved significantly, both as a result of efficiency improvement (moving towards the PPF) and technological improvements (outward shifts in PPF); and
  - since the early-1990s, the technical efficiency of the industry has remained almost constant. This shows that market reform of the 1990s did not result in any improvement in technical efficiency.

Table 4.10 Impacts of Electricity Reform on Industry Productivity

	Impacts	
	Restructuring	*Privatisation*
Partial-Index Models: Partial Factor Productivities		
Labour		
Labour productivity in whole ESI	high	high
Capital		
System Capacity Factor	high	low
System Load Factor	insignificant	insignificant
Excess Capacity	high	insignificant
Productivity of Network Length	high	insignificant
Productivity of Network Capacity	insignificant	insignificant
Fuel/Energy		
Thermal efficiency of generation	high	insignificant
Thermal efficiency of T&D	insignificant	insignificant
Environment		
CO_2 emmission of thermal generation	low	insignificant
Percentage of Hydro-Capacity	insignificant	insignificant
Financial		
Average cost	high	na
Average residential price	high	insignificant
Average business price	high	insignificant
Overal-Index Models: Efficiency Measures		
Model 1		
Pure technical efficiency (entire industry)	high	insignificant
Model 2		
Cost efficiency (entire industry) [in this analysis is equal to technical efficiency]	insignificant	na
Model 3		
Clean technocal efficiency (entire industry)	insignificant	na
Model 4		
Pure technical efficiency (thermal generation)	high	insignificant
Model 5		
Cost efficiency (thermal generation)	insignificant	insignificant
Model 6		
Pure technical efficiency (transmission & distribution)	insignificant	insignificant

Note: (1) The terms, 'insignificant', 'low', and 'high' refer to the result of hypotheses testings designed by this research. The impacts are noted as 'insignificant', if $0.005 < \Pr(F) \leq 1$; 'low', if $0.001 < \Pr(F) \leq 0.005$; and 'high', if $0 < \Pr(F) \leq 0.001$; where $\Pr(F)$ is probability of F-statistic as indicated in Tables 4.6 and 4.7.
(2) 'na' denotes 'not applicable' test.
(3) Models 1 to 6 differ from one another in terms of input-output configuration and levels of aggregation (for details, see Table 4.5).

Macro-impacts

- Analysis suggests that electricity reform has had a modest macro-impact, approximately 0.31% increase in GDP in the 1990s. Even these modest impacts should be viewed with caution due to the domination by technological improvements in the assessments of micro-to-macro flow-on impacts; low inflation prevailing in the 1990s, brought about by appropriate monetary policies; and the sensitivity of Australian economy to unemployment.

In summary, this chapter concludes that the Australian economy has performed well, not just because of electricity market re-structuring, but because it holds a rich stock of knowledge (largely the legacy of Keynes) for confronting various recessionary and inflationary problems at the macro-economic level. This conclusion empirically validates the theoretical contention of Chapter 3, namely, electricity reform is an institutional phenomenon, underpinned by ever evolving human knowledge.

5 ELECTRICITY REFORM: SOME CONTEMPORARY CHALLENGES

5.1 Introduction

The analyses in the previous chapters were entirely *ex-post*, focusing on key aspects of the Australian electricity industry, namely its evolution, nature of reforms, and the impacts of reforms on the productivity of the electricity industry and the wider economy. This chapter demonstrates how insights gained from such analysis could be usefully employed to develop *ex-ante* policy guidance for addressing present and future challenges, and hence for improving the efficacy of the electricity reform program.

Section 5.2 provides an overview of the nature of contemporary challenges that have emerged in the course of the implementation of market reform. Section 5.3 discusses how these challenges are currently being addressed by the Australian policy makers. Section 5.4 presents an alternative approach for addressing these challenges. Section 5.5 provides a summary of the main findings of this chapter.

5.2 Nature of Contemporary Challenges

Market reform changed almost every organisational and institutional facet of the Australian electricity industry. The main organisational changes included: unbundling of the vertically integrated industry into generation, transmission, distribution, and retail functions; horizontal separation of generation and retail functions; and re-organisation of transmission and distribution functions. The institutional changes included: formation of a new regulatory framework; establishment of the National Electricity Code (NEC); replacement of the traditional order-of-merit dispatch with a mandatory bid-based dispatch system; provision of more choice for consumers; introduction of third-party access to monopoly networks; and privatisation. With the exception of full privatisation most of these changes have been completed.

During the course of implementing these changes, several challenges emerged. These challenges have been discussed by various commentators, with different emphases. Quiggin (2001), for instance, discussed these challenges in terms of five components of market reform: (i) national grid and national market, (ii) corporatisation, (iii) competitive restructuring, (iv) regulation, and (v) privatisation. Quiggin argues that some of the challenges, such as price gaps between industrial and household customers, have faded away as the market has matured. Other challenges relating to organisational structure and the degree of horizontal and vertical integration will be resolved by a mixture of market processes and regulatory interventions. Quiggin also argues that some of the challenges have proven to be acute and are less likely to be addressed under the free-market institutional environment. These challenges, according to Quiggin, include:

- market power,
- price spikes,
- inadequate investments,
- regulatory issues in monopoly networks, and
- environmental aspects.

Sharma (2003b) argues that electricity reform is a multidimensional issue. The various dimensions of reform include technical, environmental, economic, social, and political. ‘Each dimension represents a specific aspect of the overall objective of the electricity industry. Collectively they symbolise the *raison d'état* of the electricity industry. An industry paraphernalia (structure, ownership, planning philosophy, rules – for simplicity, let us just call it structure) is a means to achieve the overall objective of the electricity industry in the best possible manner’ (ibid). Sharma argues that ‘the ongoing debate on electricity reform is being conducted exclusively in the economic realm, which, for practical reasons, has been further relegated to the economic indicator price’. According to Sharma, many challenges have emerged due to this narrow approach to reform.

In his other works, Sharma (2001; 2002; 2003a; 2003c) elaborates further on various challenges that have emerged as a result of such narrow approach. Sharma (2002), for example, argues that ‘the Australian regulatory framework is complex. There is a multiplicity of institutional involvement and jurisdictional contrasts. This has contributed to regulatory unaccountability, overlap, ambiguity, and inconsistency’. Sharma (2004a) classifies some challenges as ‘structural’ (for example, demand-supply response mismatch, price volatility, the trend towards vertical re-integration), ‘regulatory’ (unaccountability, overlap, ambiguity and inconsistency), and ‘other’ (employment, equity, consumer interests, environment, technical, service quality, research and development). Sharma (ibid) differs with the viewpoint often expressed in contemporary debate that ‘current regulatory challenges are due to unnecessary interference by the government and state politics’ and argues that the addressal of emerging challenges would require appreciation of the vital role of politics in open societies. Sharma hence recommends the development of a governance framework that accommodates diverse interests in a balanced manner. This approach seems to suggest a political economy approach for addressing challenges associated with market reform.

Booth (2003), Beder (2003), and Spoehr (2003) are other commentators to have commentated on challenges that have emerged in the course of electricity market reform in Australia. A major impetus to the debate on this topic was provided by the findings of the COAG Review (COAG 2002). These challenges, according the COAG (2002), can be classified into six categories:

(i) governance and regulation (issues related to complexity, overlap, unaccountability, ambiguity and inconsistency of regulatory framework);
(ii) market mechanism (issues related to market power and price spikes) and structure (issues related to horizontal and vertical integration, mergers and acquisitions);
(iii) transmission (natural monopoly and its related regulatory and ownership issues);
(iv) investments and financial market (inadequate investments and lack of incentives for new investments);
(v) retail contestability and demand side management; and
(vi) environmental issues.

The foregoing discussion suggests that regulatory issues constitute the quintessence of the contemporary challenges faced by the industry. The discussion however fails to provide meaningful understanding about the true nature these regulatory issues. This understanding can be gained by viewing them in the context of strategic policy actions taken by the Australian governments and the industry to overcome the shortcomings of existing institutions embedded in the regulatory framework.

This viewpoint can be better appreciated if one views reform as an institutional phenomenon, as argued in Chapters 2 and 3. It was argued that electricity industry, as a socio-economic sub-system, is a specialised problem-solver. The organisational actions of the industry have two main dimensions: static and dynamic. In the static dimension, industry's actions are constrained by formal and informal institutions (social means). This implies that, under normal circumstances, industry's organisations respect 'conventions' (for example, technical standards such as 50 Hz frequency), follow 'moral rules' (for example, social values such as Australia's close cultural affinity with the UK and US and to the western democracy, in general), adopt 'social norms' (for example, broadly accepted market institutions such as order-of-merit exchange process in electricity industry), and obey 'formal laws' (for example, codes, rules and regulations).

The dynamic dimension of the industry's action is about the interplay between social means (institutions) and social ends (desire for change), with a view to form a better future. In the previous chapters, it was shown that in certain years there was significant interplay between such means and ends. This resulted in the decay of old institutions and emergence of new institutions. The sources and causes of such institutional change were described as being new *social problems* (or, as in Chapter 3, organisational problems). Social problems are embedded in every social activity because of ever-present individual and organisational conflicts, aggressions, or chaos rooted in problem-solving behaviour of individuals and organisations. In other words, social problems exist because solving someone's problem often creates problems for others. Therefore, social problems have a nature quite akin to what is referred to in literature as the *Hobbesian problem of social order*. The contemporary challenges in electricity industry, by that reasoning, resemble Hobbesian problem of social order. Extending this argument, one can say that institutions emerge because they provide solutions for social problems.

This institutional perspective can also be used to describe social problems (in other words, challenges) that have arisen as a result of the implementation of market reform and for deciding how these problems could be resolved. To do so, however, one should first appreciate how the Australian electricity industry, as a socio-economic sub-system, is structured in terms of organisations (players of the game) and institutions (rules of the game). Tables 5.1 and 5.2 provide a snapshot of the organisational and institutional structure of the Australian electricity industry in 2003–2004. The main organisations are classified in terms of their functions, namely, generation, transmission, distribution, retail, consumption, regulation, and governance. These organisations are expected to solve specific problems associated with their respective areas of responsibilities. Collectively, they are expected to satisfactorily achieve the overall objective of the electricity industry, namely, supplying electricity to enhance the social wellbeing of individual members of the society.

As noted in previous chapters, there are two types of organisations in the electricity industry. The first type of organisations (shown in Table 5.1) are those that directly deal with the marketable product (electricity and electricity services) through generation, transmission, distribution, and consumption. For example: ‘Macquarie Generation’ and ‘Loy Yang Power’ are electricity generation corporates in NSW and Victoria, respectively; ‘TransGrid’ and ‘ElectraNet’ are high-voltage transmitters in NSW and SA, respectively; ‘Aurora Energy’ and ‘ETSA Utilities’ are distribution entities in Tasmania and SA, respectively; and ‘Ferrier Hodgson Electricity’ and ‘Western Power Corporation’ are retailers in Queensland and WA, respectively. Finally, the end-users of electricity are also grouped by their types of demand (that is, residential, commercial, and industrial).

The second type of organisations are those that are responsible for enforcing the agreed rules of the game that would enable the first type of organisations (as noted above) to supply electricity to the consumers. The focus of these organisations is therefore on rule-making, governance and monitoring. These organisations (often called *regulatory organisations*) must however be viewed within their institutional contexts. These organisations and their associated institutional contexts are called, in this research, the *regulatory framework* of the electricity industry. Table 5.2 (A) presents the regulatory

Table 5.1§ Organisational Structure of the Australian Electricity Industry: A Snapshot – 2003–04

	Inter-connected States inside the National Electricity Market (NEM)															
State	**NSW&ACT**	Station		Corp.	**VIC**	Station		Corp.	**QLD**	Station		Corp.	**SA**	Station		Corp.
Function	Corporations	no.	Capacity	no.	Corporations	no.	Capacity	no.	Corporations	no.	Capacity	no.	Corporations	no.	Capacity	no.
Power Generation Corporations																
	Total	**77**	**35274**	**30**		**71**	**35120**	**31**		**66**	**27334**	**27**		**30**	**11922**	**19**
Intra-State Power Corporations*																
			(MW)				**(MW)**				**(MW)**				**(MW)**	
	Total	**38**	**16381**	**10**		**26**	**8504**	**15**		**45**	**11306**	**21**		**15**	**3617**	**9**
	BHP	1	61		AGL	1	150		Bundaberg Surger Cc	1	19		AGL	1	220	
	Country Energy	3	33		Alcoa	1	150		Comalco/NRG	1	1695		ATCO Power	1	180	
	Delta electricity	4	4240		Amcor Paper	1	55		CS Energy	11	2504		BHP	2	98	
	Energy Development	2	94		AXA	1	44		CS Energy/InterGen	1	840		International Power A	1	500	
	Eraring Energy	11	3132		BHP	1	32		CSR	3	123		NRG Flinders	2	700	
	Macquarie generation	3	4690		Duke Energy	1	80		Energy Developments	1	24		Origin Energy	2	180	
	Meridian Energy Aust	5	62		Ecogen Energy	2	978		Energy Equity	1	53		small generators (coll	1	60	
	National Power (US)	1	150		Edison Mission Energ	2	1300		Farleigh Mill	1	13		Synergen Energy(IPA	4	399	
	Sithe Energies	1	162		Energy Brix	1	170		InterGen/Normandy	1	852		TXU Torrens Island	1	1280	
	SMA Corporation	7	3756		Hazelwood Power	1	1600		Marian Mill	1	18					
					Loy Yang Power	1	2000		MIM	1	45					
					Meridian Energy Austi	4	428		Oakey Power Venture	1	282					
					Meridian Energy Austi	6	45		Origin Energy	3	396					
					Pacific Hydro	2	23		Pleystowe Mill	1	10					
					Yallourn Energy	1	1450		Queensland Alumina	1	25					
									Queensland Nickel	1	38					
									Racecourse Mill	1	14					
									Stanwell Corporation	7	1615					
									Sugar North	2	32					
									Tarong Energy	3	2365					
									Transfield holding	2	344					
Inter-State Power Corporations			**(MW)**				**(MW)**				**(MW)**				**(MW)**	
	VIC	15	8306	10	NSW (Inc. SMA)	21	16028	6	NSW (Inc. SMA)	21	16028	6	VIC	15	8306	10
	QLD	24	10588	10	SA	24	10588	10								
High-voltage Transmitters			**('000 Km)**				**('000 Km)**				**('000 Km)**				**('000 Km)**	
	Total		**298**	**2**			**155**	**2**			**198**	**2**			**83**	**2**
	TransGrid				SPI PowerNet				Powerlink				ElectraNet SA			
	TransEnergie				TransEnergie				TransEnergie				TransEnergie			
System Operator																
	NEMMCO			1	NEMMCO			1	NEMMCO			1	NEMMCO			1
Distributors			**('000 MVA)**				**('000 MVA)**				**('000 MVA)**				**('000 MVA)**	
	Total		**93**	**4**			**49**	**5**			**40**	**2**			**17**	**2**
	EnergyAustralia				AGL Electricity				ENERGEX				ETSA Utilities			
	Integral Energy				CitiPower								Powercor Australia			
No. Metropolitan				2				2				1				2
	Australian Inland Energy & Water				Powercor Australia				Ergon Energy							
	Country Energy				TXU											
					United Energy											
No. Regional				2				3				1				0
Retailers			**(TWh)**				**(TWh)**				**(TWh)**				**(TWh)**	
	Total		**63.3**	**17**			**39.0**	**12**			**39.5**	**15**			**11.2**	**10**
	ActewAGL				ActewAGL				ActewAGL				AGL*			
	AGL				AGL*				AGL				ActewAGL			
	Aurora Energy				Aurora Energy				Australian Energy Service				CitiPower			
	Australian Inland Energy & Water*				Australian Energy Service				Country Energy				Country Energy			
	Australian Energy Services				Country Energy				CS Energy				ENERGEX			
	Country Energy*				ENERGEX				ENERGEX*				NRGenerating			
	Delta Electricity				EnergyAustralia				EnergyAustralia				Origin Energy			
	ENERGEX				Ergon Energy				Ergon Energy*				Tarong Energy			
	EnergyAustralia*				Integral Energy				Ferrier Hodgson Electricity				TXU			
	Eraring Energy				Origin Energy*				Integral Energy				Yallourn Energy (AusPower)			
	Ergon Energy (VIC)				TXU*				Origin Energy							
	Ferrier Hodgson Electricity				Yallourn Energy (AusPower)				Stanwell Corporation							
	Integral Energy*								Tarong Energy Corporation							
	Jackgreen International								TXU							
	Origin Energy								Yallourn Energy (AusPower)							
	TXU															
	Yallourn Energy (Auspower)															
Consumers			**('000)**				**('000)**				**('000)**				**('000)**	
Residential			2661				1943				1488				657	
Commential and Industry			320				268				164				68	
Others			133				57				32				27	
	Total		**3114**				**2268**				**1684**				**752**	
Population (Millions)			**7.0**				**4.9**				**3.7**				**1.5**	

Notes: § Table continues on the next page.

* Owners of principal power stations and embedded power stations (for WA: Pilbara interconnected system and remote-area power stations; and NT: Stations of Independent Power Producers (IPPs)).

Source: (ESAA 2003a).

Table 5.1 Organisational Structure of the Australian Electricity Industry: A Snapshot (continued)

					No Inter-state Inter-connections							
State	**TAS**	Station		Corp.	**NT**	Station		Corp.	**WA**	Station		Corp.
Function	Corporations	no.	Capacity	no.	Corporations	no.	Capacity	no.	Corporations	no.	Capacity	no.
Power Generation Corporations												
		35	**2575**	**3**		**14**	**697**	**9**		**34**	**4947**	**14**
Intra-state Power Corporations*												
			(MW)				**(MW)**				**(MW)**	
		35	**2575**	**3**		**14**	**697**	**6**		**34**	**4947**	**14**
	Amcor Paper	2	16		BHP	1	16		AGL	1	14	
	BHP	1	10		Energy Development:	2	55		Alcoa	3	268	
	Hydro Tasmania	32	2550		Energy Equity	1	9		Anaconda Nickel	1	76	
					Meridian Energy Aust	1	35		Argyle Diamond	1	20	
					Nabalco	1	105		Duke Energy	2	288	
					Power and Water Co	8	478		Edison Mission Energ	1	116	
									Goldfields Power	1	105	
									Hamersley Iron	2	140	
									Pacific Hydro	1	30	
									Robe River Iron	1	105	
									Southern Cross Ener	4	168	
									Western Power Corp	14	3381	
									Woodside Petroleum	1	120	
									Worsley Alumina	1	117	
Inter-state Power Corporations			**(MW)**				**(MW)**				**(MW)**	
		0	0	0		0	0	0		0	0	0
High-voltage Transmitters			**('000 Km)**				**('000 Km)**				**('000 Km)**	
			29	**1**			**8**	**1**			**92**	**1**
	Transend				Power and Water Authority				Western Power Corporation			
System Operator												
	Transend			**1**	Power and Water Authority			**1**	Western Power Corporation			**1**
Distributors			**('000 MVA)**				**('000 MVA)**				**('000 MVA)**	
			8	**1**			**2**	**1**			**16**	**1**
	Aurora Energy				Power and Water Authority				Western Power Corporation			
No. Metropolitan				1				1				1
No. Regional				0				0				0
Retailers			**(TWh)**				**(TWh)**				**(TWh)**	
			9.5	**1**			**1.6**	**1**			**12.1**	**1**
	Aurora Energy				Power & Water Authority				Western Power Corporation			
Consumers			**('000)**				**('000)**				**('000)**	
Residential			208				56				736	
Commercial and Industry			28				11				92	
Others			13				7				0	
			249				**74**				**828**	
Population (Millions)			**0.5**				**0.2**				**1.9**	

Notes: * Owners of principal power stations and embedded power stations (for WA: Pilbara interconnected system and remote-area power stations; and NT: Stations of Independent Power Producers (IPPs)).

Source: (ESAA 2003a).

Table 5.2 (A) Australian Regulatory Framework: A Snapshot – 2003–04

	Inter-connected States inside the National Electricity Market (NEM)					No Inter-state Inter-connections	
Regulatory Function: Regulator / *Formal Institutions (Acts)* — **State**	**NSW&ACT**	**VIC**	**QLD**	**SA**	**TAS**	**NT**	**WA**
Generation: Wholesale Market (NEM/State-Market)							
Regulation, Legislation, & Licensing	ACCC & NECA *TPA / NEC*	ACCC & NECA *TPA / NEC*	ACCC & NECA *TPA / NEC*	ACCC & NECA *TPA / NEC*	ACCC & OTTER *ECA / ESIA / TEC*	NTPWA	-
Central Coordination & Pricing – System Operator (Pool/Dispatch)	NEMMCO *mandatory pool bidding*	NEMMCO *mandatory pool bidding*	NEMMCO *mandatory pool bidding*	NEMMCO *mandatory pool bidding*	Transend *order-of-merit*	PAWA *order-of-merit*	WPC *order-of-merit*
Pricing – franchised customers	IPART, RT, & ICRC *ESA / UA*	ESC *EIA*	QCA *QCAA / EA*	ESCOSA *EA / ESCA*	OTTER & GPOC *GPOA*	UC *UCA*	OOE *ECA*
Transmission and Distribution (Monopoly Network)							
Transmission Access/Pricing	ACCC *TPA / NEC*	ACCC *TPA / NEC*	ACCC *TPA / NEC*	ACCC *TPA / NEC / EPO*	ACCC *ESIA / TEC*	PAWA	WPC
Distribution Access	MEU, IPART, & ICRC *ESA / IPARTA / UA*	ESC *EIA*	OEOT *EA / ER*	ESCOSA *EA / ESCA*	OTTER *ESIA / TEC*	UC *ENA*	OOE *ECA*
Distribution Network Service Charges	IPART, RT, & ICRC *ESA / UA*	ESC *EIA*	QCA *QCAA / EA*	ST & ESC-SA *EA / ESCA*	OTTER & GPOC *GPCA*	UC *UCA*	OOE *ECA*
Distribution Licensing & Compliance	MEU, IPART, & ICRC *ESA / IPARTA / UA*	ORG *EIA*	OOE-QT *EA / ER*	ESCOSA *EA / ESCA*	OTTER *ESIA*	UC *UCA*	-
Retail Business (Retail Market)							
Retail Licensing & Compliance	NEU, IPART, & ICRC *ESA / UA*	ESC *EIA*	OOE-QT *EA / ER*	ESCOSA *EA / ESCA*	OTTER *ESIA*	UC *UCA*	-
Customer Protection	EWON, CO, & DUS *ESA*	EIOV *EIA*	ACA & QOFT *EA*	EIOS	TEO *EOA*	-	-
Other Functions							
Safety	MEU, DUS *ESA/ UA*	OCEI & WA *E-SA / OH&SA*	ESO *E-SA*	OTTER *EA*	OEP&C *EIS&AA*	DI&B *WHA*	OOE *EA*
Environment Protection	EPA-NSW, IPART, GHGEC, & EMA *EP-A / ESA*	EPA-VIC *EP-A*	EPA-QLD & DE&H *EP-A*	EPA-SA & DE&H *APA*	DELM	- *EAA / WMCA*	-

Note: Regulatory organisations and their corresponding institutions are shown by acronyms. Institutions are in italics. Table 5.2 (B) describes these acronyms.
Source: (ESAA 2003a; Sharma 2002)

Table 5.2 (B) Australian Regulatory Framework: Acronyms Used in Part (A)

No.	Acronym	**Organisations** (Regulators)	No.	*Acronym*	**Institutions:** (Legislations – Acts)
1	ACA	Australian Consumer Association	1	*AP-A*	*Environmental Protection Act*
2	ACCC	Australian Competition and Consumer Commission	2	*EA*	*Electricity Act*
3	AEMC	Australian Energy Market Commission	3	*EAA*	*Environment Assessment Act*
4	AER	Australian Energy Regulator	4	*ECA*	*Electricity Corporation Act*
5	CO	Commonwealth Ombudsman	5	*EIA*	*Electricity Industry Act*
6	DE&H	Department of Environment and Heritage	6	*EIS&AA*	*Electricity Industry Safety and Administration Act*
7	DELM	Department of Environment and Land Management	7	*ENA*	*Electricity Network Act*
8	DI&B	Department of Industry and Business	8	*EOA*	*Electricity Ombudsman Act*
9	DUS	Department of Urban Services	9	*EPO*	*Electricity Pricing Order*
10	EIOS	Electricity Industry Ombudsman SA	10	*ESA*	*Electricity Supply Act*
11	EIOV	Energy and Industry Ombudsman Victoria	11	*E-SA*	*Electricity-Safety Act*
12	EMA	Environment Management Authority	12	*ESCA*	*Essential Service Commission Act*
13	EPA-NSW	Environment Protection Authority of NSW	13	*ESIA*	*Electricity Supply Industry Act*
14	EPA-QLD	Environment Protection Authority of QLD	14	*GPCA*	*Government Prices Commission Act*
15	EPA-SA	Environment Protection Authority of SA	15	*IPARTA*	*Independent Pricing and Regulatory Tribunal Act*
16	EPA-VIC	Environment Protection Authority of VIC	16	*NEC*	*National Electricity Code*
17	ESC	Essential Service Commission	17	*NEL*	*National Electricity Law*
18	ESCOSA	Essential Service Commission of SA	18	*OH&SA*	*Occupational, Health and Safety Act*
19	ESO	Essential Service Office	19	*QCAA*	*Queensland Competition Authority Act*
20	EWON	Energy and Water Ombudsman of NSW	20	*TEC*	*Tasmanian Electricity Code*
21	GHGEC	Greenhouse Gas Emmission Control	21	*TPA*	*Trade Practice Act*
22	GPOC	Government Prices Oversight Commission	22	*UA*	*Utilities Act*
23	ICROC	Independent Competition and Regulatory Oversight Commission	23	*UCA*	*Utilities Commission Act*
24	IPART	Independent Pricing and Regulatory Tribunal	24	*WHA*	*Work Health Act*
25	MEU	Ministry of Energy and Utilities	25	*WMCA*	*Waste Management Control Act*
26	MEC	Miniaterial Council on Energy	26	-	*mandatory pool bidding*
27	NECA	National Electricity Code Administrator	27	-	*order-of-merit*
28	NEMMCO	National Electricity Market Management Company			
29	NTPWA	NT Power and Water Authority			
30	OCEI	Office of Chief Electrical Inspector			
31	OEOT	Office of Energy of Old Treasury			
32	OEP&C	Office of Energy Planning and Conservation			
33	OOE	Office of Energy (A portfolio office of Queensland Treasury)			
34	ORG	Office of Regulator General			
35	OTTER	Office of the Tasmanian Energy Regulator			
36	PAWA	Power and Water Authority			
37	QCA	Queensland Competition Authority			
38	QOFT	Queensland Office of Fair Trading			
39	RT	Regulatory Tribunal			
40	ST & ESC-SA	State Treasurer Essential Services Commission of SA (ESCOSA)			
41	TEO	Tasmanian Electricity Ombudsman			
42	Transend	Transend			
43	UC	Utilities Commission			
44	WA	Workcover Authority			
45	WPC	Western Power Corporation			

framework of the Australian electricity industry in 2003–2004. The most recent changes will be described in Section 5.3. The main institutions (indicated in italics) and their associated regulatory organisations (indicated by their acronyms) are presented in this table, classified by regulatory functions (in rows), namely generation (wholesale market), transmission and distribution (monopoly network), retail (retail market), safety and environmental protection. For example, the Trade Practice Act (TPA) and the National Electricity Code (NEC) represent the overarching formal institutions for electricity businesses in the NEM. As can be noted from Table 5.2, various organisational activities shown in Table 5.1 are constrained by TPA and NEC. The Australian Competition and Consumer Commission (ACCC) is the main regulatory organisation at the national level that ensures compliance with TPA and NEC.

One of the main features of market reform was the introduction of a new power exchange process (electricity market institution). As can be seen from Table 5.2, the main institutions for power exchange include either the traditional *order-of-merit* (as in Tasmania, Western Australia and Northern Territory) or the newly introduced *mandatory bid-based wholesale pool* (as in New South Wales, Australian Capital Territory, Victoria, Queensland, and South Australia). The corresponding third-party organisations responsible for the management of exchange processes and plant dispatch are the National Electricity Market Management Company (NEMMCO) in the NEM states, Transend in Tasmania[46], Power and the Water Authority (PAWA) in Northern Territory, and Western Power Corporation (WPC) in Western Australia (see Table 5.2). One should also note that there are several other formal and informal institutions that are not included in Table 5.2. For example, the Australian constitution is an important formal institution that overrides all these industry-specific institutions. The ideological underpinning of the market reform – through not indicated in Table 5.2 – is an important informal institution in this regulatory framework.

On the basis of this snapshot (shown in Tables 5.1 and 5.2), one can describe the contemporary challenges faced by the electricity industry as associated with the industry's organisations. Further, challenges, in the context of present discussion, refer to the extent by which the newly established regulatory framework has failed to reconcile the divergent interests, motivations and objectives. This failure will imply that federal and state governments are left with the task of providing such reconciliation, outside the market processes. This clearly opens the room for politics and hence often-heard criticism – regulatory problem are due to government interference. Clearly, this conundrum could be better understood through a *political economy* approach. Political processes are embedded in the Australian federal-state relationship. This relationship

[46] Tasmania has, effective May 2006, joined to the NEM through the HVDC transmission line.

therefore continually influences the formation and re-formation of corresponding industry organisations.

Economic processes, on the other hand, are related to the emergence of formal and informal market institutions. These processes could be used to gauge the performance of the above noted organisations. This performance would clearly be influenced by the efficiency of market institutions – as reflected in the corresponding transaction costs.

In Chapter 4, it was shown that much of the debates on market reform, in its early 1990s, were focused on economic processes – designing a competitive electricity market, assessing its economic performance, particularly in terms of impact on industry productivity and wider economy. As also noted in Chapter 4, most commentators on the market reform did not differentiate the contributions to such gains by internal reforms of the 1980s as compared with those made by market reforms of the 1990s. They therefore ascribed overall gains to market reform of the 1990s. Chapter 4 however empirically demonstrated this not to be true. It was demonstrated that much of the gains were the accumulative contribution of productivity improvements during the mid-to-late 1980s, that is, they precede market reform. As was also elaborated in Chapter 4, narrow methodologies (used by a number of the previous studies) contributed to such positive commentaries about the impacts of market reform on economic performance.

In this respect, Quiggin (2001) also observed that debates about electricity reform in Australia have been less critical than debates about similar reforms in the UK and USA. In the UK and USA, Quiggin argued, there were some substantial rises in electricity prices in some instances that made the problems of market reform absolutely undeniable. In Australia, it took longer time till to acknowledge the challenges faced by the Australian electricity industry. For example, Booth (2003) observed that ‘although always vigorously denied by politicians and bureaucrats, it was becoming harder and harder to deny’ (p. 247) several such challenges and, by 2002, talk about ‘there is a policy vacuum in Canberra’ (ibid.) became commonplace.

COAG Review (2002) acknowledged the prevalence of these challenges only when they became apparent through numerous submissions in the review process. Despite such acknowledgment, it appears that the approach recommended by the in the COAG Review has failed to adequately appreciate the true nature of these challenges (this aspect is discussed in the next section). As the analysis of this research suggests, a true appreciation of the nature of these challenges require a political economy approach.

5.3 Addressal of Challenges: Current Approaches

Corresponding to the above-noted challenges, the COAG Review provided the following recommendations:

(i) establishing a national regulatory framework to encompass federal, state and territory regulatory frameworks;

(ii) allowing the current mandatory bid-based pool market to perform as intended;

(iii) giving NEMMCO some responsibility to identify transmission capacity needs and introducing some explicit incentives that penalise/reward transmission entities according to their performance and NEM requirements;

(iv) moving towards the removal of price controls (that is, abolishing the Electricity Tariff Equalisation Fund in NSW and Benchmarking Pricing Agreement in Queensland) and enhancing NEMMCO's role to facilitate financial contracts;

(v) mandating the use of interval meters, removing retail price caps, introducing 'pay-as-bid' mechanism into NEMMCO's dispatch and market systems for demand reduction; and

(vi) introducing an environment-related institutional framework in co-ordination with market reform (for example, introducing economy-wide emission trading).

Ministerial Council on Energy (MCE), in recognition of these recommendations, released its own review in December 2003. This was endorsed by the COAG and led to a new agreement between the Australian governments. This agreement sought to create a truly national and efficient electricity market working under the discipline of new regulatory and governance arrangements (Sharma 2005). A new set of policy initiatives were launched by the Australian governments (DPMC 2004). Salient points of these policy initiatives include specific organisational changes for governance, rule making, and market regulation. These changes are as follows:

a) Ministerial Council on Energy (MCE), which was established in June 2001, became a single energy market governance organisation. The MCE directly reports to the COAG. Two principal objectives are defined for this organisation: (i) providing national oversight and coordination of policy development to address the opportunities and challenges facing Australia's energy sector into the future; and (ii) providing national leadership so that consideration of broader convergence issues and environmental impacts are effectively integrated into the energy sector decision-making (MCE 2003). Further, a national legislative framework is proposed to be developed by the MCE (ibid). This legislative framework, while not violating the Australian commonwealth and state constitutions, will create a new institutional environment for a fair inter-state competition (MCE 2001-05).

b) MCE (2003) recommended a new statutory authority – the Australian Energy Market Commission (AEMC) – to be established, with the responsibility for rule-making and market development, funded by an industry levy. The AEMC has now been established and has started its activities. It has assumed all rule-making and market devolvement functions of NECA and NEMMCO in respect to the national electricity wholesale market and transmission networks (Sharma 2005). It 'is generally not empowered to initiate any significant change to rules; instead it is responsible for managing the rule change process' (ibid). The AEMC has 'three commissioners, two of which including the chair will be appointed by the states. The state appointed commissioners (including chair) must have the support of at least six state MCE Ministers' (ibid). The AEMC is based in Sydney (ibid). The NECA, which previously held the responsibility of rule-making, has now been dissolved (see Table 5.3).

c) The MCE (2003) also recommended the establishment of another entity – the Australian Energy Regulator (AER). The AER, which has already started its activity, is responsible for economic regulations of the electricity market. Like the AEMC, the AER is funded by an industry levy. The AER is a constituent part of the

ACCC, but operates as a separate legal entity. In order to enhance the AEMC's and AER's organisational visibility and their organisational actions, they are located separately from ACCC. The AER is located in Melbourne. It has three members, two of which are appointed by the states and the third by the ACCC. One of these members chairs the AER (Sharma 2005).

d) 'The ACCC has retained responsibility for competition regulation, competition-related Code change authorisation, and industry access Code approval. NEMMCO continues to be responsible for day-to-day operation and administration of both the power system and electricity wholesale spot market in the NEM' (Sharma 2005).

e) The market rules, which are embodied in the NEC, are being remade as statutory rules under National Electricity Law (NEL). Therefore, NEC will turn into NEL (see Table 5.3). 'The new NEL will also embody the rule change process. Further, the decision of ACCC will be subject to merits review by the Australian Competition Tribunal but not of AEMC and AER; their decisions will be subject only to a jurisdictional review' (Sharma 2005).

The MCE has the authority to provide policy directions to AEMC with respect to rule-making or market reviews; approve arrangements for the funding of AEMC and AER; and recommend appointments of commissioners to AEMC and members of AER. It does not however engage in direct day-to-day activities of the NEM, AEMC, and AER (Sharma 2005).

These changes are shown in Table 5.3, which is a modified version of Table 5.2. The process of implementation of these changes is still in progress and is scheduled to be completed by 2006 (MCE 2003, p. 14). Organisational structure of the electricity industry in terms of (marketable) product-related organisations (listed in Table 5.1) has not changed significantly.

According to the problem-solving framework presented in this thesis, the ongoing changes are nothing but a part of *error-elimination* process, aimed at correcting the shortcomings of market reform and providing redress to the associated challenges.

Table 5.3 Australian Regulatory Framework: A Snapshot – 2006

State	Inter-connected States inside the National Electricity Market (NEM)					No Inter-state Inter-connections	
Regulatory Function: Regulator / *Formal Institutions (Acts)*	**NSW&ACT**	**VIC**	**QLD**	**SA**	**TAS**	**NT**	**WA**
Generation: Wholesale Market (NEM/State-Market)							
Regulation, Legislation, & Licensing	AEMC & AER (ACCC) *NEC → NEL* (TPA)*	AEMC & AER (ACCC) *NEC → NEL* (TPA)*	AEMC & AER (ACCC) *NEC → NEL* (TPA)*	AEMC & AER (ACCC) *NEC → NEL* (TPA)*	AEMC & AER (ACCC) *NEC → NEL* (TPA)*	NTPWA	-
Central Coordination & Pricing – System Operator (Pool/Dispatch)	NEMMCO *mandatory pool bidding*	NEMMCO *mandatory pool bidding*	NEMMCO *mandatory pool bidding*	NEMMCO *mandatory pool bidding*	NEMMCO *mandatory pool bidding*	PAWA *order-of-merit*	WPC *order-of-merit*
Pricing – franchised customers	IPART, RT, & ICRC *ESA / UA*	ESC *EIA*	QCA *QCAA / EA*	ESCOSA *EA / ESCA*	OTTER & GPOC *GPOA*	UC *UCA*	OOE *ECA*
Transmission and Distribution (Monopoly Network)							
Transmission Access/Pricing	AER (ACCC) *NEC → NEL (TPA)*	AER (ACCC) *NEC → NEL (TPA)*	AER (ACCC) *NEC → NEL (TPA)*	AER (ACCC) *NEC → NEL (TPA)*	AER (ACCC) *NEC → NEL (TPA)*	PAWA	WPC
Distribution Access	MEU, IPART, & ICRC *ESA / IPARTA / UA*	ESC *EIA*	OEOT *EA / ER*	ESCOSA *EA / ESCA*	OTTER *ESIA / TEC*	UC *ENA*	OOE *ECA*
Distribution Network Service Charges	IPART, RT, & ICRC *ESA / UA*	ESC *EIA*	QCA *QCAA / EA*	ST & ESC-SA *EA / ESCA*	OTTER & GPOC *GPCA*	UC *UCA*	OOE *ECA*
Distribution Licensing & Compliance	MEU, IPART, & ICRC *ESA / IPARTA / UA*	ORG *EIA*	OOE-QT *EA / ER*	ESCOSA *EA / ESCA*	OTTER *ESIA*	UC *UCA*	-
Retail Business (Retail Market)							
Retail Licensing & Compliance	NEU, IPART, & ICRC *ESA / UA*	ESC *EIA*	OOE-QT *EA / ER*	ESCOSA *EA / ESCA*	OTTER *ESIA*	UC *UCA*	-
Customer Protection	EWON, CO, & DUS *ESA*	EIOV *EIA*	ACA & QOFT *EA*	EIOS	TEO *EOA*	-	-
Other Functions							
Safety	MEU, DUS *ESA/ UA*	OCEI & WA *E-SA / OH&SA*	ESO *E-SA*	OTTER *EA*	OEP&C *EIS&AA*	DI&B *WHA*	OOE *EA*
Environment Protection	EPA-NSW, IPART, GHGEC, & EMA *EP-A / ESA*	EPA-VIC *EP-A*	EPA-QLD & DE&H *EP-A*	EPA-SA & DE&H *APA*	DELM	- *EAA / WMCA*	-

Source: Table 5.2; MCE (various); and Sharma (2005)
Note: Regulatory organisations and their corresponding institutions are shown by acronyms. Institutions are shown in italics. See Table 5.2 (B) for the list of Acronyms.
* NEC will turn into NEL

Error-elimination is a component of the dynamic two-stage process of 'tentative-solutions-and-error-eliminations', as discussed in Chapter 3. This point is important to be appreciated, because the essence of the idea behind reform (its social motivations and cognitions) has remained unchanged. The main idea has been that competitive markets will improve economic growth and social well-being of Australia.

The current approach is aimed to address existing challenges, particularly regulatory challenges. In other words, it is believed that these changes will address regulatory complexity, overlap, unaccountability, ambiguity and inconsistency. This approach, notwithstanding its somewhat increased emphasis on political processes, is still quintessentially neoclassical. It sees political processes embedded in economics, and hence recommends economic solutions (for example, financial incentives for states) to fix political problems. It fails to acknowledge that economics is embedded in politics, especially in dynamic actions of individuals and organisations. This approach is therefore unlikely to address the current challenges. Instead a political economy approach is recommended by this research.

5.4 A Political Economy Approach

The previous sections argued that current approach to address the challenges faced by the electricity industry is essentially neoclassical and hence inadequate. This research recommends a political economy approach to provide such redress. This section provides an outline of the key elements of such an approach.

5.4.1 Political Processes, Formal Institutions, and the Polity

Political processes are essentially related to *political markets* (markets for exchanging political power, knowledge, ideas, beliefs, or any other vital information). These processes influence the formation and reformation of shared 'mental models' at the societal level and lead to the emergence of new 'formal institutions' and their enforcement 'regulatory organisations'. These processes, can be understood in the context of Australian parliamentary democracy and associated federal-state politics. This would help to better appreciate the sources and causes of the current challenges faced by the Australian electricity industry, and hence ways to address them.

Australia is a federation of six states and two territories. The Australian federation, as a socio-economic system, is organised in the form of Westminster-style parliamentary democracy, with clear demarcation between rights and responsibilities of various components of the Australian federation (Sharma 2004b). The Australian federal system is characterised by extreme vertical fiscal imbalance, with the Commonwealth collecting nearly eighty per cent of tax revenues and responsible for only fifty per cent of outlays (Painter 1998, cited in Sharma 2005). This makes the states' budgets dependent on financial transfers from the Commonwealth. A large proportion of these financial transfers are in the form of various conditional, purpose-specific grants. Therefore, the federal-state relationship is adversarial (ibid). The fundamental structure of federal-state politics in Australia has been shaped by such financial interdependency.

As noted in Chapter 2, it was because of this federal-state politics that any national approach towards electricity industry was delayed in the past. This is in spite of the belief that prevailed even in the 1950s that a national approach would be economically beneficial for Australia. Such politics, together with the realisation, by the politicians, of the electoral appeal of electricity, resulted in the creation of vertically integrated, state-based, monopolistic electricity industries – with virtually no inter-state interaction. It was also under this institutional environment that electricity industries thrived until the inception of market reform in the early 1990s. Further, it was shown that the political backdrop for market reform also included a desire by the commonwealth government to persuade state governments to employ a series of policies that were outside the commonwealth's domain.

This institutional environment – not surprisingly – presented significant challenges for the policy-makers as they tried to develop and implement a national approach to electricity reform. A need for more coherent organisational cooperation between state and commonwealth governments was realised from the early stages of the implementation of market reform. However, the faith-like approach towards the market, and a special emphasis on economic processes (restructuring of the electricity market), caused lack of attention to be paid to political processes. It was expected that new market arrangements would ultimately resolve the underlying political challenges. This however did not happen. The outcome, as also pointed out by the COAG Review, was regulatory complexity – overlaps, unaccountability. The Ministerial Council on Energy (MCE) has therefore assumed responsibility for addressing this issue (see DPMC 2004; MCE 2003). The MCE's success in this mission would clearly depend on ensuring adequate inter-state cooperation consistent with the Australian constitution.

Therefore, the problem of governance and regulation is deeply rooted in the Australian federalism. In Chapter 2, it was discussed that the idea of inter-state competition – for attracting resource development – was challenged in the 1980s. The argument was that such inter-state competition might be against national interest because of states bidding down social returns simply for obtaining the benefits of economic development at state level (Stevenson & CRFFR 1976).

This was a major social issue associated with market reform of the 1990s, and it is responsible for many of the contemporary challenges faced by the electricity industry. Quite akin to Hobbesian problem of social order, this problem also implies that solving one state's problem may create problems for other states. This has also created the need for the intermediation by a third-party enforcement organisation that would promote national interests. This role has now been given to COAG and MCE. One may ask whether a change in the constitution might be necessary for resolving this problem. The immediate answer is no, because not all inter-state competition would be fierce. Competition in economic activities (that is, production, consumption, and distribution) will be useful for national prosperity. What Australian federalism requires is to move on to a new stage of fair competition that would promote national interests, rather than fierce competition for the sake of promoting individual states interests. As Booth notes: 'The "Warring Tribes" must not be allowed to win out over the national interest of Australia in the 21st century' (Booth 2003. p. 301).

In the pre-reform central statutory authorities, the vertically integrated electricity industry in most of the states was self-governed and self-regulated. Under this model, the governance, rule-making and market regulation were generally undertaken by a single organisational entity and this entity was directly accountable to the relevant state minister. This organisational structure was free from any significant transaction costs across its sub-organisations. As can be seen in Tables 5.1, 5.2 and 5.3, market reform has drastically changed this organisational structure. The reform has vertically and horizontally unbundled the functions of the organisational entities noted above. This has also required an unbundling of the governance, rule-making, and market regulation functions and hence it has resulted in the creation of several new and independent regulatory organisations. Consequently, the issue of 'transaction costs' has become paramount.

The above discussion suggests that under the Australian federalism, integration of state electricity industries and formation of a national statutory authority is almost impossible. As many commentators have also stated, the contemporary challenges relating to governance and regulation have been inevitable outcome of the national approach undertaken by the market planners (see, for example, Sharma 2004a). This has also increased the transaction costs of reform. For example, in current regulatory framework, ACCC has still retained its power for approving any change to NEL, implying that every change to NEL will be reviewed by ACCC, AEMC and AER. In order to resolve this issue, MCE has provisioned a Memorandum of Understanding (MoU) between these three organisations. The MoU will address consultation, cooperation, code-change authorisation and staffing arrangements. Despite the intent behind this MoU, high transaction costs will be inevitable in short term, as also pointed out by RELA (2003a; 2003b).

Against this backdrop, this research contends that a satisfactory redress for the emerging challenges could be achieved through a two-stage institutional change process. In the first stage, policy-making will occur through political processes. In the second stage, policy outcomes of the first-stage would be tested through economic processes, using the notions of 'transaction cost' and 'productivity'. In this way, both political and economic processes are taken into consideration in the process of shaping new institutions that would reconcile diverse interests. While political processes would largely guide the formation of new formal institutions and their third-party enforcement organisations, economic processes would continuously reveal the performance of such formal institutions and hence influence organisational performance.

This point contrasts with the view held by neoclassical economists. These economists consider no role for polity in the economy. While the formation of formal institutions is a necessary condition for resolving social problems, the formation of informal institutions is sufficient condition for such resolution. The success of this twin solution would depend on the extent to which a mutually beneficial outcomes is achieved that is acceptable to all (or most) of the players of the game. This would happen when emerged informal institution finds a wide acceptance among the players of the game. One of the most important such informal institution is the market institution for electricity industry, which will be discussed below.

5.4.2 Economic Processes, Informal Institution, and the Economy

Economic processes are *exchange processes* or *market institutions* (both formal and informal) in the economic markets (for example, markets for materials, labour, capital, goods and services). As discussed in Chapter 3, market institutions are shaped by political process. The viability of market institution depends on their broad acceptability by various economic interests. This acceptability, clearly, depends on their effectiveness in providing a reconciliation for various economic interests. A broadly accepted market institution is an informal institution, implying that compliance with market rules has no need for being monitored and enforced by any external enforcement organisation on a day-to-day basis. The viability of such an informal institution can be assessed in terms of its economic performance, as reflected in transaction costs and productivity.

The emergence of viable, informal, market institutions is vital for solving social problems and hence for resolving the contemporary challenges in the electricity industry. It is these institutions that would determine if the rules of the game are fair or not. Since the late nineteenth and early twentieth centuries, after Karl Mark's criticism of the shortcomings of capitalistic market economy, several attempts have been made to address the issue of 'how the spontaneous interaction of number of people, each possessing only bits of knowledge, brings about a state of affairs in which prices corresponds to costs etc.' (Hayek 1937, p. 189). After World War Two, although Keynesian ideas found broad political acceptance in the western countries, the intellectual debate was still underway about this issue. In this respect, one can refer to the debates between neoclassical viewpoints of Hayek (1937) and Marxian perspective of Lange (1964). The viewpoint of Schumpeter (Schumpeter 1950), who has not been classified in any particular school of thought, has also been notable.

Mantzavinos points out that there have been three approaches that take the issue of institutions and human knowledge into consideration 'more seriously and treat it in a theoretically more satisfactory way' (Mantzavinos 2001, p. 190). These three approaches, according to Mantzavinos (2001, pp. 188–226), include: (i) the *neo-Schumpeterian* approach that emphasises the evolution of human knowledge and stresses the role of novelty in economic processes (the role of creative entrepreneurs); (ii) the German *Wettbewerbstheorie* (theory of competition) – also inspired by Schumpeter – that focuses on the dynamics of the economy rather than the statics of equilibrium stated in the neoclassical economics; and (iii) the modern *Austrian economics* – inspired by Hayek – developed by Kirzner (1992) that also stress the dynamic character of activities in market places which systematically lead to an equilibrium. Mantzavinos, however, excludes developments made in the Marxian school of thought, in particular Lange's approach that consists of some strong institutional implications for the market. Lange (1964) recognises the important role of a particular market institution at industry level in a decentralised socialist economy, using a well-developed accounting system working under a central economic board.

In the Australian state electricity industries, as discussed in Chapter 2, prior to the implementation of market reform, a market model was in place that it is often described as being Keynesian. This market model was akin to the Langean market model. Prior to market reform, there was well-developed accounting system that allowed order-of-merit power exchange process (as a market institution) to work reasonably efficiently, under the guidance of a central authority. The current market reforms appear to have weakened the essence of this accounting system. Many of the privatised corporations have no longer any obligation to expose their financial data to any central authority. In fact, in unbundled and segregated industry, there is no central authority. This has caused asymmetry of information and, hence, weakened regulatory organisations. This has complicated the measurement of the X factor in the incentive-based regulation that has become a vital part of the newly established regulatory process. What has happened is that instead of standardising a new accounting system at the national level, market reform seems to have resulted in the decimation of the old state-based accounting system. This, this research contends, is a major reason for price volatility. As noted in Chapter 4, in pre-reform market institutions, electricity costs and prices were largely in balance and hence there was also no price volatility as such.

Investments were also more stable under the pre-reform rate-of-return regulation. The current incentive-based regulation seems to have endangered the flow of new investments, as also observed by many commentators. This is mainly because of the increased regulatory risk in current market arrangements. Risks in current market institution (that is, mandatory bid-based pool) are high, and this can be due to market power, strategic biddings or other exogenous factors (for example, terrorism, natural disaster, international oil shocks). Further, this risk is not limited to electricity markets and exists in all markets of this type (stock exchange markets). The specificity of electricity as a commodity, however, makes the situation even more volatile in the electricity markets.

As mentioned earlier, the COAG Review had refused to question the structure of the new electricity market. The emphasis is to 'make the current pool system perform as intended'. This is while similar models used in the UK and US have been modified in response to the shortcomings observed in their electricity markets. The Australian pool is now the only market of this kind in the world (Booth 2003). Although it is true that the Australian NEM has not experienced the situations observed in the UK or California, but there is no guarantee that such situations or incidents will not occur in Australia. The shortcomings of this market model therefore must be diagnosed and something should be done about it.

The foregoing discussion suggests that the COAG Review has failed to focus policy attention on informal institutions. As mentioned earlier, this is due to the ideological underpinnings of market reform. Further, such ideology transcends the political party divide. For example, in the early 1990s, both Labor and Liberal parties supported this ideology. It should also be noted here that market reform was initiated by the Labor governments, and the pace of the reform accelerated after the Liberal government came to power in 1996. It is also interesting to note that a similar situation has been observed in the UK, under Conservatives and Labor governments, and in the US, under the Republican and Democrat administrations.

In Chapter 2, it was argued that the fall of Soviet Union was seen by some as an endorsement of neoclassical economics and its contingent free-market principles. The events of the 1970s and 1980s also caused Keynesianism to be weakened. This also brought about political pressure on social democratic governments of Western Europe (for example, Scandinavian countries) and moderate decentralised socialist countries in Eastern Europe (for example, Yugoslavia and Czechoslovakia) to adopt free-market models, although some of these countries had already experienced good results from their own models which were developed on the basis of institutional realities prevalent in these countries.

Theories are abstractive frameworks that could be used to provide a logical explanation about the past and developing inferences about the future. Care however needs to be exercised while developing such inferences due to the variability of future and human actions. The political economy approach presented in this thesis provides a more realistic approach as compared with conventional (neoclassical) approach, for developing a fuller explanation for the past as well as for inferring the future. It is more realistic because it explicitly appreciates the roles of institutions in society. It acknowledges institutional differences between different countries and argues that there is no single all-encompassing policy remedy for all countries – an impression often given by the neoclassical approach.

In summary, a satisfactory redress for the challenges faced by the electricity industry, requires a balanced attention towards both political and economic processes. The current approach to electricity reform focus attention on economic processes only (market mechanisms). Other dimensions of reform, for example, social and environmental receive scant attention. Unless these dimensions of reform are satisfactorily addressed, the reform is unlikely to progress. And satisfactory addressal of these dimensions requires recourse to the interests balancing mechanism that is integral to political processes.

5.5 Conclusions

The major conclusions of this chapter are as follows:

- Several challenges have emerged as a result of implementing market reform in Australia. These challenges include: market power; price spikes; inadequate investments; regulatory complexity; employment, social equity, and environmental damage.

- A new set of policy initiatives have been undertaken in 2005 by the federal and state governments to address some of these challenges, in particular regulatory complexity. This approach, while an improvement over the approach to reform of the 1990s, is still limited in its ability to provide understanding about the true nature of challenges faced by the industry and guidance for addressing them.

- A *political economy* approach is recommended by this research for achieving these goals. This approach, it is argued, has the ability to provide satisfactory redress for issues that emerge due to the specificity of electricity and electricity systems, and state-federal tensions and conflicts. It also has the ability to satisfactorily reconcile various competing interests.

6 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

6.1 Conclusions

The major conclusions of this research, in summary, are as follows.

Rationale for Electricity Reform

- Human knowledge about electricity predates the inception of the electricity industry in the 1880s.
- Since its inception in the 1880s, the Australian electricity industry has undergone continuous and significant changes – in its structure, ownership, and regulatory arrangements. These changes have been more pronounced in certain time-periods as compared with others. For example, changes introduced in the mid-1990s. Such changes have come to be called – in the common parlance – electricity reform or simply, market reform.
- Electricity reform is an institutional phenomenon. Changes, over time, in culture, social beliefs, and economic ideologies, in national and global contexts, have significantly influenced the institutional settings of the Australian electricity industry.
- This institutional phenomenon arose from a continuous and complex interplay between the electricity industry's organisations and institutions over time. For example, vertical integration of the industry during the consolidation era (1945–1985) was associated with a particular social belief and economic ideology – Keynesianism. This ideology encouraged government ownership and regulation of strategic industries including electricity. The underlying argument was that if industry is under 'natural monopoly' condition and is 'increasing returns to scale', government intervention in economic activities is justified. This is while, the essence of Western capitalism opposed any large-scale governmental interventions in economic activities. Such arguments also affected the organisation of the

Australian electricity industry. However, once energy crises took place in the 1970s, foundations of Keynesianism started to be questioned by the proponents of neo-liberal ideology (also known as the 'market ideology'). The aim of this questioning was to remove the influence of Keynesianism, which had by then been prevalent for nearly four decades. This influence, of course, did not vanish. It is only that neo-liberal ideology has become more prevalent.

- The understanding of the causality of this institutional phenomenon has been gained in this research through a comprehensive review of the evolution of the Australian electricity industry. This review has described how organisational and institutional dynamism at a particular time was shaped by the dynamism of previous time period. It has also enabled the delineation of the influence of political, cultural, social and other factors on the shaping of various electricity organisations and institutions.
- The above reasoning about the nature of electricity reforms, while useful, was found – in this research – to be inadequate for fully explaining the true nature of electricity reform as an institutional phenomenon. It is so because it did not explain how electricity organisations and institutions were created in the first place, and how they evolved over time. This explanation would – this research contended – require an examination of the 'human behaviour', that is, how humans – through *motivation* and *cognition* – constantly create and recreate institutions and organisations. It is in this examination therefore resides a fuller understanding of why electricity reform has taken place in Australia, why it has a particular shape and size, why there is disparity between our expectations from reform and its actual outcomes, and what could be done to progress the current reform program.
- The examination of human nature (as hence real rationale for electricity reform) is carried out in this research by employing a 'problem-solving framework' in conjunction with the historical review (as noted above).
- This framework – using a 'political economy' approach, explained how individual behaviour and actions (guided by motivation and cognition) created various electricity organisations, and how these organisations influenced the evolution of institutions, and these institutions, in turn, influenced human behaviour. In short, how human-organisational-institutional dynamics influenced electricity reform. The political economy approach seeks understanding about the rationale for electricity

reforms through *political* and *economic* processes in the industry and society. In this approach, electricity industry is looked upon as a 'socio-economic sub-system' that learns through 'trial and error'. The industry accumulates a stock of electricity related human knowledge in various forms of shared 'mental models' as solutions for the problems experienced by the industry.

- This sets into motion an organisational learning process that prompts the emergence of new institutions through a chain of two-stage process of 'trial and error' or 'tentative-solution-and-error-elimination' using the faculty of human imagination and creativity. In this process, what is important is the effectiveness, workability, and acceptability of the emerged institutions for addressing the goals and needs of the industry and society. For example, in the early years, it was understood that free competition and private ownership are not good models for the organisational structure of the electricity industry. Public ownership and command-and-control promised a better solution. However, not every model for introducing public ownership and regulation was acceptable in the Western countries including Australia. Marxism was calling for similar change too. Keynesianism ultimately provided an economically workable and politically acceptable solution in Australia – just like many other Western countries. Therefore, while a 'tentative-solution' is constrained by some broader institutions in the society such as ideological beliefs, in 'error-elimination' (if appropriate solution has not emerged yet) indeed more alternatives solutions would be debated, even if they challenge institutions of higher hierarchy in society (for example, ideological beliefs). This also implies that the choice of reform-model would be free from rationalistic behaviour of human beings, but always constrained by some conventions, moral rules, social norms, and formal laws that carry elements of human rationalities.

- Changes in institutions may improve economic performance of organisations. This would largely depend upon the type of institutions which emerge and the stage of their diffusion. The historical review in this research showed that institutional changes have brought about an overall improvement in economic performance of the Australian electricity industry. For example, the establishment of standards (AC/DC, voltage, and frequency) as new social conventions during the early years and War and Depression years, and vertical-integration of industry during the consolidation era (1945–1985) brought about significant productivity improvements.

- However, this research also demonstrated that, one should not conclude that there is a one-to-one correspondence between institutional settings and performance of organisations. For example, while institutional settings of the Australian electricity industry remained almost unchanged during the 1980s (the so-called internal reform period), some organisational actions (namely, firmer command-and-control and better management) substantially improved the economic performance of the state electricity industries. In other words, in the long run (when institutions are well disseminated) improvements in economic performance can be associated with institutional changes. However, it is always organisational actions – through learning process – which are responsible for improvement in economic performance. Theoretical foundation of this research – in conceptually differentiating between 'organisations' and 'institutions' – played a significant role in raising, testing, and validating this contention.
- The emergence of formal institutions (formal laws, rules and regulations), especially in the early stages, may significantly increase the transaction costs and cause inefficiencies. This refers to early stages of reform, when direct intervention by regulatory organisations and government increases. Such transaction costs are not limited to economic markets and are often even more in political markets, where negotiations are ongoing to establish new formal rules and regulations. This has been observed in the early stage of reform of the Australian electricity industry in the past, until a time, when (due to wider acceptability) the established formal institutions started to work as informal institutions (conventions, moral rules, or social norms). The political and economic markets – for certain times – then start working with minimum transaction costs and hence minimum direct intervention by regulatory organisations and government. However, there are always a possibilities of market failure due to internal and external institutional factors. For example, during the oil shocks of the 1970s, the energy markets were distracted world-wide. In Australia, despite cheap coal, electricity industry got affected (increase in transaction costs in electricity market and other related political markets) in the early 1980s. Aluminium smelters moved to Australia with the hope of benefiting from

Australia's cheap electricity prices, while the industry faced imported inflation. As a result of that, a significant rise (for the first time) in the real electricity prices occurred. Failing to understand this fact, the industry was accused for being inefficient (whereas, the Australian electricity prices were still among the lowest in OECD).

- The emergence of informal institutions (for example, 'conventions' as for well disseminated technology and 'social norms' as for a well-accepted market structure) may improve economic performance of organisations because of lower transaction costs (compared to formal institutions) and provide a mutually beneficial environment, that is, an environment which is widely acceptable to various beneficiary organisations again due to its lower transaction costs. For example, a guiding principle of the electricity market for more than five decades was order-of-merit. This principle was working efficiently in the sense that electricity prices were as close as possible to the cost of electricity supply.
- Dynamic transformation of 'formal institutions' into 'informal institutions', this thesis contends, is possible through a chain of two-stage process of "tentative-solutions-and-error-elimination". This process, in the first stage works through political processes (negotiation, lobbying, rule making) and secondly get tested (verified) through economic processes (market exchange processes). This process continues over and over again, but there are certain periods in which a relatively efficient market emerges. Therefore, in contrast with the view of the advocates of market reform, this thesis argues that an appropriate electricity market structure (as an informal institution) only emerges through such a process, instead of being designed at once. This process often takes a long time. Apparently, according to historical evidence, the structure of electricity market in Australian state electricity industries prior to the current reform (except during the early 1980s, which the market was distorted by some external shocks) was very efficient.

Impacts of Electricity Reforms

This research argues that current approaches for assessing the impacts of electricity reform on the productivity of electricity industry (called *micro-impacts* in this research) and on wider economy (*macro-impacts*) are narrow. These approaches portray humans as ‘economic’ beings, motivated solely by their economic interests, namely cost minimisation and profit maximisation (human beings as *Homo oeconomicus*). Further, a society, in such approaches, is portrayed solely in terms of its ‘economic’ dimension, for example, gross domestic product and price levels. Such portrayals of human society are also reflected in the selection of various methodologies for assessing industry’s performance. The assessment of industry performance based on these methodologies, this research contends, reflects a limited (that is, economic only) aspect of industry performance, and ignores institutional aspects (interplay between ends and means of the industry). This therefore provides rather limited insights for developing policy measures that could be taken to improve industry performance. This also explains why there is significant disparity between expectations from electricity reform and its actual outcomes.

This research develops a more comprehensive approach for assessing industry performance, and for assessing the impact of electricity reforms on the performance of the electricity industry and the wider economy. The main findings are noted below.

Micro-impacts

- The **labour productivity** of the electricity industry has shown a significant improvement as a result of industry restructuring and privatisation. For example, the overall mean of labour productivity for state electricity industries with vertically integrated structure, over the period 1955–2002, was 1.3 GWh/person. This measure for state industries with functionally unbundled structure (reformed) was 4.6 GWh/person. Care should however be exercised in interpreting these results because of underlying data-related issues and changes in the structure of datasets, for example: lack of detailed data of a reliable time-series for labour-force by industry’s sub-sectors); lack of data for outsourced work and contract workers; and impact on labour-force of mergers and acquisitions in the electricity and gas industries.

- The **capital productivity**, overall, has shown significant improvements in terms of certain indicators, while in terms of other indicators, no improvement is evident, for example:

i) The capital productivity of generation (as measured in terms of System Capacity Factor, System Load Factor, and Excess Capacity – three inter-related capital productivity indicators) appears to have improved slightly as a result of reform, specifically in terms of System Capacity Factor and Excess Capacity. These improvements appears to have resulted from industry restructuring and not privatisation. Moreover, much of these productivity gains have come from a reduction in excess generating capacity because the System Load Factor – an important indicator of capital productivity – does not appear to have been affected by industry restructuring or privatisation. This also shows that electricity reform has largely failed to trigger a demand-side response. Moreover, the reductions in excess capacities have caused increase in the risk of power failure.

ii) The capital productivity of transmission and distribution, as measured in terms of productivity of network length per customer, has shown some improvement as a result of industry restructuring. However, the productivity of network capacity – another indicator of capital productivity – shows no evidence of any appreciable improvement.

- The **energy efficiency** of thermal generation has shown some improvement, since the introduction of reform. Overall, the mean of thermal efficiency for vertical integrated electricity industries has improved from 29.5% (for the period 1955–2002) to 34.8% since the introduction of restructuring. This result should however be interpreted cautiously because much of this efficiency improvement is due to autonomous technological improvements. Further, analysis shows that privatisation has had no impact on energy efficiency of thermal generation. The energy efficiency of transmission and distribution too has not shown any noticeable improvement as a result of industry restructuring and privatisation.

- The technological improvements in thermal generation (as noted above) have contributed to relatively small improvement in **environmental productivity** (as measured in terms of CO_2 emissions per unit of electricity generation) – 1 MWh/tonnes for vertically integrated utilities, to 1.1 MWh/tonnes for functionally unbundled industries. The analysis shows that privatisation has had no significant impact on environmental productivity.

- The **financial productivity** was measured in terms of average real cost of electricity, and real electricity prices for the residential and business sectors.

  i) Average **real cost** has declined significantly as a result of restructuring – from 11.6 cent/KWh for vertically integrated industries, to 6.5 cent/KWh for functionally unbundled industries. Due to the unavailability of data, one cannot comment on the impact of privatisation on real cost (in privatised environment, cost information is confidential).

  ii) The **real electricity prices** for both residential and industry sectors have also shown a significant decrease as a result of industry restructuring. For example, real electricity price in businesses and industries have declined from 11.4 cent/KWh for vertically integrated industries to 6.3 cent/KWh for functionally unbundled industries. Industry privatisation, the analysis shows, had had no impact on real electricity prices. Like other results, these results too should be viewed with caution, because much of the declining trend in prices was evident prior to the introduction of electricity reforms. It would therefore be inappropriate to attribute price declines to solely to market reform.

  iii) Analysis in this research suggests that there is a degree of coincidence between industry restructuring and technological improvements, for example, in information technology and telecommunication. This suggests that care needs to be exercised in attributing cost and price reductions solely to electricity reform. The reasons for declining costs and prices impacts could only be ascertained by separating out the effects of technological improvements from industry reform. This separation is made in this research by developing various Malmquist TFPs (see below for detailed results).

- This research also assessed the impact of industry restructuring and privatisation on various **efficiency** measures. Following points are the main findings:

i) **Pure technical efficiency** of the industry has significantly improved as a result of industry restructuring, from 0.926 to 0.998. This measure has also improved in the thermal generation segment of the industry from 0.932 to 0.985. However, privatisation had not impact on pure technical efficiency.

ii) The **technical** and **cost efficiencies** in the industry have been numerically the same. The interpretation of this finding is interesting, especially if one views it in the context of the measurement-framework applied in this research, which used financial data directly as inputs/outputs and relaxed behavioural assumptions. This is in contrast with the conventional measurement frameworks, which use financial data as unit costs/prices and regard industries as utility/profit optimizers – a behavioural assumption. This implies that what really forms the production possibility frontier (PPF) of the electricity industry is actually a technological constraint rather than financial constraint.

iii) The impact of reform on **clean-efficiency** of the industry has been insignificant. This result is consistent with what was stated above regarding environmental productivity. Further, due to lack of data, this research was not able to determine the impact of privatisation on clean-efficiency.

iv) The impact of reform (both restructuring and privatisation) on **cost efficiency** of thermal generation has been insignificant.

v) **Pure technical efficiency** of transmission and distribution has not been affected at all by restructuring or privatisation.

The main points relating to the assessment of the impact of industry restructuring and privatisation on **TFP index and its decomposition** are noted below:

- Much of the productivity gains in the electricity industry have been achieved due to autonomous technological improvements – more specifically, investment made in the 1980s. The decomposition of changes in TFP index suggests that:

    - from the early-to-mid 1980s, the TFP of the electricity industry declined mainly as a result of inefficiencies that had occurred in that period (moving away from the PPF);

- from the mid-1980s to early-1990s (the internal reforms period), the TFP of the industry improved significantly, both as a result of efficiency improvement (moving towards the PPF) and technological improvements (outward shifts in PPF); and
- since the early-1990s, the technical efficiency of the industry has remained almost constant. This shows that market reform of the 1990s did not result in any improvement in technical efficiency.

Macro-impacts

- Analysis suggests that electricity reform has had a modest macro-impact, approximately 0.31% increase in GDP in the 1990s. Even these modest impacts should be viewed with caution due to the domination by technological improvements in the assessments of micro-to-macro flow-on impacts; low inflation prevailing in the 1990s, brought about by appropriate monetary policies; and the sensitivity of the Australian economy to unemployment.

In summary, this chapter concludes that the Australian economy has performed well, not just because of electricity market re-structuring, but because it holds a rich stock of knowledge (largely the legacy of Keynes) for confronting various recessionary and inflationary problems at the macro-economic level. This conclusion empirically validates the theoretical contention of Chapter 3, namely, electricity reform is an institutional phenomenon, underpinned by ever evolving human knowledge.

Efficacy of Electricity Reform

This research shows that:

- Several challenges have emerged as a result of implementing market reform in Australia. These challenges include: market power; price spikes; inadequate investments; regulatory complexity; employment, social equity, and environmental damage.

- A new set of policy initiatives have been undertaken in 2005 by the federal and state governments to address some of these challenges, in particular regulatory complexity. This approach, while an improvement over the approach to reform of the 1990s, is still limited in its ability to provide understanding about the true nature of challenges faced by the industry and guidance for addressing them.

- A *political economy* approach is recommended by this research for achieving these goals. This approach, it is argued, has the ability to provide satisfactory redress for issues that emerge due to the specificity of electricity and electricity systems, and state-federal tensions and conflicts. It also has the ability to satisfactorily reconcile various competing interests.

6.2 Recommendations for Further Research

This research has emphasised the importance of institutional context of electricity reform in Australia. A historical review, viewed in a problem-solving framework that employed a political economy approach, was used for this purpose. This was the first application of its kind in the context of Australia. There is, this research argues, a considerable scope for further improvement in the application of the approach, for example, by deepening the historical review, associating various organisations actions to specific political developments, and analysing political and economic processes in terms of, respectively, 'formal' and 'informal' models of political economy. There is also a considerable scope for further improvement in the theoretical contention of this research. This, as mentioned in Chapter 3, requires a recourse to a broader class of analytical frameworks from social theory, organisational analysis and decision theory.

This approach could also be applied to make cross-country comparisons of electricity reform. This would demonstrate the importance of institutional context. It could also show why 'one-model-fits-all' is not an appropriate solution for all countries.

Improvement are also possible in specific methodological applications of this research. For example, the panel data for productivity analysis in Chapter 4 comprised of seven cross-sections. This allowed application of Data Envelop Analysis (DEA). However, it did not allow the use of more sophisticated productivity measuring approaches, such as, Stochastic Frontier Approach (SFA). This leaves significant area for further development of the productivity analysis. For example, for the generation segment of the industry, it would be more insightful to develop a more comprehensive panel data for all individual power plants across Australian states. Another avenue would be to develop international benchmarking (for example, across OECD countries). Yet another recommendation would be to develop a more comprehensive data-set for transmission and distribution segments of the industry.

APPENDIX 1.1: Individuals, Organisations and Institutions

If national economy[47] is defined as *socio-economic system*, electricity industry is a *socio-economic sub-system*. In this definition, a socio-economic sub-system, in general terms, is considered as a set of *organisations* in the economy that are specialised to collectively provide certain commodities/services, which meet certain social needs of *individuals* and organisations in the society. According to electricity industry, for example, various organisations such as power generators, transmission and distribution networks, system operators, industry regulators and others work collectively in order to provide electricity which meets certain social needs such as lighting, cooking, heating, cooling, and so on. The gas, oil, water, telecommunication, banking and insurance industries are also socio-economic sub-systems. Further, socio-economic systems reflects a systematic or habitual employment work of group of individuals with a habitual are influenced by and simultaneously reflect social means or *institutions* in a society.

As individuals, organisations, and institutions are used to define socio-economic sub-system, it will be useful to clarify the definition of these concepts. Having these definitions and conceptual notes is crucial for the consistency of the analysis of this thesis.

Individuals

The individuals are the smallest units of human society. They are members of households, firms, industries, communities, and societies. The individuals in the society are like atoms/cells in chemistry/biology (see Table 1). They are active human elements in the society. They are the ultimate players of the game in the society. The other two elements of the socio-economic sub-systems (that is, the organisations and institutions) are indeed two distinct social products of the interactions of the individuals with each other.

Each individual behaves in a unique way at every moment. The individual behaves differently at different times, even if s/he is under the same circumstances in terms of

[47] Every socio-economic system has its own peculiarity which makes it different from one country to another. For example, socio-economic system of the USA compared to China and so on.

the physical conditions and the available resources. In normal conditions, any change in the socio-economic sub-systems or in the society as a whole is a direct result of the individual's actions.[48] Therefore, knowing about individual behaviour – especially that of entrepreneurs and leaders – is of immense importance for analysing the evolution of the socio-economic sub-systems. In Section 3.3 the behaviour of individuals is analysed by undertaking an adequate account of their motivational and cognitive aspects.

Organisations

The organisations are corporate actors or collective units of societies, such as households, firms, unions, industries, and states. It is obvious that individuals are not isolated people like the eponymous hero of Daniel Defoe's novel, *Robinson Crusoe* (Defoe 2001). Every human activity or, more specifically, *production*, *distribution* and *exchange* is a social process, 'meaning that nobody can perform them – at least the two last named – by himself' (Schumpeter 1909). Hence, the individuals interact with each other. They form collective units (that is, the organisations) to cooperate towards certain ends that none of them can easily achieve in isolation. This is the intrinsic rationale behind the fact that human beings are a social species.

The organisations in society are like the molecules/organs in chemistry/biology (see Table 1) In this metaphorical analogy, one may also correspond larger societal systems of the society (at higher hierarchical levels) with larger components in chemical/biological systems. For example, the socio-economic sub-systems in society may correspond to a material/group-of-organs in chemistry/biology. Likewise, the whole of society (socio-economic system) may correspond to a composite-material/organism in chemistry/biology (see Table 1).

The organisations – just like the individuals – are the active human elements of the society. They are collective players of the game (analogous to teams) in the society. The behaviour of the organisation and individuals are constrained by certain social norms and rules – the institutions. Each organisation behaves in a unique way at every moment. Moreover, every organisation behaves differently at different times, even

[48] There are also changes which are due to non-human actions such as natural disasters.

though being under the same circumstances in terms of their physical conditions and the available resources. In Section 3.3 the behaviour of organisations is discussed alongside the behaviour of individuals.

Table 61 Analogy between Some Fundamental Elements of Systems in Four Different Disciplines

Economics/Sociology	Chemistry	Biology
Individual	Atom	Cell
Organisation	Molecule	Organ
Socio-economic Sub-system (Industry)	Material	Group-of-Organs
Socio-economic System (Economy/Society)	Composite-Material	Organism

Institutions

Institutions are social constraints. They ‘are rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction’ (North 1990, p. 3). Another definition for the institutions is that they are *shared mental models* that are the outcome of the acts of communication between individuals in the society (Denzau & North 1994). Unlike the individuals and organisation, which are directly observable elements as noted in Table 1, the institutions – while describable – are not directly observable. This is simply because what is observable is only the players of the game. The rules of the game are merely perceivable in the mind. The main concept behind the institutions is that ‘the whole socioeconomic process is structured and directed through the institutions prevailing at a certain time and place’ (Mantzavinos 2001, p. 65). In other words, with regard to Table 1, the institutions are the disciplines themselves, namely economics, sociology, chemistry and biology.

The institutions consist of two types: informal and formal institutions. The informal institutions include *conventions*, *moral rules*, and *social norms*. The formal institutions, on the other hand, include *constitutions*, *statutes*, *common laws*, and *regulations*. The difference between the informal and formal institutions essentially relates to their enforcement organisations which can be metaphorised to the *referees* in the game analogy. The informal institutions essentially do not need any third-party agency (or more precisely any *large* third-party agency) as their enforcement organisation. The function of the enforcement organisations is to make new institutions or monitor the compliance of the old institutions (that is, to watch how the institutions are obeyed or violated by individuals or organisations). The enforcement organisations for the informal institutions include 'self-policing' for conventions, 'first party' (that is, a person her/himself) for moral rules, and 'social forces' as a third party (such as respected/elected individual(s) in society) for social norms. The formal institutions, on the other hand, do need large third-party organisations as their enforcement organisations, such as the state (Mantzavinos 2001, p. 85) – or, according to Hobbes (1999), the *Leviathan*. Thus, among all kinds of institutions, formal institutions require large external enforcement organisations. Typical examples for such large external enforcement organisations would be the Catholic Church and the government.

The institutions – unlike the individuals and organisations – are passive human elements in the society. This implies that the emergence of institutions is the outcome of the human actions (by individuals/organisations) and that changes in the institutions do not occur as a result of institutions' will or their motivational or cognitive aspects, which they have none.[49] In Chapter 3 the process of emergence or decay of the institutions are discussed.

The above-described concepts are fundamental human elements of the socio-economic sub-systems (that is, the individuals, organisations, and institutions) continually interact with each other in a society over time. Figure 1 provides a snapshot of such mutual interactions.

Institutions and organisations are two closely related concepts and are sometimes used interchangeably. This issue creates theoretical problems for those analyses which use organisations and institutions as their fundamental elements for explaining the evolution. It is frequently observed that analysts refer to institutions, while they are

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[49] One should not associate the motivational and cognitive aspects of the enforcement organisations behind the formal institutions as the institutions' motivational and cognitive aspects. Such organisations (for example, the government), just like other organisations, posses their motivational and cognitive aspects, and may act on the basis of their interests or agenda driven by such aspects.

talking about organisations or vice versa. There is therefore an ambiguous terminological situation regarding the organisation and institution.

For instance, Davis, North, and Smorodin (1971), used the term ‘institutional environment’ for institutions and the term ‘institutional arrangement’ for organisations (cited in Khalil 1995). Further, Scott Masten’s distinction between two kinds of institutions, as Khalil (1995) pointed out, is another example for ‘awkward lexicon’ in this area. Masten distinguishes between the ‘broad sense’ versus the ‘narrow sense’ of institutions (cited in Khalil 1995). The former is used as conventions/contracts which underpin networks (that is, coalitions of independent transactors connected by commercial contracts) as well as organisations (that is, firms). The latter, on the other hand, is used to strictly denote organisations (ibid).

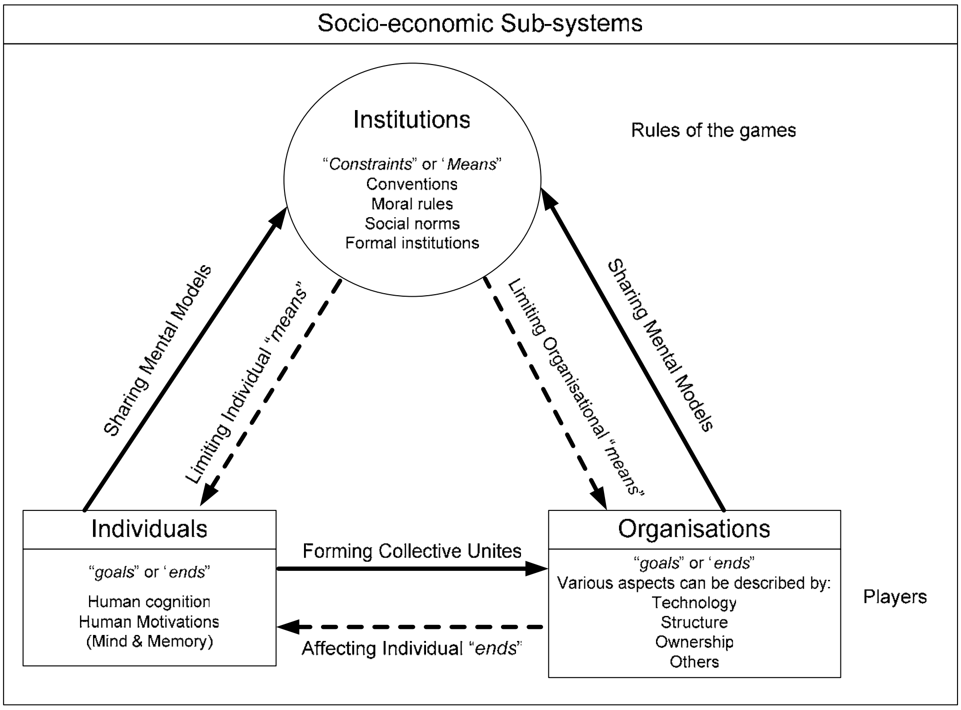

Figure 1 Interactions between Fundamental Human Elements of Socio-economic sub-systems

The terminological ambiguity often arises when one asks incorrect questions about institutions. For example, one such incorrect question would be ‘how does an institution function?’ In this case, if the researcher is not careful, the line of argumentation would lead to an erroneous explanation. This problem is known as *functional fallacy*, often seen in sociology (Mantzavinos 2001, p. 84). The functional fallacy shifts the emphasis of the analysis from the role of institutions to the role of organisations.

Therefore, there is a need to make a precise distinction between organisations and institutions. One of the serious attempts towards conceptual distinction between organisations and institutions was made by North (1990). North argues that 'Conceptually, what must be clearly differentiated are the rules from the players' (ibid, p. 4). Khalil (1995), however, criticises North's approach, not because of the definitions he provides for organisations and institutions, but because of North's failure in showing that 'the distinction between organisations and institutions entails that there is no one-to-one correspondence between the set of institutions and the performance of organisations. North's identification of the two – by attributing the performance of the organisation to its institutions – indicates that he failed to operationalize the organisation/institution distinction' (ibid, p. 446).

Khalil then argues that the difficulty of 'The organisation/institution distinction stems from the basic difference between ends and means. While ends define the organisation, means include – besides material and technological resources – paradigms and conventions or, in short, institutions' (ibid, p. 447). Hence, Khalil suggests that the 'rules' can be better differentiated from the 'players' if one can consistently differentiate ends from means. In other words, one should keep in mind that while the possibility of mutual interaction between ends and means over time are likely, a sharp distinction should be drawn between the ends and means in order to avoid any theoretical misconception. As mentioned in the introduction of this chapter, it is often argued that such distinction can be well attained under (Schumpeterian) methodological individualism (see, for example, Khalil 1995; Mantzavinos 2001). The extents of validation of this theoretical assertion will be empirically examined in this chapter, in the context of the Australian electricity reforms.

Therefore, to sum up, in this background it was argued that the electricity industry is an area of immense concern for key decision-makers in society. In the 1990s, a radical reform was undertaken in the Australian electricity industry. A national approach towards the industry has been initiated for the electricity industry. While there has been less doubt about economic gains of such a national approach, much of the debate has been left out through the economic and technocratic arena, insisting on the current reform-model under the premises of the NCP, while many institutional dimensions of such an approach have been ignored. In other words, much of the debate has been focused on the concept of market, competition and choice, with less attention given to their institutional underpinnings. In other words, this approach ignores the appreciation of the institutional nature of the reform phenomenon, and the human element that underpins decision-making problems. This is not helpful for the future of the electricity industry and for the prosperity of Australia as a nation. This thesis calls for a deeper institutional approach towards electricity reform in the context of Australia. Such an institutional approach should be able to consider the human element that underpins decision-making.

APPENDIX 1.2: Peculiarities of Electricity

Electricity as a commodity/service has some special characteristics and peculiarities that contribute to its importance in every economy. Whilst electricity is generated and controlled, it is one of the cleanest and most convenient forms of energy, with largest range of applications. Electricity has a significant influence on the quality of human life and is a symbol of modern life. *Electrification* is the first in the list of the top-20 greatest engineering achievements of the twentieth century (greatachievements.org 2005). None of the technological achievements of the 20th century, including aeroplanes, spacecraft, computers, and telecommunication can operate without electricity (Armstrong 2000).

The special physics of electricity makes electricity different from ordinary commodities/services. It is important to clarify this point that – despite the importance of economic factors (prices and costs) in the process of generation and supply of electricity – electricity, as *electrons* in the wires, essentially moves largely free from economic factors. Also, electric current in the wires does not follow demand-side willingness in favour of purchasing a particular source of electricity (for example, green electricity versus thermal electricity). In a physical sense, electricity flows in the wires on the basis of certain physical rules such as the *Ohm's Law* and *Kirchoff's Laws* (Slone 2000; LC 1998; THUOJ 2002).

Meanwhile, electricity is being demanded not for its own sake, but for providing specific final services such as mechanical movement, lighting, cooling, or heating and so on. For this reason, the electricity demand is usually called a *derived demand*. This implies that the demand of electric appliances, which produce those final services, dictate the electricity demand. In addition, electricity is not easily storable and therefore, as a product, can not be physically separated from its transportation, which is a service (see Hunt & Shuttleworth 1996). Thus, electricity requires a real-time supply for every unit of its demand. All these characteristics make electricity a special commodity.

Further, electricity as an industry has some special peculiarities. For long time, there was a general consensus among economists that the electricity industry is a natural monopoly and, hence, it was believed that the normal *market mechanism* is not applicable for electricity as a commodity. 'An industry is a natural monopoly if total costs of production are lower when a single firm produces the entire industry output than when any collective of two or more firms divide the total among themselves' (Newman 1998, p. 603). This implies a condition, which competitive market fails to operate and, hence, formation of a monopoly becomes a natural outcome of a unconditional competition (see Sharkey 1982). It is only in recent decades – after the emergence of what is called Distributed Generations – that this belief for the generation function of the industry has been changed, while the transmission and distribution functions are still being considered as natural monopolies (Hunt & Shuttleworth 1996).

Another peculiarity of the electricity industry is associated with environmental concerns of society. In the process of electricity generation, in most cases, electricity creates negative environmental externalities such as emission of greenhouse and other hazardous gases (for example, CO2, CO, NOx and SOx), particularly in fossil-based thermal electricity generation (IEA 1999). The aspect of negative externalities, however, is not limited to fossil-based electricity (generated by coal, oil, and gas). Even renewable-based electricity generation (green electricity) is not fully free from negative externalities. For example, although being free from the emission of greenhouse gases (that is CO2), large hydro-electric dams may cause negative impacts on the ecosystem and wild life. In the case of wind turbines, unpleasant noises and visual pollution are often considered as negative externalities of wind farms for their surrounding environment. The challenging problem in these respects is that under the current institutions (culture, regulations, and accounting systems), none of these externalities are well reflected in the cost functions of electricity generation. Therefore, social costs (for example, the costs people have to pay for medical treatment as a result of diseases caused by environmental pollution) are often neglected. This is the main reason behind the fact that many fossil-based thermal technologies are considered less costly as compared to many environmentally benign renewable technologies, while they are not necessarily so if one take social costs into account (see, for example, Fathollahzadeh 2000).

One should also keep this in mind that standardisations of voltages and synchronisation of frequencies in the electricity network are very crucial conditions for having a reliable electricity supply. Such standardisations – being technical conditions – are required to be in place as *social conventions*.

Special characteristics and peculiarities of electricity as a commodity/service have significantly contributed to the importance of electricity industry and its critical roles in modern economies. The more developed an economy is the more reliant that would be on its electricity industry. These peculiarities have always influenced the structure of the industry over time and have contributed a lot in the changes that have taken place in the industry.

APPENDIX 2.1: First Recorded Applications of Electricity in Australia

State	Event	Source
NSW	The first battery-operated electric arc light, which was installed at the Sydney Observatory in 1863 as part of the celebrations of the Prince of Wales' marriage.	(EANSW 1986, p. 1)
VIC	The first arc lights in Melbourne, which were powered by a series of fifty cell batteries, to celebrate the Duke of Edinburgh's visit in 1867.	(ETU 2004)
VIC	The first night-game of Australian football at Melbourne Cricket Ground under electric light, in 1879.	(Pyers 2001, p. 7)
SA	The first demonstration of electric light on Adelaide's streets in 1881.	(Linn 1996)
QLD	The first demonstration of electric light in Brisbane using eight arc lights, which were erected along Queen Street in 1882.	(Scholz Electrical Company 2004)
TAS	The first demonstration of electric light in Tasmania, which lit the windows of several Launceston shops, given by the Australian Light company of Melbourne, in 1883.	(Read 1986, p. 9)
QLD	The first Parliament House in Australia to have an electricity supply was Queensland Parliament in 1886.	(Scholz Electrical Company 2004)
NSW	The first electrified town (i.e. Tamworth) in New South Wales in 1888.	(EANSW 1986)
VIC	The first Australian electric tram in Melbourne in 1888.	(RailPage 2004, p. 1)
WA	The first electric streetlight in Perth, erected and illuminated by WA Electric Light and Power Co. in 1892.	(Western Power 2004)
VIC	The first city in Australia to operate a power station was Melbourne, where by 1894, most of the city's streets were lit with electricity; twenty General Electric Dynamos supplied 3000 volts DC to a network of lighting covering sixty miles of street cables.	(Integral Energy 2004, p. 2)& (ETU 2004)
TAS	The first hydro-electric power station in Australia began operating on South Esk River in Tasmania in 1895.	(Pyers 2001, p. 15)
NSW	The first public power station in Sydney was established at Ultimo by Department of Railways and it began generating power for traction purposes in 1899.	(EANSW 1986, p. 1)
WA	The first electric tramways in Perth, commenced tram operations along Hay Street from East Perth to Milligan Street in 1899.	(Public Transport Authority 2004)
NT	The first electric power application in Darwin for refrigeration purposes in 1912.	(Phelts 2004)

APPENDIX 4.1: List of Existing Studies on Impacts of Electricity Reform

1- Industry Association Commission (IAC 1989a; 1989b)
2- Industry Commission (IC 1991)
3- Bureau of Industry Economics (BIE 1992; 1994)
4- Electricity Supply Association of Australia (ESAA 1992; 1994)
5- ESAA (various years)
6- Lawrence, Swan and Zeitsch (1990; 1991)
7- Swan Consultants (1991; 1992)
8- Zeitsch, Lawrence and Salerian (1992)
9- Steering Committee on National Performance Monitoring of Government Trading Enterprises (SCNPMGTE 1992)
10- Zeitsch & Lawrence (1993)
11- London Economics (1993)
12- Orchison and Beardow (1993)
13- Price et al. (1992; 1992)
14- Pearson (1993)
15- Pierce, Price and Rose (1995)
16- Coelli (1998)
17- Independent Pricing and Regulatory Tribunal (IPART 1999)
18- Lawrence (1999)
19- Industry Commission (IC 1995)
20- Quiggin (1996; 1997)
21- PC (1999)
22- Whiteman (2000; 1999)
23- Short et al. (2001)
24- Short and Swan (2002)
25- South Australian Independent Industry Regulator (SAIIR 2002).

APPENDIX 4.2: Mathematical Specification of Micro-Impact Models

Two sets of models are developed in this thesis for micro-impact analysis. These include: (i) partial-index productivity models, and (ii) overall-index productivity models.

(i) Partial-index productivity models:

The general specification of the partial-index productivity model is as follows:

$$PFP_i = \frac{O}{I_i} \tag{1}$$

where, PFP_i is the partial factor productivity of firms; O is electricity output or any output-related variable of firms; I_i is input or any input-related variable of firms; $_i$ represents five factors of production, namely labour, capital, energy, environment, and financial. Table 4.4 in Chapter 4 presents various model configurations for this general specification.

(ii) Overall-index productivity models:

Following Coelli (1998) and for overall-index productivity models, the Malmquist (output-oriented) TFP index is defined as follows:

$$m_o(y_{t-1}, x_{t-1}; y_t, x_t) = \frac{d_o^t(y_t, x_t)}{d_o^{t-1}(y_{t-1}, x_{t-1})} \times \left[\frac{d_o^{t-1}(y_t, x_t)}{d_o^t(y_t, x_t)} \times \frac{d_o^{t-1}(y_{t-1}, x_{t-1})}{d_o^t(y_{t-1}, x_{t-1})} \right]^{1/2} \tag{2}$$

where, for example, $d_o^{t-1}(y_t, x_t)$ represents the distance of a representative firm at year t from the PPF at year t-1.

A value of m_o greater than one indicates positive TFP growth from year t-1 to year t, while a value of m_o less than one indicates a negative TFP growth. The ratio outside the square brackets in equation (2) measures the relative efficiency change between years t and t-1 – relative proximity to PPF. The remaining part of equation (2) is a measure of technological change – shifts in the PPF (usually) to a higher position.

There are generally two main methods to estimate the Malmquist TFP index: the Data Envelope Analysis (DEA) and stochastic frontier Approach (SFA) (see Coelli 1998). This study has adopted the DEA because of the small size of cross-section data. This approach assumes a constant return to scale (CRS) technology. This assumption, according to Grifell-Tatjé and Lovel (1995), avoids the interpretation problem that is encountered with TFP changes, when variable return to scale (VRS) technology is assumed. In the case of VRS, the estimated TFP changes using this approach may not properly reflect the TFP gains or losses (see also Coelli 1998).

In this study, six models are developed. The specifications of these models are described in Table 4.5 in Chapter 4. Various interpretations of the measured efficiencies corresponding to each model are also shown in Table 4.5 in Chapter 4. For the ith firm, four distance functions must be calculated between two periods, *t-1* and *t*. This requires solving four linear programming (LP) problems as follows:

$$\begin{aligned} &[d_o^t(y_t, x_t)]^{-1} = \max_{\Phi,\lambda} \Phi \\ &st \quad -\Phi y_{it} + Y_t\lambda \geq 0 \\ &\qquad x_{it} - X_t\lambda \geq 0 \\ &\qquad \lambda \geq 0 \end{aligned} \tag{3}$$

$$\begin{aligned} &[d_o^{t-1}(y_{t-1}, x_{t-1})]^{-1} = \max_{\Phi,\lambda} \Phi \\ &st \quad -\Phi y_{it-1} + Y_{t-1}\lambda \geq 0 \\ &\qquad x_{it-1} - X_{t-1}\lambda \geq 0 \\ &\qquad \lambda \geq 0 \end{aligned} \tag{4}$$

$$\begin{aligned} &[d_o^t(y_{t-1}, x_{t-1})]^{-1} = \max_{\Phi,\lambda} \Phi \\ &st \quad -\Phi y_{it-1} + Y_t\lambda \geq 0 \\ &\qquad x_{it-1} - X_t\lambda \geq 0 \\ &\qquad \lambda \geq 0 \end{aligned} \tag{5}$$

$$\begin{aligned} &[d_o^{t-1}(y_t, x_t)]^{-1} = \max_{\Phi,\lambda} \Phi \\ &st \quad -\Phi y_{it} + Y_{t-1}\lambda \geq 0 \\ &\qquad x_{it} - X_{t-1}\lambda \geq 0 \\ &\qquad \lambda \geq 0 \end{aligned} \tag{6}$$

where notations are defined as follows:

y_{it} is a M×1 vector of output quantities for the i^{th} firm in the t^{th} period

x_{it} is a K×1 vector of input quantities for the i^{th} firm in the t^{th} period

Y_t is a N×M matrix of output quantities for all N firms in the t^{th} period

X_t is a N×K vector of input quantities for all N firm in the t^{th} period

λ is a N×1 vector of weights; and

Φ is a scaler.

APPENDIX 4-3: Excel Macro-Programming for a Typical Micro-impact Model

The following macro-program is for the Model 1 of Table 4.5. This is a typical example, but other related macro-programs are basically the same.

```
Sub Macro4()
' Macro4 Macro
' Macro recorded 25/02/2003 by Reza Fathollahzadeh
Dim sI As String
Dim nI As Integer

For nI = 6 To 159
        sI = Trim(Str(nI))
        SolverLoad LoadArea:="$CG$" & sI & ":$CV$" & sI
        SolverOptions MaxTime:=1000, Iterations:=1000, Precision:=0.00000001,
        AssumeLinear:=True, StepThru:=False, Estimates:=1, Derivatives:=1,
        SearchOption:=1, IntTolerance:=5, Scaling:=False, Convergence:=0.000001,
        AssumeNonNeg:=False
        SolverSolve UserFinish:=True
Next nI

For nI = 13 To 159
        sI = Trim(Str(nI))
        SolverLoad LoadArea:="$CX$" & sI & ":$DM$" & sI
        SolverOptions MaxTime:=1000, Iterations:=1000, Precision:=0.00000001,
        AssumeLinear:=True, StepThru:=False, Estimates:=1, Derivatives:=1,
        SearchOption:=1, IntTolerance:=5, Scaling:=False, Convergence:=0.000001,
        AssumeNonNeg:=False
        SolverSolve UserFinish:=True
Next nI

For nI = 6 To 152
        sI = Trim(Str(nI))
        SolverLoad LoadArea:="$DO$" & sI & ":$ED$" & sI
        SolverOptions MaxTime:=1000, Iterations:=1000, Precision:=0.00000001,
        AssumeLinear:=True, StepThru:=False, Estimates:=1, Derivatives:=1,
        SearchOption:=1, IntTolerance:=5, Scaling:=False, Convergence:=0.000001,
        AssumeNonNeg:=False
        SolverSolve UserFinish:=True
Next nI

End Sub
```

APPENDIX 4.4: Mathematical Specification of Macro-impact Model

The structural form of the macro-impact model of this research is an ad hoc econometric model. The model consists of two sets of equations for electricity demand and aggregate production function (by each state), respectively. These equations are simultaneous through a set of identities for state-based energy balances. The partial adjustment method is employed in this study (Moroney 1992) in order to capture dynamic inter-relationship between macroeconomic variables. This method is a way of justifying the application of the Koyck (1954) transformation (see also FM Fisher & Kaysen 1962; Houthakker & Taylor 1970; Moroney 1992). In this method, the gap between the desired level of a variable (for example, electricity demand or aggregate production) and its actual level is gradually adjusted over time. This allows measurement of impulse-, short-, and long-term impacts of a policy change on instrumental variables. Further, in each set of equations, the *fixed-effect* method is applied over the available panel dataset in order to distinguish state-specific intercepts in each equation.

Electricity demand function

Desired electricity demand depends upon real electricity prices and real income (or production). The level of income in this study is measured by Gross State Product (GSP) at State levels. A general functional form of the desired electricity demand function is shown in equation (7):

$$e_{it}^{*} = g(y_{it}, p_{it}, FU_{it}) \tag{7}$$

Where e_{it}^{*} is the physical desired quantity demanded for electricity (MWh); y_{it} is the real GSP ($m); p_{it} is the real electricity price (¢/kWh); and FU_{it} is a dummy variable for the reform of the 1990s (functional unbundling). *i* represents States and *t* represents time. The value of FU is zero for the vertically integrated industry and one for the functional unbundled industry. A simple log-log functional form of the equation (7) can be specified as:

$$\ln(e_{it}) = \alpha_{0i} + \alpha_1 \ln(y_{it}) + \alpha_2 \ln(p_{it}) + \alpha_3 FU_{it} \tag{8}$$

where $\alpha_{0i}, \alpha_1, \alpha_2, \alpha_3$ are unknown coefficients to be estimated. Note that equation (7) and (8) contain no disturbance term since they only specify a desired relationship. The equilibrium electricity demand is unlikely to be fully adjusted in response to changes in price, income, and reform-dummy variables within one year. The flow adjustment process can be modelled by a suitable Koyck transformation as follows:

$$\ln(e_{it}) - \ln(e_{it-1}) = \delta[\ln(e^*_{it}) - \ln(e_{it-1})] \tag{9}$$

where δ, such that $0 < \delta < 1$, is known as the coefficient of adjustment; $[\ln(e_{it}) - \ln(e_{it-1})]$ is actual change; and $[\ln(e^*_{it}) - \ln(e_{it-1})]$ is desired change. Substituting equation (8) in (9) and solving for $\ln(e_{it})$, and appending a disturbance term, one obtains the electricity demand function as follows:

$$\ln(e_{it}) = \beta_{0i} + \beta_1 \ln(y_{it}) + \beta_2 \ln(p_{it}) + \beta_3 FU_{it} + \beta_4 \ln(e_{it-1}) + \varepsilon_{it} \tag{10}$$

where $\beta_{0i} = \delta\alpha_{0i}$, $\beta_1 = \delta\alpha_1$, $\beta_2 = \delta\alpha_2$, $\beta_3 = \delta\alpha_3$, $\beta_4 = (1-\delta)$.

Real production function

A general functional form of the desired production function is specified as follows:

$$y^*_{it} = f(K_{it}, L_{it}, PE_{it}) \tag{11}$$

where y^*_{it} is the desired level of production (\$m); K_{it} is the physical capital stock (\$m); L_{it} is the labour force (thousand people); and PE_{it} is total primary energy supply (TJ). A simple log-log functional form of the equation (11) can be specified as:

$$\ln(y_{it}) = \gamma_{0i} + \gamma_1 \ln(K_{it}) + \gamma_2 \ln(L_{it}) + \gamma_3 \ln(PE_{it}) \qquad \gamma_{0i}, \gamma_1, \gamma_2, \gamma_3, \gamma_4 > 0 \tag{12}$$

where $\gamma_{0i}, \gamma_1, \gamma_2, \gamma_3, \gamma_4$ are unknown coefficients to be estimated. Theoretically, greater *K*, *L*, and *PE* would stimulate higher real income, thus $\gamma_{0i}, \gamma_1, \gamma_2, \gamma_3, \gamma_4 > 0$.

The equilibrium production level is unlikely to be fully adjusted to changes in capital, labour, and primary energy variables within one year. The flow adjustment process can be modelled by a suitable Koyck transformation as follows:

$$\ln(y_{it}) - \ln(y_{it-1}) = \xi[\ln(y_{it}^{*}) - \ln(y_{it-1})] \tag{13}$$

where ξ, such that $0 < \xi < 1$, is known as the coefficient of adjustment and where $[\ln(y_{it}) - \ln(y_{it-1})]$ is actual change and $[\ln(y_{it}^{*}) - \ln(y_{it-1})]$ is desired change. Substituting equation (12) in (13) and solving for $\ln(y_{it})$, and appending a disturbance term, one obtains the production function as follows:

$$\ln(y_{it}) = \lambda_{0i} + \lambda_1 \ln(K_{it}) + \lambda_2 \ln(L_{it}) + \lambda_3 \ln(PE_{it}) + \lambda_4 \ln(y_{it-1}) + e_{it} \tag{14}$$

where $\lambda_{0i} = \xi\gamma_{0i}$, $\lambda_1 = \xi\gamma_1$, $\lambda_2 = \xi\gamma_2$, $\lambda_3 = \xi\gamma_3$, $\lambda_4 = (1-\xi)$.

State-based energy balance identity

Equations (10) and (14) are simultaneous through State-based energy balance identities. For modelling purposes, a set of State-based energy balances are represented by:

$$\ln(PE_{it}) \equiv A_i + B\ln(e_{it}) + R_{it} \tag{15}$$

where, A_i and B and R_{it} can be measured by ordinary least-square (OLS) method. R_{it} firstly should be considered as the disturbance term of the regression, but after estimating A_i and B, the interpretation of R_{it} (measured by TJ unit) is that it represents the remainder of the energy balance identity.

By substituting this identity in equation (14), one can re-write the system of two simultaneous equations as follows:

Structural form of the model

$$\begin{cases} \ln(e_{it}) = \beta_{0i} + \beta_1 \ln(y_{it}) + \beta_2 \ln(p_{it}) + \beta_3 FU_{it} + \beta_4 \ln(e_{it-1}) + \varepsilon_{it} \\ \ln(y_{it}) = \lambda_{0i} + \lambda_1 \ln(K_{it}) + \lambda_2 \ln(L_{it}) + \lambda_3 (A_i + B\ln(e_{it}) + R_{it}) + \lambda_4 \ln(y_{it-1}) + e_{it} \end{cases} \tag{16}$$

Therefore, the system (16) consists of equations of the structural form of the macroeconomic model of this thesis. It will be useful to re-write the structural form of the macroeconomic model in matrix algebra, as follows:

$$\mathrm{B}y_{it} = \Gamma X_{it} + u_{it} \tag{16a}$$

where B is 2×2 matrix of the coefficients of endogenous variables, y_{it} is the 2×1 vector of endogenous variables, Γ is the 2×8 matrix of the coefficients of the predetermined variables (exogenous and lagged-endogenous variables), and u_{it} is the 2×1 vector of disturbance terms. With suitable partitions one can yet re-write (16a) as follows:

$$\mathrm{B}y_{it} = \left[\Gamma_1 \vdots \Gamma_2\right]\begin{bmatrix} x_{it} \\ \cdots \\ y_{it-1} \end{bmatrix} + u_{it} \tag{16b}$$

Where $\mathrm{B} = \begin{bmatrix} 1 & -\beta_1 \\ -\lambda_3 B & 1 \end{bmatrix}$, $y_{it} = \begin{bmatrix} e_{it} \\ y_{it} \end{bmatrix}$, $\Gamma_1 = \begin{bmatrix} \beta_{0i} & \beta_2 & 0 & 0 & 0 & \beta_3 \\ (\lambda_{0i} + \lambda_3 A_i) & 0 & \lambda_1 & \lambda_2 & \lambda_3 & 0 \end{bmatrix}$,

$\Gamma_2 = \begin{bmatrix} \beta_4 & 0 \\ 0 & \lambda_4 \end{bmatrix}$, $x'_{it} = \left[1 \quad \ln(p_{it}) \quad \ln(K_{it}) \quad \ln(L_{it}) \quad R_{it} \quad FU_{it}\right], y_{it-1} = \begin{bmatrix} e_{it-1} \\ y_{it-1} \end{bmatrix}$, and

$u_{it} = \begin{bmatrix} \varepsilon_{it} \\ e_{it} \end{bmatrix}$.

Reduced form of the model

While the structural form of the macro-impact model of this research captures the impulse impacts of policy variables (or instrumental variables) on electricity demand and real production (that is, endogenous variables), the reduced form captures the short-term impacts of such policy variables. The short term, in the context of this definition, consists of one financial year, when simultaneity of system (16) takes place. The reduced form is the form of the model where endogenous variables are stated only by pre-determined variables. In other words, one should algebraically solve the system (16) with regard to pre-determined variables. Thus, the reduced form of the system (16) is:

$$y_{it} = \Pi X_{it} + v_{it} \tag{17}$$

Where, $\Pi = [\Pi_1 \vdots \Pi_2]$, $\Pi_1 = \mathrm{B}^{-1}\Gamma_1$, $\Pi_2 = \mathrm{B}^{-1}\Gamma_2$, and $\nu_{it} = \mathrm{B}^{-1}u_{it}$.

Final form of the model

In the long term, full adjustments will take place and desired variables will equate actual ones. In other words, $e_{it} = e_{it-1}$ and $y_{it}=y_{it-1}$. Thus the final form of the system (16) is:

$$y_{it} = \Xi X_{it} + \iota_{it} \tag{18}$$

where, $\Xi = (I - \Pi_2)^{-1}\Pi_1$, and $\iota_{it} = (I - \Pi_2)^{-1}\nu_t = (I - \Pi_2)^{-1}\mathrm{B}^{-1}u_t$.

Some econometrics Notes

As a single equation, it should be noted that in the equation (10), if p_{it}, y_{it}, and FU_{it} are predetermined instrumental variables and ε_{it} is not autocorrelated, consistent estimates for the parameters of this equation are obtained by applying OLS (Kmenta 1971, pp. 537–536). However, if the original disturbance follows a first-order autoregressive process $\varepsilon_{it} = \rho\varepsilon_{it-1} + \mu_{it}$ where $\mu \sim N(0,\sigma_\mu^2)$ and $E(\mu_{it}\varepsilon_{it}) = 0$, maximum likelihood estimates (MLEs) of equation (10) can be obtained by iterative search for the value of $|\rho| < 1$ (Zellner & M. 1970).

Similarly, in equation (14), as a single equation, if e_t follows a first-order autoregressive process $e_{it} = \psi e_{it-1} + \zeta_{it}$ where $\zeta_{it} \sim N(0,\sigma_\zeta^2)$ and $E(\zeta_{it}e_{it}) = 0$, MLEs of equation (14) can be obtained by searching a grid over $|\psi| < 1$. However, single equation techniques will lead to inconsistent estimators, since e_{it} and y_{it} are endogenous variables and are determined simultaneously.

Given the p_{it}, FU_{it}, K_{it}, L_{it}, $e_{it\text{-}1}$ and $y_{it\text{-}1}$ as predetermined variables, one can employ the instrumental variable technique to obtain consistent estimates for coefficients of system (16). In this study the Three-Stage Least Squares (3SLS) method is used for this purpose, which provides asymptotic efficient estimates.

APPENDIX 4.5: Computer Program (Eviews) Outputs for Macro-impact Model

Structural Equations:

System: SIMULSYS3
Estimation Method: Three-Stage Least Squares
Date: 01/20/05 Time: 13:45
Sample: 1990 2002
Included observations: 13
Total system (unbalanced) observations 175
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.033559	0.015362	2.184523	0.0304
C(2)	-0.033648	0.013414	-2.508365	0.0132
C(3)	0.016238	0.001695	9.582360	0.0000
C(4)	0.889141	0.016515	53.83722	0.0000
C(11)	0.881120	0.130895	6.731516	0.0000
C(12)	0.837623	0.127260	6.581969	0.0000
C(13)	0.856260	0.121991	7.019046	0.0000
C(14)	0.757609	0.114923	6.592337	0.0000
C(15)	0.766213	0.119660	6.403267	0.0000
C(16)	0.748363	0.104279	7.176579	0.0000
C(17)	0.620503	0.100328	6.184712	0.0000
C(21)	0.099205	0.008197	12.10237	0.0000
C(22)	0.108166	0.043342	2.495648	0.0136
C(23)	0.286674	0.022210	12.90718	0.0000
C(24)	0.697247	0.029193	23.88393	0.0000
C(31)	-1.392148	0.094459	-14.73808	0.0000
C(32)	-1.324012	0.089702	-14.76016	0.0000
C(33)	-1.366087	0.086515	-15.79025	0.0000
C(34)	-1.240637	0.075704	-16.38810	0.0000
C(35)	-1.194666	0.077772	-15.36113	0.0000
C(36)	-1.359810	0.073545	-18.48953	0.0000
C(37)	-1.227839	0.075789	-16.20075	0.0000

Determinant residual covariance 2.97E-55

Equation: LOG(E_NSW) = C(1)*LOG(Y_NSW) + C(2)*LOG(P_NSW) + C(3)*FU_NSW + C(4)*LOG(E_NSW(-1)) + C(11)
Instruments: LOG(P_NSW) LOG(E_NSW(-1)) FU_NSW C
Observations: 13

R-squared	0.962383	Mean dependent var	10.89496
Adjusted R-squared	0.943574	S.D. dependent var	0.116592
S.E. of regression	0.027696	Sum squared resid	0.006136
Durbin-Watson stat	1.949026		

Equation: LOG(E_VIC) = C(1)*LOG(Y_VIC) + C(2)*LOG(P_VIC) + C(3)*FU_VIC + C(4)*LOG(E_VIC(-1)) + C(12)
Instruments: LOG(P_VIC) LOG(E_VIC(-1)) FU_VIC C
Observations: 13

R-squared	0.975090	Mean dependent var	10.43055
Adjusted R-squared	0.962634	S.D. dependent var	0.087759
S.E. of regression	0.016964	Sum squared resid	0.002302
Durbin-Watson stat	1.740482		

Equation: LOG(E_QLD) = C(1)*LOG(Y_QLD) + C(2)*LOG(P_QLD) + C(3)*FU_QLD + C(4)*LOG(E_QLD(-1)) + C(13)
Instruments: LOG(P_QLD) LOG(E_QLD(-1)) FU_QLD C
Observations: 13

R-squared	0.979363	Mean dependent var	10.24742
Adjusted R-squared	0.969045	S.D. dependent var	0.209750

S.E. of regression	0.036904	Sum squared resid	0.010895
Durbin-Watson stat	2.303756		

Equation: LOG(E_SA) = C(1)*LOG(Y_SA) + C(2)*LOG(P_SA) + C(3)
*FU_SA + C(4)*LOG(E_SA(-1)) + C(14)
Instruments: LOG(P_SA) LOG(E_SA(-1)) FU_SA C
Observations: 13

R-squared	0.970899	Mean dependent var	9.156590
Adjusted R-squared	0.956349	S.D. dependent var	0.134369
S.E. of regression	0.028073	Sum squared resid	0.006305
Durbin-Watson stat	1.862818		

Equation: LOG(E_WA) = C(1)*LOG(Y_WA) + C(2)*LOG(P_WA) + C(3)
*FU_WA + C(4)*LOG(E_WA(-1)) + C(15)
Instruments: LOG(P_WA) LOG(E_WA(-1)) FU_WA C
Observations: 13

R-squared	0.960491	Mean dependent var	9.265154
Adjusted R-squared	0.940736	S.D. dependent var	0.106483
S.E. of regression	0.025922	Sum squared resid	0.005376
Durbin-Watson stat	1.194432		

Equation: LOG(E_TAS) = C(1)*LOG(Y_TAS) + C(2)*LOG(P_TAS) +
C(3)*FU_TAS + C(4)*LOG(E_TAS(-1)) + C(16)
Instruments: LOG(P_TAS) LOG(E_TAS(-1)) FU_TAS C
Observations: 13

R-squared	0.891894	Mean dependent var	9.070421
Adjusted R-squared	0.837840	S.D. dependent var	0.062400
S.E. of regression	0.025128	Sum squared resid	0.005051
Durbin-Watson stat	1.799839		

Equation: LOG(E_NT) = C(1)*LOG(Y_NT) + C(2)*LOG(P_NT) + C(3)
*FU_NT + C(4)*LOG(E_NT(-1)) + C(17)
Instruments: LOG(P_NT) LOG(E_NT(-1)) FU_NT C
Observations: 13

R-squared	0.965424	Mean dependent var	7.144448
Adjusted R-squared	0.948135	S.D. dependent var	0.192402
S.E. of regression	0.043817	Sum squared resid	0.015360
Durbin-Watson stat	1.356504		

Equation: LOG(Y_NSW) = C(21)*LOG(K_NSW) + C(22)*LOG(L_NSW)
+ C(23)*(0.6640385043*LOG(E_NSW) + 3.03420913 + R_NSW)
+ C(24)*LOG(Y_NSW(-1)) + C(31)
Instruments: LOG(K_NSW) LOG(L_NSW) LOG(Y_NSW(-1)) C
Observations: 12

R-squared	0.991906	Mean dependent var	12.26403
Adjusted R-squared	0.987282	S.D. dependent var	0.133687
S.E. of regression	0.015077	Sum squared resid	0.001591
Durbin-Watson stat	0.455734		

Equation: LOG(Y_VIC) = C(21)*LOG(K_VIC) + C(22)*LOG(L_VIC) +
C(23)*(0.6640385043*LOG(E_VIC) + 2.974006859 + R_VIC) +
C(24)*LOG(Y_VIC(-1)) + C(32)
Instruments: LOG(K_VIC) LOG(L_VIC) LOG(Y_VIC(-1)) C
Observations: 12

R-squared	0.980268	Mean dependent var	11.86863
Adjusted R-squared	0.968993	S.D. dependent var	0.143195
S.E. of regression	0.025215	Sum squared resid	0.004451
Durbin-Watson stat	1.002578		

Equation: LOG(Y_QLD) = C(21)*LOG(K_QLD) + C(22)*LOG(L_QLD) +
C(23)*(0.6640385043*LOG(E_QLD) + 2.963116807 + R_QLD) +
C(24)*LOG(Y_QLD(-1)) + C(33)
Instruments: LOG(K_QLD) LOG(L_QLD) LOG(Y_QLD(-1)) C

Observations: 12

R-squared	0.990083	Mean dependent var	11.39907
Adjusted R-squared	0.984416	S.D. dependent var	0.171815
S.E. of regression	0.021449	Sum squared resid	0.003220
Durbin-Watson stat	1.119999		

Equation: LOG(Y_SA) = C(21)*LOG(K_SA) + C(22)*LOG(L_SA) + C(23)*(0.6640385043*LOG(E_SA) + 3.038063876 + R_SA) + C(24)*LOG(Y_SA(-1)) + C(34)
Instruments: LOG(K_SA) LOG(L_SA) LOG(Y_SA(-1)) C
Observations: 12

R-squared	0.961781	Mean dependent var	10.57238
Adjusted R-squared	0.939942	S.D. dependent var	0.100183
S.E. of regression	0.024552	Sum squared resid	0.004220
Durbin-Watson stat	2.234697		

Equation: LOG(Y_WA) = C(21)*LOG(K_WA) + C(22)*LOG(L_WA) + C(23)*(0.6640385043*LOG(E_WA) + 3.016969813 + R_WA) + C(24)*LOG(Y_WA(-1)) + C(35)
Instruments: LOG(K_WA) LOG(L_WA) LOG(Y_WA(-1)) C
Observations: 12

R-squared	0.985245	Mean dependent var	11.06023
Adjusted R-squared	0.976814	S.D. dependent var	0.148005
S.E. of regression	0.022536	Sum squared resid	0.003555
Durbin-Watson stat	2.691751		

Equation: LOG(Y_TAS) = C(21)*LOG(K_TAS) + C(22)*LOG(L_TAS) + C(23)*(0.6640385043*LOG(E_TAS) + 3.0556305 + R_TAS) + C(24)*LOG(Y_TAS(-1)) + C(36)
Instruments: LOG(K_TAS) LOG(L_TAS) LOG(Y_TAS(-1)) C
Observations: 12

R-squared	0.868319	Mean dependent var	9.304516
Adjusted R-squared	0.793072	S.D. dependent var	0.060870
S.E. of regression	0.027689	Sum squared resid	0.005367
Durbin-Watson stat	1.887749		

Equation: LOG(Y_NT) = C(21)*LOG(K_NT) + C(22)*LOG(L_NT) + C(23)*(0.6640385043*LOG(E_NT) + 3.863974005 + R_NT) + C(24)*LOG(Y_NT(-1)) + C(37)
Instruments: LOG(K_NT) LOG(L_NT) LOG(Y_NT(-1)) C
Observations: 12

R-squared	0.971271	Mean dependent var	8.891192
Adjusted R-squared	0.954855	S.D. dependent var	0.138738
S.E. of regression	0.029478	Sum squared resid	0.006083
Durbin-Watson stat	2.076144		

Energy Balance Identity:

Dependent Variable: LOG(PE?)
Method: Pooled EGLS (Cross-section SUR)
Date: 01/14/05 Time: 19:53
Sample: 1990 2002
Included observations: 13
Number of cross-sections used: 7
Total panel (balanced) observations: 91
One-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(E?)	0.664039	0.002275	291.8305	0.0000
_NSW—C	3.034209	0.025948	116.9357	0.0000
_VIC—C	2.974007	0.024556	121.1089	0.0000
_QLD—C	2.963117	0.024611	120.3973	0.0000
_SA—C	3.038064	0.022163	137.0775	0.0000
_WA—C	3.016970	0.022229	135.7210	0.0000
_TAS—C	3.055630	0.022360	136.6538	0.0000
_NT—C	3.863974	0.025327	152.5606	0.0000

Weighted Statistics

Log likelihood	334.8465		

Unweighted Statistics

R-squared	0.995479	Mean dependent var	9.415951
Adjusted R-squared	0.995098	S.D. dependent var	0.546268
S.E. of regression	0.038247	Sum squared resid	0.121416
Durbin-Watson stat	0.957970		

APPENDIX 4.6: Results of Micro-impact Models and Raw Dataset

The Result of Partial Factor Productivity Measures: New South Wales and Australian Capital Territory (Part A) 1995–1978

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	**Unit**	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1955	NSW&ACT	0.3	44.5	na	na	na	na	24.4	85.2	0.8	5.5	17.1	18.1	18.8
1956	NSW&ACT	0.3	44.2	na	na	na	na	25.1	86.7	0.8	5.3	17.2	17.1	18.1
1957	NSW&ACT	0.4	42.3	na	na	na	na	25.7	88.7	0.8	6.2	17.1	15.8	17.8
1958	NSW&ACT	0.4	43.1	na	na	na	na	27.1	87.2	0.8	7.5	16.4	16.1	17.0
1959	NSW&ACT	0.4	42.0	na	na	na	na	28.3	85.3	0.9	12.1	16.1	15.7	16.5
1960	NSW&ACT	0.4	41.3	na	na	na	na	29.3	86.3	0.9	17.9	15.3	14.9	15.7
1961	NSW&ACT	0.5	39.1	na	na	na	na	30.8	87.9	1.0	15.9	14.8	14.2	15.5
1962	NSW&ACT	0.5	37.2	na	na	na	na	30.6	90.3	0.9	21.2	14.9	14.6	15.9
1963	NSW&ACT	0.5	36.2	na	na	na	na	30.8	98.0	1.0	19.7	14.8	14.2	15.3
1964	NSW&ACT	0.6	40.4	na	na	na	na	32.4	93.2	1.0	18.4	13.9	13.9	14.4
1965	NSW&ACT	0.6	39.8	na	na	na	na	33.3	98.6	1.0	17.6	13.2	13.0	13.0
1966	NSW&ACT	0.6	37.0	na	na	na	na	33.7	97.2	1.0	21.5	12.7	12.4	12.4
1967	NSW&ACT	0.6	33.4	na	na	na	na	33.6	102.0	1.0	25.3	12.2	12.1	11.9
1968	NSW&ACT	0.7	33.9	na	na	na	na	34.2	100.6	1.1	24.8	11.8	11.8	11.5
1969	NSW&ACT	0.7	32.2	na	na	68.5	502.5	34.8	102.0	1.1	27.0	11.7	11.6	11.4
1970	NSW&ACT	0.8	33.5	na	na	73.8	514.6	34.9	101.3	1.1	26.7	11.1	11.3	10.8
1971	NSW&ACT	0.9	31.6	na	na	91.8	523.4	35.1	107.7	1.1	24.6	10.8	10.9	10.4
1972	NSW&ACT	0.9	30.4	na	na	95.4	501.0	33.6	107.0	1.0	25.4	10.6	10.6	10.2
1973	NSW&ACT	1.0	29.0	na	na	99.4	492.1	33.9	103.7	1.0	26.7	10.3	10.4	10.0
1974	NSW&ACT	1.0	27.0	na	na	102.3	500.0	34.0	105.9	1.1	28.0	9.6	9.5	9.1
1975	NSW&ACT	1.0	26.3	na	na	100.4	519.1	32.7	113.1	1.0	29.3	9.0	8.9	9.0
1976	NSW&ACT	1.0	26.4	na	na	111.4	520.9	32.8	118.9	1.0	30.0	9.0	8.8	9.1
1977	NSW&ACT	1.1	32.8	na	na	119.5	523.9	33.3	100.7	1.0	31.1	8.6	8.4	8.8
1978	NSW&ACT	1.1	31.4	na	na	121.9	652.0	32.5	100.2	1.0	29.1	8.4	8.1	8.6

The Result of Partial Factor Productivity Measures: New South Wales and Australian Capital Territory (Part B) 1979–2001

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	**Unit**	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1979	NSW&ACT	1.2	31.1	na	na	130.0	539.8	33.0	103.0	1.0	27.8	8.3	7.9	8.4
1980	NSW&ACT	1.2	36.3	na	na	134.6	552.6	33.9	94.1	1.0	27.9	8.8	7.7	8.3
1981	NSW&ACT	1.3	35.4	na	na	144.9	569.2	33.7	98.9	1.0	26.6	8.2	7.7	8.5
1982	NSW&ACT	1.2	31.7	na	na	141.2	565.1	32.9	103.9	1.0	24.4	9.5	8.2	9.3
1983	NSW&ACT	1.2	31.8	na	na	139.5	535.7	33.6	96.3	1.0	23.1	10.9	9.9	12.2
1984	NSW&ACT	1.3	31.2	na	na	146.2	505.1	32.6	94.6	1.0	20.9	10.6	9.8	11.1
1985	NSW&ACT	1.4	31.0	na	na	157.1	519.5	34.5	99.7	1.1	20.3	10.4	9.3	10.0
1986	NSW&ACT	1.5	33.6	na	na	153.8	560.0	34.9	100.1	1.1	20.4	10.0	9.2	9.3
1987	NSW&ACT	1.6	33.5	na	na	158.8	569.3	34.8	100.5	1.1	19.6	9.6	8.7	8.7
1988	NSW&ACT	1.7	34.6	na	na	162.1	578.7	35.5	100.6	1.1	19.4	9.5	8.7	8.6
1989	NSW&ACT	1.9	36.7	58.2	36.9	162.9	594.3	35.7	91.5	1.1	19.6	8.9	8.9	8.6
1990	NSW&ACT	2.0	40.0	58.9	32.0	173.0	617.7	36.3	92.8	1.1	20.4	8.3	8.5	8.4
1991	NSW&ACT	2.1	42.1	59.3	29.0	175.9	657.4	36.8	95.9	1.1	21.3	7.9	8.5	8.3
1992	NSW&ACT	2.2	42.4	58.2	27.1	174.7	653.5	36.9	95.2	1.1	21.3	7.9	8.6	8.4
1993	NSW&ACT	2.7	42.0	59.7	29.6	180.9	658.8	37.2	94.4	1.1	20.3	7.3	8.8	8.0
1994	NSW&ACT	2.9	40.7	60.4	32.6	179.2	670.7	37.4	93.0	1.2	19.3	6.6	8.7	7.4
1995	NSW&ACT	3.0	42.3	58.4	27.7	183.3	636.0	37.6	92.6	1.2	19.4	6.7	8.3	6.6
1996	NSW&ACT	3.4	43.6	60.5	27.9	178.7	626.0	36.8	89.5	1.1	19.4	6.4	8.1	5.9
1997	NSW&ACT	4.0	45.0	62.6	28.2	182.0	643.5	37.5	90.4	1.2	19.5	6.6	8.0	5.6
1998	NSW&ACT	4.6	44.7	59.7	25.1	209.1	687.5	36.8	93.5	1.1	19.5	6.6	8.1	5.6
1999	NSW&ACT	4.9	46.6	60.0	22.3	210.7	694.6	37.6	94.9	1.2	18.8	6.8	7.8	5.9
2000	NSW&ACT	5.1	48.4	59.4	18.5	206.3	699.1	37.4	92.9	1.2	19.0	6.7	7.6	5.7
2001	NSW&ACT	5.4	50.2	64.0	21.5	211.4	710.3	38.1	92.9	1.2	18.8	6.5	8.0	5.4

The Result of Partial Factor Productivity Measures: Victoria (Part A) 1995–1978

Year	Factor / Variable / Unit / State	Labour L-P-ESI GWh/TotL	Capital SCF %	SLF %	Excess-C %	T&D-NL GWh/Km	T&D-NC GWh/Mva	Fuel Termal Eff %	T&D-Eff %	Environment CO2-TG MWh/T-CO2	Hydro-C %	Financial (costs) A-R-Cost cent/Kwh	R-R-P cent/KWh	B-R-P cent/KWh
1955	VIC	0.4	49.9	na	na	na	na	17.3	84.6	0.5	11.4	14.5	16.2	14.9
1956	VIC	0.4	56.0	na	na	na	na	17.2	86.2	0.5	12.7	13.5	15.2	14.7
1957	VIC	0.4	49.0	na	na	na	na	17.8	86.0	0.5	21.5	13.7	14.8	16.1
1958	VIC	0.4	49.5	na	na	na	na	18.2	88.2	0.6	21.1	14.5	14.6	16.3
1959	VIC	0.4	45.2	na	na	na	na	17.8	90.0	0.5	21.9	13.7	14.9	16.7
1960	VIC	0.4	46.3	na	na	na	na	17.5	89.1	0.5	26.3	13.9	14.6	16.5
1961	VIC	0.4	42.7	na	na	na	na	17.2	91.0	0.5	28.4	13.9	13.8	15.6
1962	VIC	0.4	39.1	na	na	na	na	17.5	89.9	0.5	29.1	14.6	13.7	15.4
1963	VIC	0.5	41.1	na	na	na	na	18.1	96.0	0.5	28.8	14.4	13.7	15.0
1964	VIC	0.5	45.4	na	na	na	na	18.5	99.8	0.6	29.0	13.7	13.4	13.8
1965	VIC	0.6	40.9	na	na	na	na	19.1	102.6	0.6	24.0	12.6	13.1	13.2
1966	VIC	0.6	43.9	na	na	na	na	20.2	95.1	0.6	28.0	12.6	13.2	13.1
1967	VIC	0.6	39.9	na	na	na	na	21.2	92.8	0.6	28.4	13.4	12.7	12.6
1968	VIC	0.7	39.5	na	na	na	na	22.2	92.1	0.7	27.4	13.0	12.3	12.7
1969	VIC	0.7	40.0	na	na	96.6	569.5	23.7	89.5	0.7	29.6	12.8	12.4	13.0
1970	VIC	0.8	39.7	na	na	99.0	499.3	24.7	90.3	0.7	29.0	12.3	12.0	12.5
1971	VIC	0.8	39.8	na	na	102.9	448.7	25.1	96.5	0.7	28.9	12.6	11.4	11.7
1972	VIC	0.8	38.7	na	na	105.5	450.3	24.9	97.0	0.7	29.9	12.1	10.6	11.2
1973	VIC	0.9	37.4	na	na	170.5	467.6	24.8	103.2	0.7	32.9	11.4	9.9	10.3
1974	VIC	1.0	37.2	na	na	117.5	490.4	24.6	98.8	0.7	33.0	10.5	9.7	9.9
1975	VIC	1.1	39.0	na	na	123.8	515.1	24.5	98.9	0.7	34.3	9.9	9.1	9.5
1976	VIC	1.1	39.9	na	na	127.6	529.9	25.1	94.3	0.7	31.9	9.7	8.8	9.2
1977	VIC	1.1	40.7	na	na	132.6	551.9	24.4	97.9	0.7	31.9	9.1	8.4	9.3
1978	VIC	1.1	40.6	na	na	135.9	561.6	24.1	101.9	0.7	31.9	9.3	8.5	9.4

The Result of Partial Factor Productivity Measures: Victoria (Part B) 1979–2001

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	**Unit**	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1979	VIC	1.2	41.8	na	na	142.1	582.9	23.8	100.8	0.7	30.6	9.4	8.7	9.6
1980	VIC	1.2	41.6	na	na	145.4	577.2	23.6	99.9	0.7	29.3	9.6	8.7	9.6
1981	VIC	1.2	41.3	na	na	154.8	611.0	24.2	98.4	0.8	28.9	9.2	9.1	9.6
1982	VIC	1.2	44.0	na	na	161.1	622.8	23.3	88.8	0.7	26.5	10.5	9.6	10.1
1983	VIC	1.2	41.6	na	na	160.7	610.6	24.3	94.0	0.8	26.5	10.4	10.1	10.7
1984	VIC	1.3	38.7	na	na	164.3	579.6	24.5	97.0	0.8	24.6	10.5	10.4	10.6
1985	VIC	1.3	43.7	na	na	165.9	582.2	28.0	90.6	0.9	25.4	11.5	10.6	10.9
1986	VIC	1.4	42.1	na	na	171.0	590.3	27.7	92.9	0.9	24.0	11.3	10.3	10.4
1987	VIC	1.5	43.8	na	na	177.3	622.8	30.4	89.0	0.9	22.4	10.4	10.0	9.9
1988	VIC	1.7	47.2	na	na	194.6	679.8	31.6	91.7	0.9	22.4	9.4	10.0	8.9
1989	VIC	1.6	49.6	66.9	25.8	211.0	735.0	30.1	92.0	0.9	21.7	9.0	9.7	8.2
1990	VIC	2.0	51.7	65.7	21.4	195.3	788.1	31.1	89.9	1.0	21.7	8.9	9.4	7.9
1991	VIC	2.1	52.7	70.8	25.5	226.0	731.6	31.2	92.3	0.9	21.7	9.2	9.4	8.0
1992	VIC	2.2	52.8	71.4	26.0	241.7	745.4	30.4	91.2	0.9	21.7	10.2	9.9	7.9
1993	VIC	3.1	51.4	66.0	22.1	244.7	760.8	30.9	91.9	0.9	21.7	11.8	10.8	7.7
1994	VIC	4.3	51.6	67.3	23.3	243.1	729.8	34.9	93.8	1.1	20.8	8.4	11.3	7.6
1995	VIC	4.9	51.8	70.7	26.7	246.7	765.1	32.3	97.5	1.0	20.5	7.5	11.2	7.3
1996	VIC	4.6	54.3	68.9	21.2	245.1	805.6	32.8	97.1	1.0	20.5	na	10.8	6.8
1997	VIC	5.1	53.5	67.4	20.5	243.7	849.1	31.8	94.0	0.9	19.4	na	10.7	6.4
1998	VIC	5.4	60.5	75.9	20.3	243.3	848.2	32.8	92.8	1.0	19.1	na	10.7	6.1
1999	VIC	5.7	62.3	75.5	17.5	242.5	793.0	32.0	90.0	0.9	18.8	na	10.4	6.4
2000	VIC	5.9	63.4	73.5	13.7	244.5	818.3	32.0	90.9	0.9	18.8	na	10.2	6.4
2001	VIC	6.0	62.6	71.1	12.0	246.5	820.4	32.0	90.5	0.9	18.7	na	10.8	6.6

The Result of Partial Factor Productivity Measures: Queensland (Part A) 1995–1978

Year	Factor Variable Unit State	Labour *L-P-ESI* GWh/TotL	Capital *SCF* %	*SLF* %	*Excess-C* %	*T&D-NL* GWh/Km	*T&D-NC* GWh/Mva	Fuel *Termal Eff* %	*T&D-Eff* %	Environment *CO2-TG* MWh/T-CO2	*Hydro-C* %	Financial (costs) *A-R-Cost* cent/Kwh	*R-R-P* cent/KWh	*B-R-P* cent/KWh
1955	QLD	0.3	40.4	na	na	na	na	19.0	91.7	0.6	1.0	19.4	17.7	22.6
1956	QLD	0.3	39.7	na	na	na	na	19.8	91.8	0.6	0.9	18.1	16.6	20.1
1957	QLD	0.3	40.2	na	na	na	na	21.1	90.6	0.7	0.8	17.8	16.9	19.5
1958	QLD	0.3	37.8	na	na	na	na	21.8	90.7	0.7	7.1	17.3	17.2	19.2
1959	QLD	0.3	33.6	na	na	na	na	23.0	90.8	0.7	11.2	17.2	16.9	18.2
1960	QLD	0.4	36.0	na	na	na	na	22.7	91.5	0.7	11.2	16.5	16.9	17.5
1961	QLD	0.4	39.5	na	na	na	na	23.9	90.9	0.7	11.1	15.9	15.8	16.9
1962	QLD	0.4	37.4	na	na	na	na	23.8	91.0	0.7	9.9	16.6	15.2	18.2
1963	QLD	0.4	40.6	na	na	na	na	24.4	89.8	0.8	9.9	16.2	14.6	17.0
1964	QLD	0.4	38.0	na	na	na	na	25.0	88.8	0.8	14.8	15.7	14.3	16.4
1965	QLD	0.4	40.0	na	na	na	na	25.6	89.4	0.8	14.0	15.1	13.6	15.8
1966	QLD	0.5	41.4	na	na	na	na	25.8	89.4	0.8	13.1	14.1	13.0	14.6
1967	QLD	0.5	39.2	na	na	na	na	26.8	89.9	0.8	11.3	13.6	12.6	13.7
1968	QLD	0.6	39.3	na	na	na	na	27.8	88.8	0.9	10.0	12.7	12.4	13.2
1969	QLD	0.6	36.7	na	na	57.6	700.5	29.4	89.5	0.9	8.5	12.6	12.8	13.3
1970	QLD	0.6	34.9	na	na	59.6	636.8	28.9	89.5	0.9	7.6	12.6	12.4	12.7
1971	QLD	0.6	37.3	na	na	59.4	634.4	29.2	89.7	0.9	7.5	12.3	11.7	12.1
1972	QLD	0.7	38.4	na	na	64.2	585.0	30.6	90.0	0.9	7.0	11.7	10.9	11.2
1973	QLD	0.8	39.7	na	na	68.2	609.3	31.1	89.6	1.0	6.6	11.0	10.7	11.1
1974	QLD	0.8	41.9	na	na	73.0	638.7	30.8	91.6	1.0	6.4	10.3	10.1	10.5
1975	QLD	0.9	45.5	na	na	76.4	642.0	31.0	91.2	1.0	6.4	10.4	10.1	10.9
1976	QLD	0.9	46.4	na	na	73.6	601.5	30.9	89.8	1.0	6.3	10.4	10.7	11.3
1977	QLD	0.9	45.1	na	na	77.0	617.1	31.3	90.2	1.0	5.6	10.2	10.3	10.9
1978	QLD	1.0	39.9	na	na	79.1	615.2	31.7	90.1	1.0	4.6	9.5	9.8	10.5

The Result of Partial Factor Productivity Measures: Queensland (Part B) 1979–2001

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	**Unit**	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1979	QLD	1.0	39.2	na	na	80.7	550.7	33.6	88.9	1.0	4.3	9.5	9.9	10.7
1980	QLD	1.0	42.6	na	na	83.9	562.9	34.1	90.2	1.1	4.3	11.0	10.0	10.5
1981	QLD	1.0	41.9	na	na	89.5	544.7	34.3	89.2	1.1	4.0	11.2	9.9	10.8
1982	QLD	1.1	41.9	na	na	93.6	574.2	33.6	89.8	1.0	3.7	10.9	10.1	10.9
1983	QLD	1.2	46.5	na	na	99.4	614.6	33.5	91.0	1.0	3.7	11.0	10.7	10.5
1984	QLD	1.3	46.3	na	na	111.3	684.4	33.9	91.5	1.0	9.1	11.1	11.0	9.0
1985	QLD	1.5	44.1	na	na	115.1	706.1	34.5	90.9	1.1	13.1	10.9	11.8	9.1
1986	QLD	1.7	47.3	na	na	117.2	717.0	36.2	90.7	1.1	13.2	10.6	11.9	8.8
1987	QLD	2.0	52.2	na	na	119.4	726.6	36.5	90.1	1.1	13.7	10.0	11.3	8.3
1988	QLD	2.4	51.9	na	na	121.0	742.6	37.3	90.6	1.2	12.9	9.7	10.7	8.1
1989	QLD	2.6	53.3	67.8	21.4	123.7	765.2	37.6	91.0	1.2	12.4	9.0	10.0	7.7
1990	QLD	2.9	56.8	72.3	21.5	127.5	792.9	38.0	91.2	1.2	12.4	8.4	9.3	7.2
1991	QLD	3.0	58.8	73.1	19.5	133.0	780.0	38.1	91.5	1.2	12.4	8.5	8.9	6.9
1992	QLD	3.2	59.3	74.3	20.2	135.6	781.3	38.0	90.7	1.2	12.0	8.0	8.9	7.0
1993	QLD	3.4	56.8	74.8	24.0	140.1	799.4	37.8	90.9	1.2	11.0	6.0	8.9	6.9
1994	QLD	3.7	56.3	77.5	27.3	138.5	778.2	37.9	84.1	1.2	10.1	5.6	8.8	7.2
1995	QLD	4.2	52.4	79.7	34.3	150.7	865.9	37.9	91.0	1.2	9.2	5.1	8.5	6.4
1996	QLD	3.4	54.6	79.1	31.0	152.7	865.7	37.1	90.0	1.1	9.2	5.3	8.2	5.8
1997	QLD	3.9	55.6	78.6	29.2	158.1	885.1	37.6	91.4	1.2	9.0	4.7	8.0	5.5
1998	QLD	4.6	61.6	76.5	19.5	171.9	975.3	36.2	89.7	1.1	8.7	5.4	8.0	5.0
1999	QLD	4.7	56.7	76.6	26.0	181.2	966.1	36.3	89.4	1.1	7.8	8.4	7.9	6.9
2000	QLD	4.7	58.4	77.3	24.4	185.3	1134.2	37.2	89.6	1.2	7.6	7.3	7.7	6.5
2001	QLD	4.7	58.4	78.1	25.3	191.4	1181.4	37.1	89.7	1.2	7.2	6.9	8.3	6.6

The Result of Partial Factor Productivity Measures: South Australia (Part A) 1995–1978

Year	Factor / Variable / Unit / State	Labour	Capital					Fuel		Environment		Financial (costs)		
		L-P-ESI	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
		GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
1955	SA	0.3	41.3	na	na	na	na	24.9	88.4	0.8	na	16.8	16.5	16.4
1956	SA	0.3	43.9	na	na	na	na	25.0	88.2	0.8	na	16.6	15.8	16.8
1957	SA	0.4	43.0	na	na	na	na	25.9	88.4	0.8	na	16.5	15.1	16.0
1958	SA	0.4	45.1	na	na	na	na	26.2	87.5	0.8	na	15.5	14.8	14.4
1959	SA	0.4	44.7	na	na	na	na	26.8	86.2	0.8	na	16.1	14.6	16.0
1960	SA	0.4	46.3	na	na	na	na	26.8	88.5	0.8	na	14.9	14.2	14.1
1961	SA	0.4	41.1	na	na	na	na	26.9	87.3	0.8	na	14.8	13.1	14.9
1962	SA	0.4	40.9	na	na	na	na	27.5	86.0	0.8	na	14.4	13.0	13.7
1963	SA	0.4	43.8	na	na	na	na	27.5	86.5	0.8	na	14.5	12.6	14.1
1964	SA	0.5	43.4	na	na	na	na	27.7	85.3	0.8	na	14.3	12.4	14.3
1965	SA	0.5	44.4	na	na	na	na	26.3	86.9	0.8	na	13.1	11.6	13.0
1966	SA	0.5	50.2	na	na	na	na	27.2	88.4	0.8	na	12.3	11.0	12.0
1967	SA	0.6	45.2	na	na	na	na	26.6	88.6	0.8	na	11.9	10.5	11.8
1968	SA	0.7	51.4	na	na	na	na	27.8	88.6	0.9	na	11.2	10.2	10.8
1969	SA	0.7	45.4	na	na	66.9	693.1	28.8	89.3	0.9	na	11.0	9.8	10.7
1970	SA	0.8	48.9	na	na	69.1	596.0	28.7	89.9	0.9	na	10.6	9.6	10.3
1971	SA	0.8	45.3	na	na	69.6	580.9	29.9	90.6	1.1	na	10.5	9.2	10.1
1972	SA	0.9	46.2	na	na	67.4	554.5	30.0	90.0	1.2	na	10.6	9.0	10.2
1973	SA	1.0	50.2	na	na	64.8	572.3	30.5	90.5	1.2	na	9.7	8.5	9.3
1974	SA	1.0	47.9	na	na	73.7	583.7	30.4	91.0	1.2	na	8.9	7.9	9.0
1975	SA	1.1	49.9	na	na	73.6	589.5	29.7	90.6	1.2	na	8.8	7.6	8.7
1976	SA	1.1	50.8	na	na	74.9	609.9	29.6	90.7	1.2	na	8.7	7.7	8.8
1977	SA	1.3	43.1	na	na	82.1	672.3	29.4	91.6	1.2	na	7.9	7.1	7.9
1978	SA	1.3	45.3	na	na	83.5	630.5	30.2	91.5	1.3	na	7.8	7.3	7.8

The Result of Partial Factor Productivity Measures: South Australia (Part B) 1979–2001

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	**Unit**	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1979	SA	1.4	44.6	na	na	85.0	637.6	31.1	91.9	1.4	na	7.8	7.4	8.1
1980	SA	1.4	40.8	na	na	84.8	637.1	31.8	91.3	1.4	na	8.2	7.5	8.1
1981	SA	1.5	38.9	na	na	87.1	636.6	31.8	89.9	1.4	na	8.2	8.0	8.5
1982	SA	1.5	39.9	na	na	89.1	631.8	32.3	90.7	1.4	na	8.4	8.5	9.3
1983	SA	1.6	41.6	na	na	94.3	643.6	32.6	93.1	1.5	na	10.1	9.4	9.9
1984	SA	1.5	38.7	na	na	88.0	579.8	33.0	90.9	1.5	na	11.9	10.1	10.8
1985	SA	1.6	36.9	na	na	91.7	588.6	32.7	91.0	1.5	na	13.6	11.0	11.5
1986	SA	1.6	34.5	na	na	92.6	565.0	33.6	90.5	1.4	na	13.4	10.9	11.0
1987	SA	1.5	34.8	na	na	91.8	558.2	34.5	89.7	1.4	na	12.7	10.2	10.6
1988	SA	1.5	36.4	na	na	95.9	555.3	34.6	90.5	1.4	na	12.4	10.3	10.7
1989	SA	1.6	39.5	56.7	30.3	98.8	585.6	34.8	90.3	1.4	na	10.3	10.1	10.1
1990	SA	1.8	42.7	55.7	23.3	102.9	586.7	34.5	91.1	1.3	na	9.5	9.7	9.6
1991	SA	1.9	34.6	42.5	18.7	103.7	557.6	34.3	91.3	1.3	na	8.4	9.5	9.1
1992	SA	2.4	39.5	48.4	18.3	101.9	528.3	34.3	90.4	1.3	na	8.1	9.8	9.3
1993	SA	2.6	40.5	48.9	17.2	104.9	548.9	35.0	91.9	1.4	na	7.5	9.8	9.0
1994	SA	3.4	44.3	52.3	15.4	96.1	604.0	35.1	91.6	1.4	na	7.0	9.8	8.1
1995	SA	3.7	41.4	43.7	5.2	102.6	609.7	35.2	92.0	1.4	na	6.2	9.6	7.2
1996	SA	3.4	39.6	40.7	2.8	107.8	609.2	39.7	89.2	1.5	na	6.1	9.5	7.0
1997	SA	3.7	34.2	35.1	2.7	113.5	608.8	34.1	90.5	1.3	na	6.0	9.6	6.9
1998	SA	4.3	35.8	36.5	2.0	130.8	643.9	34.4	91.7	1.3	na	na	10.3	6.8
1999	SA	4.7	36.8	37.9	3.1	133.7	677.9	33.5	92.5	1.3	na	na	10.4	6.9
2000	SA	6.4	39.1	38.7	-1.1	140.4	178.1	35.2	93.3	1.3	na	na	11.0	7.7
2001	SA	5.1	38.5	42.7	9.7	75.2	1388.0	35.0	93.0	1.4	na	na	11.2	8.2

The Result of Partial Factor Productivity Measures: Western Australia (Part A) 1995–1978

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	Unit	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1955	WA	0.3	33.5	na	na	na	na	22.8	85.1	0.7	na	22.4	24.8	21.4
1956	WA	0.3	31.9	na	na	na	na	24.1	85.3	0.8	na	21.7	23.7	20.7
1957	WA	0.3	29.2	na	na	na	na	24.5	86.8	0.8	0.8	20.6	22.4	19.7
1958	WA	0.3	30.9	na	na	na	na	24.7	86.9	0.8	0.8	20.4	22.0	19.6
1959	WA	0.3	29.2	na	na	na	na	24.7	86.3	0.8	0.7	20.2	22.1	19.7
1960	WA	0.3	30.6	na	na	na	na	25.0	86.8	0.8	0.7	19.7	21.7	19.0
1961	WA	0.3	30.8	na	na	na	na	25.2	87.7	0.8	0.6	18.3	19.8	17.8
1962	WA	0.4	33.1	na	na	na	na	25.8	87.4	0.8	0.6	17.3	18.7	17.3
1963	WA	0.4	36.9	na	na	na	na	26.7	87.0	0.8	0.6	16.7	18.0	17.2
1964	WA	0.5	41.9	na	na	na	na	27.1	87.4	0.9	0.6	16.4	17.2	16.4
1965	WA	0.5	46.3	na	na	na	na	27.2	87.5	0.9	0.6	15.3	16.3	15.8
1966	WA	0.5	43.0	na	na	na	na	27.7	87.0	0.9	0.5	14.3	15.4	14.9
1967	WA	0.5	41.3	na	na	na	na	28.7	87.5	0.9	0.4	13.5	14.6	14.0
1968	WA	0.5	38.7	na	na	na	na	29.5	91.2	0.9	0.4	13.2	14.5	13.9
1969	WA	0.6	40.8	na	na	97.0	619.1	30.2	87.9	1.0	0.3	12.3	13.8	13.3
1970	WA	0.7	45.8	na	na	92.3	575.6	29.4	87.4	1.0	0.3	11.5	13.4	12.4
1971	WA	0.7	42.4	na	na	85.6	510.7	29.9	87.6	1.0	0.3	11.8	12.5	11.8
1972	WA	0.7	38.8	na	na	90.8	534.1	30.4	90.0	1.0	0.2	11.9	12.6	12.3
1973	WA	0.7	35.7	na	na	94.3	529.6	31.5	89.4	1.1	0.2	11.7	12.9	11.9
1974	WA	0.7	34.3	na	na	77.3	570.8	31.5	89.8	1.1	0.2	11.4	11.7	10.8
1975	WA	0.7	38.0	na	na	73.3	459.6	30.0	87.5	1.0	0.2	11.9	11.9	11.2
1976	WA	0.7	35.0	na	na	76.0	454.5	30.0	88.8	1.0	0.2	12.4	13.4	12.7
1977	WA	0.8	36.5	na	na	76.7	468.5	29.3	90.0	0.9	0.1	12.2	10.9	11.3
1978	WA	0.9	38.6	na	na	77.8	440.8	29.8	90.2	1.0	0.1	12.5	12.0	12.0

The Result of Partial Factor Productivity Measures: Western Australia (Part B) 1979–2001

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	**Unit**	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1979	WA	0.9	35.5	na	na	77.8	448.7	30.5	91.0	1.0	0.1	12.7	12.3	11.9
1980	WA	1.0	38.2	na	na	75.7	464.1	30.4	90.6	1.0	0.1	12.4	11.7	11.1
1981	WA	1.0	35.3	na	na	77.9	440.4	31.2	91.5	1.0	0.1	13.5	12.8	11.7
1982	WA	1.0	33.5	na	na	78.5	424.1	32.2	90.6	1.0	0.1	13.8	13.0	12.4
1983	WA	1.0	35.0	na	na	77.5	429.8	32.0	91.1	1.0	0.1	15.1	14.7	12.3
1984	WA	1.0	35.9	na	na	77.3	431.0	31.5	91.1	1.0	0.1	16.1	14.5	13.8
1985	WA	1.1	36.6	na	na	82.8	449.7	32.0	90.5	1.0	0.1	14.3	14.4	13.4
1986	WA	1.1	35.8	na	na	84.0	442.2	32.2	91.5	1.2	0.1	13.4	13.8	12.9
1987	WA	1.3	38.0	na	na	90.4	471.8	32.0	93.4	1.2	0.1	12.8	13.9	12.9
1988	WA	1.3	41.1	na	na	97.4	476.9	31.7	93.8	1.2	na	11.5	13.9	12.3
1989	WA	1.6	45.7	59.9	23.7	108.8	627.0	32.0	94.2	1.2	na	10.8	12.9	11.8
1990	WA	1.7	46.3	60.2	23.2	96.7	676.5	32.0	94.6	1.2	na	10.4	12.7	11.3
1991	WA	1.8	46.7	63.8	26.7	99.2	664.1	32.3	94.6	1.1	na	11.0	13.0	11.5
1992	WA	2.0	42.8	63.2	32.4	98.8	640.2	32.9	94.9	1.1	0.1	10.8	13.2	11.6
1993	WA	2.1	44.1	62.9	29.9	101.5	642.6	33.6	95.1	1.2	0.1	10.3	13.4	11.2
1994	WA	2.4	44.8	64.0	30.0	128.4	649.4	33.2	94.2	1.2	0.1	8.9	12.5	10.6
1995	WA	3.0	47.0	64.2	26.8	130.8	705.9	33.4	94.9	1.2	0.1	9.4	12.6	9.6
1996	WA	3.0	46.2	60.4	23.5	130.9	715.8	31.1	96.5	1.1	0.1	9.3	12.0	9.2
1997	WA	3.1	43.4	57.0	23.8	130.9	726.0	32.4	91.4	1.2	0.1	9.2	11.9	9.1
1998	WA	3.4	43.6	59.4	26.7	127.4	765.2	32.1	91.1	1.2	0.1	6.8	11.4	9.3
1999	WA	3.6	41.9	59.5	29.5	127.9	751.0	33.8	91.8	1.2	0.1	6.5	11.3	8.9
2000	WA	4.4	43.0	56.2	23.5	104.7	775.3	32.6	92.2	1.2	0.1	5.9	11.1	8.8
2001	WA	4.7	41.9	54.7	23.4	134.3	751.0	32.9	92.0	1.2	0.1	5.9	11.6	8.0

The Result of Partial Factor Productivity Measures: Tasmania (Part A) 1995–1978

Year	Factor Variable Unit State	Labour *L-P-ESI* GWh/TotL	Capital *SCF* %	*SLF* %	*Excess-C* %	*T&D-NL* GWh/Km	*T&D-NC* GWh/Mva	Fuel *Termal Eff* %	*T&D-Eff* %	Environment *CO2-TG* MWh/T-CO2	*Hydro-C* %	Financial (costs) *A-R-Cost* cent/Kwh	*R-R-P* cent/KWh	*B-R-P* cent/KWh
1955	TAS	0.9	47.1	na	na	na	na	24.2	86.4	1.0	100.0	4.7	7.7	2.9
1956	TAS	1.0	45.4	na	na	na	na	24.1	87.4	1.0	100.0	4.9	8.8	3.3
1957	TAS	1.1	50.4	na	na	na	na	24.1	87.9	1.0	99.9	4.3	8.9	3.1
1958	TAS	1.0	53.4	na	na	na	na	29.1	88.1	1.2	99.9	4.7	9.0	3.2
1959	TAS	1.1	55.9	na	na	na	na	28.4	87.6	1.1	99.9	4.7	8.9	3.2
1960	TAS	1.0	51.8	na	na	na	na	28.1	88.5	1.1	99.9	4.9	8.9	3.3
1961	TAS	1.0	51.5	na	na	na	na	30.0	88.8	1.2	99.9	5.0	8.9	3.4
1962	TAS	1.0	51.5	na	na	na	na	30.0	89.4	1.2	99.9	5.0	9.6	3.6
1963	TAS	1.2	58.2	na	na	na	na	30.1	88.3	1.2	99.9	4.6	9.6	3.7
1964	TAS	1.2	50.3	na	na	na	na	30.5	89.5	1.2	99.9	4.7	9.5	3.8
1965	TAS	1.3	49.4	na	na	na	na	30.4	91.0	1.2	100.0	4.5	9.1	3.6
1966	TAS	1.4	54.0	na	na	na	na	30.0	90.9	1.2	99.9	4.6	8.9	3.6
1967	TAS	1.4	54.2	na	na	na	na	29.1	90.0	1.2	99.9	4.6	8.7	3.7
1968	TAS	1.3	43.7	na	na	na	na	17.3	89.5	0.7	95.6	5.2	8.8	3.8
1969	TAS	1.6	52.1	na	na	227.4	909.9	21.1	89.6	0.8	94.7	4.5	8.8	3.7
1970	TAS	1.7	55.4	na	na	246.4	963.4	31.6	90.6	1.3	95.7	4.2	8.7	3.7
1971	TAS	1.6	47.3	na	na	257.1	971.7	33.7	90.7	1.3	87.9	4.3	7.9	3.7
1972	TAS	2.0	48.8	na	na	273.5	969.2	32.6	91.5	1.3	88.0	4.3	8.2	3.6
1973	TAS	2.1	48.2	na	na	263.5	1087.8	29.6	91.6	1.2	88.4	4.2	8.1	3.6
1974	TAS	2.1	49.5	na	na	257.2	1188.6	30.0	91.8	1.2	89.1	3.9	7.2	3.4
1975	TAS	2.2	46.2	na	na	256.2	1180.5	29.3	90.6	1.1	81.9	4.3	6.9	3.3
1976	TAS	2.1	45.9	na	na	252.7	1186.3	31.3	90.7	1.2	81.9	4.4	7.2	3.4
1977	TAS	2.4	53.2	na	na	290.5	1348.2	28.1	91.2	1.1	83.1	3.7	6.4	2.9
1978	TAS	2.5	49.3	na	na	301.2	1345.5	23.4	91.8	0.9	85.3	3.8	6.6	2.8

The Result of Partial Factor Productivity Measures: Tasmania (Part B) 1979–2001

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	Unit	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1979	TAS	2.6	49.0	na	na	319.2	1383.0	36.9	91.4	1.4	86.4	3.7	6.6	2.8
1980	TAS	2.6	50.0	na	na	321.1	1355.7	34.2	91.9	1.3	86.4	3.6	6.0	2.7
1981	TAS	2.6	51.0	na	na	313.0	1257.4	38.2	90.2	1.5	86.4	3.8	6.4	2.8
1982	TAS	2.7	49.3	na	na	317.0	1264.0	39.3	91.9	1.5	87.0	3.9	6.7	3.0
1983	TAS	2.6	48.4	na	na	310.7	1220.0	37.7	92.0	1.4	87.0	4.2	6.7	3.0
1984	TAS	2.6	47.4	na	na	306.2	1248.4	38.5	91.4	1.5	87.5	4.5	7.2	3.3
1985	TAS	2.3	48.2	na	na	313.6	1249.6	38.0	91.6	1.4	87.5	4.6	7.7	3.4
1986	TAS	2.3	46.2	na	na	312.0	1259.6	30.9	91.8	1.2	88.1	4.3	7.4	3.3
1987	TAS	2.2	43.7	na	na	306.2	1138.5	32.4	92.2	1.3	88.8	4.7	7.6	3.4
1988	TAS	3.8	43.3	na	na	318.4	1217.7	38.0	92.4	1.5	89.5	4.6	7.5	3.4
1989	TAS	3.8	43.9	70.1	37.4	313.9	1218.0	35.2	91.7	1.3	89.5	4.2	7.5	3.4
1990	TAS	3.5	44.5	72.1	38.4	307.1	1190.3	37.5	91.4	1.4	89.5	4.6	7.7	3.4
1991	TAS	3.0	44.4	71.3	37.6	308.3	1194.9	37.5	92.4	1.4	89.5	5.0	7.6	3.6
1992	TAS	3.3	41.4	70.3	41.1	304.7	1339.4	32.2	92.1	1.3	90.1	4.6	8.1	3.8
1993	TAS	3.6	41.5	70.5	41.2	300.0	1323.6	33.2	92.6	1.3	89.9	5.2	8.4	3.7
1994	TAS	4.4	40.5	73.7	45.0	298.0	1106.3	35.1	92.6	1.4	90.2	4.7	8.5	3.8
1995	TAS	4.7	39.6	71.1	44.3	283.4	1028.0	41.5	92.5	1.7	90.2	4.9	7.9	3.9
1996	TAS	4.9	41.7	72.4	42.5	295.2	1193.1	39.4	92.6	1.6	90.2	4.4	7.7	3.8
1997	TAS	5.3	43.7	73.7	40.6	306.6	1395.4	36.5	92.8	1.5	90.2	4.1	7.5	3.8
1998	TAS	5.7	44.1	70.8	37.7	322.1	1144.1	31.7	92.7	1.3	90.2	4.0	7.7	3.8
1999	TAS	5.4	45.0	72.0	37.6	312.4	1160.0	25.4	93.4	1.0	90.2	5.0	8.2	3.7
2000	TAS	6.0	45.6	71.6	36.4	327.2	1200.6	32.0	93.6	1.3	90.2	4.9	8.3	3.6
2001	TAS	5.9	46.0	72.5	36.5	330.3	1213.3	33.4	93.4	1.3	90.2	5.0	8.7	3.3

The Result of Partial Factor Productivity Measures: Northern Territory (Part A) 1995–1978

Year	Factor Variable Unit State	Labour	Capital					Fuel		Environment		Financial (costs)		
		L-P-ESI	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
		GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
1955	NT	0.4	40.0	na	na	na	na	28.9	266.0	1.2	na	6.3	17.8	50.5
1956	NT	0.4	39.3	na	na	na	na	25.9	254.4	1.0	na	12.8	15.7	24.2
1957	NT	0.6	31.6	na	na	na	na	30.9	262.6	1.2	19.8	9.5	13.7	16.4
1958	NT	0.4	33.0	na	na	na	na	31.3	262.0	1.2	17.1	8.8	15.6	21.4
1959	NT	0.4	37.6	na	na	na	na	31.7	234.2	1.3	17.2	10.6	18.4	23.1
1960	NT	0.5	40.1	na	na	na	na	31.7	251.5	1.3	16.1	9.4	16.3	24.3
1961	NT	0.5	35.1	na	na	na	na	32.2	250.5	1.3	23.0	8.4	15.9	20.5
1962	NT	0.6	24.0	na	na	na	na	32.4	254.9	1.3	13.8	7.8	15.4	19.6
1963	NT	0.3	26.7	na	na	na	na	22.1	79.2	0.9	14.1	18.9	25.3	23.3
1964	NT	0.2	32.7	na	na	na	na	22.9	88.5	0.9	13.9	22.5	24.7	24.2
1965	NT	0.2	31.7	na	na	na	na	25.2	165.3	1.0	na	20.7	25.3	22.5
1966	NT	0.2	34.7	na	na	na	na	24.6	168.3	0.9	na	20.3	24.3	21.7
1967	NT	0.2	25.5	na	na	na	na	24.9	172.2	1.0	na	19.8	23.3	21.1
1968	NT	0.2	23.5	na	na	na	na	24.3	173.5	0.9	na	19.2	22.2	17.7
1969	NT	0.5	27.5	na	na	241.0	1339.3	24.4	87.8	0.9	na	17.1	16.8	15.9
1970	NT	0.6	32.6	na	na	239.3	1535.6	24.3	88.7	0.9	na	15.2	15.3	14.2
1971	NT	0.7	35.5	na	na	255.5	1363.8	24.5	88.1	0.9	na	14.5	15.3	13.0
1972	NT	0.7	30.3	na	na	259.6	1392.1	25.4	84.1	1.0	na	13.7	13.1	14.5
1973	NT	0.8	35.4	na	na	288.2	1546.4	25.1	84.3	1.0	na	12.9	12.3	13.5
1974	NT	0.9	34.8	na	na	260.1	1832.4	25.5	94.6	1.0	na	12.7	11.0	10.9
1975	NT	0.6	29.0	na	na	270.1	1903.2	27.9	104.3	1.1	na	12.3	11.7	10.6
1976	NT	0.6	28.3	na	na	282.7	1991.9	25.4	88.1	1.0	na	14.5	12.1	10.4
1977	NT	0.8	31.7	na	na	221.0	954.1	25.3	82.3	1.0	na	16.3	11.9	10.0
1978	NT	0.5	30.0	na	na	211.5	721.2	25.3	77.9	1.0	na	23.4	11.9	9.8

The Result of Partial Factor Productivity Measures: Northern Territory (Part B) 1979–2001

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	**Unit**	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1979	NT	0.4	28.0	na	na	223.4	847.3	28.4	82.9	1.1	na	17.9	10.1	13.0
1980	NT	0.5	27.3	na	na	231.2	915.3	28.6	82.4	1.1	na	27.9	9.6	12.3
1981	NT	0.5	27.8	na	na	246.2	824.7	29.5	86.5	1.1	na	30.6	9.3	11.7
1982	NT	0.6	29.3	na	na	224.0	853.3	29.5	88.9	1.1	na	29.0	9.9	12.4
1983	NT	0.6	30.1	na	na	207.5	762.0	29.3	88.1	1.1	na	28.6	11.2	13.4
1984	NT	0.7	32.1	na	na	191.3	828.3	29.2	89.7	1.1	na	28.6	11.8	14.1
1985	NT	0.7	35.8	na	na	160.4	847.8	28.8	90.3	1.1	na	26.8	11.9	14.7
1986	NT	0.8	38.9	na	na	173.6	917.7	29.7	89.8	1.2	na	24.1	14.3	16.8
1987	NT	1.0	24.0	na	na	182.2	632.9	27.7	92.1	1.2	na	24.5	14.5	17.2
1988	NT	1.1	31.0	na	na	188.4	658.5	28.3	93.2	1.5	na	22.4	13.5	16.2
1989	NT	1.1	32.0	na	na	302.5	623.3	31.8	89.7	1.7	na	23.5	13.3	15.6
1990	NT	1.3	34.4	na	na	213.8	706.6	32.0	89.3	1.7	na	19.3	12.2	14.1
1991	NT	1.4	35.4	na	na	225.0	735.6	32.1	88.6	1.7	na	18.0	11.8	13.4
1992	NT	1.8	36.1	na	na	217.0	692.8	32.0	86.1	1.7	na	16.5	12.2	13.7
1993	NT	1.8	35.9	na	na	219.0	729.7	31.4	92.1	1.7	na	17.2	12.1	13.9
1994	NT	2.3	37.5	na	na	194.2	631.8	31.6	93.4	1.7	na	15.6	12.0	13.9
1995	NT	2.4	36.0	88.4	59.3	207.5	688.8	31.1	93.3	1.7	na	15.1	11.7	13.3
1996	NT	2.6	38.5	87.0	55.8	213.7	722.6	29.4	94.2	1.6	na	12.2	11.1	12.7
1997	NT	2.5	39.5	85.8	54.0	219.3	754.6	31.1	92.4	1.7	na	11.3	10.9	12.5
1998	NT	2.6	41.5	81.4	49.1	234.1	819.0	31.6	94.8	1.7	na	10.9	10.9	11.6
1999	NT	3.1	40.4	84.5	52.1	200.8	813.6	30.9	93.7	1.6	na	11.1	11.4	11.8
2000	NT	3.2	37.5	87.3	57.0	206.4	811.7	33.2	92.4	1.8	na	10.5	11.4	11.4
2001	NT	3.3	38.1	86.4	56.0	202.6	811.6	32.0	92.2	1.7	na	10.2	11.7	11.5

The Result of Partial Factor Productivity Measures: Australia (Part A) 1995–1978

Year	Factor Variable Unit State	Labour *L-P-ESI* GWh/TotL	Capital *SCF* %	 *SLF* %	 *Excess-C* %	 *T&D-NL* GWh/Km	 *T&D-NC* GWh/Mva	Fuel *Termal Eff* %	 *T&D-Eff* %	Environment *CO2-TG* MWh/T-CO2	 *Hydro-C* %	Financial (costs) *A-R-Cost* cent/Kwh	 *R-R-P* cent/KWh	 *B-R-P* cent/KWh
1955	Australia	0.3	44.9	na	na	na	na	21.0	86.5	0.6	15.8	15.5	17.0	15.8
1956	Australia	0.4	46.0	na	na	na	na	21.3	87.6	0.7	17.1	15.1	16.2	15.2
1957	Australia	0.4	43.9	na	na	na	na	22.0	88.4	0.7	19.3	14.8	15.5	14.9
1958	Australia	0.4	44.6	na	na	na	na	22.8	88.5	0.7	19.7	14.6	15.6	14.6
1959	Australia	0.4	42.5	na	na	na	na	23.1	88.1	0.7	21.2	14.5	15.6	14.8
1960	Australia	0.4	42.8	na	na	na	na	23.3	88.6	0.7	24.8	14.1	15.0	14.3
1961	Australia	0.5	40.9	na	na	na	na	23.7	89.7	0.7	24.3	13.7	14.2	13.9
1962	Australia	0.5	39.0	na	na	na	na	23.8	90.3	0.7	26.1	14.1	14.4	14.2
1963	Australia	0.5	40.4	na	na	na	na	24.3	93.8	0.7	25.5	13.9	14.1	13.7
1964	Australia	0.5	42.6	na	na	na	na	25.2	93.1	0.8	26.4	13.3	13.8	13.0
1965	Australia	0.6	41.7	na	na	na	na	25.7	96.4	0.8	25.2	12.4	13.1	12.1
1966	Australia	0.6	42.0	na	na	na	na	26.4	94.0	0.8	26.6	12.2	12.8	11.7
1967	Australia	0.6	38.6	na	na	na	na	26.9	95.2	0.8	27.5	12.1	12.3	11.4
1968	Australia	0.7	38.2	na	na	na	na	27.9	94.5	0.8	26.6	11.8	12.0	11.3
1969	Australia	0.7	37.6	na	na	80.0	586.3	29.1	94.0	0.9	27.4	11.4	11.9	11.0
1970	Australia	0.8	38.5	na	na	83.9	560.8	29.5	94.1	0.9	27.0	10.9	11.6	10.5
1971	Australia	0.8	37.1	na	na	92.7	543.4	30.0	98.1	0.9	26.0	10.8	11.0	10.0
1972	Australia	0.9	36.3	na	na	96.0	529.9	29.7	98.2	0.9	26.3	10.5	10.5	9.7
1973	Australia	1.0	35.4	na	na	107.1	537.7	30.1	98.4	0.9	27.3	10.1	10.2	9.4
1974	Australia	1.0	34.4	na	na	102.2	556.6	29.8	98.5	0.9	27.6	9.4	9.5	8.8
1975	Australia	1.0	34.9	na	na	102.6	565.2	29.2	100.6	0.9	28.4	9.1	9.1	8.7
1976	Australia	1.1	35.4	na	na	106.9	565.7	29.2	100.8	0.9	27.7	9.2	9.2	8.9
1977	Australia	1.1	38.5	na	na	113.4	584.9	29.4	96.1	0.9	27.4	8.7	8.7	8.5
1978	Australia	1.2	37.2	na	na	115.7	635.0	29.2	96.8	0.9	26.6	8.6	8.6	8.4

The Result of Partial Factor Productivity Measures: Australia (Part B) 1979–2001

	Factor	Labour	Capital					Fuel		Environment		Financial (costs)		
	Variable	*L-P-ESI*	*SCF*	*SLF*	*Excess-C*	*T&D-NL*	*T&D-NC*	*Termal Eff*	*T&D-Eff*	*CO2-TG*	*Hydro-C*	*A-R-Cost*	*R-R-P*	*B-R-P*
Year	Unit	GWh/TotL	%	%	%	GWh/Km	GWh/Mva	%	%	MWh/T-CO2	%	cent/Kwh	cent/KWh	cent/KWh
	State													
1979	Australia	1.2	37.0	na	na	120.9	589.1	29.6	97.5	0.9	25.7	8.6	8.5	8.5
1980	Australia	1.2	39.7	na	na	123.1	594.9	30.1	94.1	1.0	25.3	9.1	8.4	8.4
1981	Australia	1.3	38.9	na	na	130.1	601.0	30.3	95.4	1.0	24.1	8.9	8.6	8.6
1982	Australia	1.3	37.8	na	na	131.1	604.1	29.4	94.9	0.9	22.6	9.8	9.1	9.2
1983	Australia	1.3	37.9	na	na	131.0	593.7	30.3	93.9	1.0	22.1	10.6	10.2	10.4
1984	Australia	1.4	36.8	na	na	135.4	577.0	30.3	93.9	1.0	21.3	10.8	10.4	10.0
1985	Australia	1.4	37.5	na	na	140.9	588.2	32.2	94.1	1.0	21.3	10.9	10.4	9.8
1986	Australia	1.5	38.4	na	na	141.6	607.4	32.6	94.8	1.0	21.2	10.6	10.3	9.3
1987	Australia	1.6	39.2	na	na	145.5	618.4	33.5	94.0	1.1	20.7	10.1	9.9	8.9
1988	Australia	1.8	40.9	na	na	151.7	639.8	34.3	94.8	1.1	20.9	9.6	9.7	8.6
1989	Australia	1.9	43.2	na	73.9	157.2	678.7	33.9	91.6	1.1	20.7	8.9	9.6	8.3
1990	Australia	2.1	46.0	na	72.5	156.8	707.6	34.5	91.7	1.1	21.1	8.5	9.2	8.0
1991	Australia	2.2	47.0	na	72.1	163.9	708.1	34.7	93.5	1.1	21.4	8.5	9.1	8.0
1992	Australia	2.4	47.1	na	71.8	165.2	707.1	34.6	92.8	1.1	21.4	8.6	9.4	8.0
1993	Australia	2.8	46.4	na	72.3	169.5	717.0	35.0	92.9	1.1	20.7	8.3	9.6	7.8
1994	Australia	3.3	46.3	na	73.5	170.5	711.8	36.2	91.4	1.1	20.0	7.0	9.7	7.5
1995	Australia	3.6	46.3	na	72.2	175.9	720.0	35.6	93.5	1.1	19.6	6.8	9.4	6.9
1996	Australia	3.7	47.8	na	72.2	176.0	730.2	35.2	92.0	1.1	19.6	na	9.1	6.4
1997	Australia	4.1	48.0	na	72.9	179.8	755.3	35.2	91.7	1.1	19.2	na	9.0	6.0
1998	Australia	4.6	50.8	na	72.1	194.5	789.9	34.9	92.2	1.1	19.0	na	9.1	6.4
1999	Australia	4.9	50.9	na	71.9	197.1	783.7	35.0	92.2	1.1	18.1	na	8.9	6.4
2000	Australia	5.2	52.5	na	71.0	193.4	667.5	35.2	91.8	1.1	18.0	na	8.7	6.3
2001	Australia	5.3	52.7	na	72.6	186.9	861.6	35.5	91.6	1.1	17.5	na	9.2	6.2

The Result of Decomposition of Total Factor Productivity: NSW&ACT (Part A) Model 1–Model 4

Year	States	Model1			Model2			Model3			Model4		
		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	NSW&ACT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	NSW&ACT	0.908	1.030	0.935	0.950	1.029	0.978	0.950	1.029	0.978	1.000	1.096	1.096
1982	NSW&ACT	0.919	1.025	0.943	0.919	1.077	0.990	0.919	1.130	1.039	1.000	1.177	1.177
1983	NSW&ACT	0.976	0.965	0.941	0.950	1.084	1.029	0.950	1.137	1.080	1.000	1.382	1.382
1984	NSW&ACT	0.904	0.942	0.852	0.904	1.010	0.913	1.000	1.007	1.007	1.000	1.416	1.416
1985	NSW&ACT	1.000	0.908	0.908	1.000	1.003	1.003	1.000	1.131	1.131	1.000	1.438	1.438
1986	NSW&ACT	1.000	0.928	0.928	1.000	1.040	1.040	1.000	1.172	1.172	1.000	1.484	1.484
1987	NSW&ACT	1.000	0.941	0.941	1.000	1.070	1.070	1.000	1.207	1.207	1.000	1.521	1.521
1988	NSW&ACT	1.000	0.960	0.960	1.000	1.093	1.093	1.000	1.232	1.232	1.000	1.585	1.585
1989	NSW&ACT	0.977	0.966	0.944	0.977	1.100	1.075	0.977	1.226	1.198	1.000	1.630	1.630
1990	NSW&ACT	1.000	0.979	0.979	1.000	1.114	1.114	1.000	1.262	1.262	1.000	1.696	1.696
1991	NSW&ACT	1.000	1.024	1.024	1.000	1.164	1.164	1.000	1.330	1.330	1.000	1.782	1.782
1992	NSW&ACT	1.000	1.023	1.023	1.000	1.164	1.164	1.000	1.331	1.331	1.000	1.832	1.832
1993	NSW&ACT	1.000	1.022	1.022	1.000	1.163	1.163	1.000	1.330	1.330	1.000	1.908	1.908
1994	NSW&ACT	1.000	1.031	1.031	1.000	1.168	1.168	1.000	1.334	1.334	1.000	1.933	1.933
1995	NSW&ACT	1.000	1.039	1.039	1.000	1.181	1.181	1.000	1.334	1.334	1.000	1.907	1.907
1996	NSW&ACT	0.945	1.076	1.016	na	na	na	na	na	na	na	na	na
1997	NSW&ACT	1.000	1.072	1.072	na	na	na	na	na	na	na	na	na
1998	NSW&ACT	1.000	1.157	1.157	na	na	na	na	na	na	na	na	na
1999	NSW&ACT	1.000	1.164	1.164	na	na	na	na	na	na	na	na	na
2000	NSW&ACT	1.000	1.175	1.175	na	na	na	na	na	na	na	na	na
2001	NSW&ACT	1.000	1.200	1.200	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: NSW&ACT (Part B) Model 5–Model 6

	States	Model5			Model6			Model7		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	NSW&ACT	1.000	1.000	1.000	1.000	1.000	1.000	na	na	na
1981	NSW&ACT	1.000	0.982	0.982	1.000	0.982	0.982	na	na	na
1982	NSW&ACT	0.996	0.928	0.924	1.000	0.926	0.926	na	na	na
1983	NSW&ACT	1.000	0.939	0.939	1.000	0.939	0.939	na	na	na
1984	NSW&ACT	0.998	0.929	0.927	1.000	0.922	0.922	na	na	na
1985	NSW&ACT	1.000	0.962	0.962	1.000	0.973	0.973	na	na	na
1986	NSW&ACT	1.000	0.995	0.995	1.000	1.006	1.006	na	na	na
1987	NSW&ACT	1.000	0.981	0.981	1.000	0.985	0.985	na	na	na
1988	NSW&ACT	0.952	1.049	0.998	0.952	1.052	1.002	na	na	na
1989	NSW&ACT	0.998	1.045	1.043	0.998	1.049	1.046	na	na	na
1990	NSW&ACT	1.000	1.049	1.049	1.000	1.057	1.057	na	na	na
1991	NSW&ACT	0.966	1.093	1.056	1.000	1.088	1.088	na	na	na
1992	NSW&ACT	1.000	1.091	1.091	1.000	1.104	1.104	na	na	na
1993	NSW&ACT	1.000	1.092	1.092	1.000	1.105	1.105	na	na	na
1994	NSW&ACT	1.000	1.100	1.100	1.000	1.113	1.113	na	na	na
1995	NSW&ACT	1.000	1.107	1.107	1.000	1.119	1.119	na	na	na
1996	NSW&ACT	1.000	1.094	1.094	0.993	1.111	1.103	na	na	na
1997	NSW&ACT	0.997	1.960	1.955	0.997	1.982	1.977	1.000	1.000	1.000
1998	NSW&ACT	1.000	1.920	1.920	1.000	1.942	1.942	1.000	1.019	1.019
1999	NSW&ACT	1.000	1.970	1.970	1.000	1.995	1.995	1.000	1.033	1.033
2000	NSW&ACT	1.000	1.978	1.978	1.000	2.003	2.003	1.000	1.015	1.015
2001	NSW&ACT	1.000	2.234	2.234	1.000	2.262	2.262	1.000	1.016	1.016

The Result of Decomposition of Total Factor Productivity: Victoria (Part A) Model 1–Model 4

Year	States	Model1			Model2			Model3			Model4		
		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	VIC	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	VIC	0.807	1.146	0.924	0.807	1.078	0.870	0.807	1.078	0.870	1.000	1.092	1.092
1982	VIC	0.856	1.040	0.890	0.856	1.060	0.906	0.856	1.060	0.906	1.000	1.159	1.159
1983	VIC	0.832	1.103	0.917	0.832	1.123	0.934	0.832	1.123	0.934	1.000	1.316	1.316
1984	VIC	0.815	1.140	0.930	0.815	1.161	0.947	0.815	1.161	0.947	1.000	1.384	1.384
1985	VIC	0.819	1.163	0.953	0.819	1.185	0.971	0.819	1.185	0.971	1.000	1.398	1.398
1986	VIC	0.859	1.093	0.939	0.859	1.113	0.956	0.859	1.113	0.956	1.000	1.474	1.474
1987	VIC	0.861	1.087	0.936	0.861	1.107	0.953	0.861	1.107	0.953	1.000	1.568	1.568
1988	VIC	0.959	1.066	1.023	0.959	1.086	1.042	0.959	1.086	1.042	1.000	1.695	1.695
1989	VIC	1.000	1.093	1.093	1.000	1.113	1.113	1.000	1.113	1.113	1.000	1.759	1.759
1990	VIC	1.000	1.127	1.127	1.000	1.148	1.148	1.000	1.148	1.148	1.000	1.810	1.810
1991	VIC	1.000	1.155	1.155	1.000	1.176	1.176	1.000	1.176	1.176	1.000	1.889	1.889
1992	VIC	1.000	1.168	1.168	1.000	1.180	1.180	1.000	1.180	1.180	1.000	1.949	1.949
1993	VIC	1.000	1.227	1.227	1.000	1.225	1.225	1.000	1.225	1.225	1.000	2.110	2.110
1994	VIC	1.000	1.332	1.332	1.000	1.330	1.330	1.000	1.330	1.330	1.000	2.478	2.478
1995	VIC	1.000	1.402	1.402	1.000	1.399	1.399	1.000	1.399	1.399	1.000	2.603	2.603
1996	VIC	1.000	1.388	1.388	na	na	na	na	na	na	na	na	na
1997	VIC	1.000	1.407	1.407	na	na	na	na	na	na	na	na	na
1998	VIC	1.000	1.443	1.443	na	na	na	na	na	na	na	na	na
1999	VIC	1.000	1.491	1.491	na	na	na	na	na	na	na	na	na
2000	VIC	1.000	1.538	1.538	na	na	na	na	na	na	na	na	na
2001	VIC	1.000	1.557	1.557	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: Victoria (Part B) Model 5–Model 6

	States		Model5			Model6			Model7	
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	VIC	1.000	1.000	1.000	1.000	1.000	1.000	na	na	na
1981	VIC	1.000	1.011	1.011	1.000	1.011	1.011	na	na	na
1982	VIC	1.000	1.037	1.037	1.000	1.037	1.037	na	na	na
1983	VIC	1.000	1.000	1.000	1.000	1.000	1.000	na	na	na
1984	VIC	1.000	0.948	0.948	1.000	0.948	0.948	na	na	na
1985	VIC	1.000	1.065	1.065	1.000	1.065	1.065	na	na	na
1986	VIC	1.000	1.033	1.033	1.000	1.033	1.033	na	na	na
1987	VIC	1.000	1.099	1.099	1.000	1.099	1.099	na	na	na
1988	VIC	1.000	1.135	1.135	1.000	1.135	1.135	na	na	na
1989	VIC	1.000	1.181	1.181	1.000	1.181	1.181	na	na	na
1990	VIC	1.000	1.240	1.240	1.000	1.240	1.240	na	na	na
1991	VIC	1.000	1.268	1.268	1.000	1.267	1.267	na	na	na
1992	VIC	1.000	1.274	1.274	1.000	1.273	1.273	na	na	na
1993	VIC	1.000	1.236	1.236	1.000	1.235	1.235	na	na	na
1994	VIC	1.000	1.380	1.380	1.000	1.379	1.379	na	na	na
1995	VIC	1.000	1.449	1.449	1.000	1.448	1.448	na	na	na
1996	VIC	1.000	1.450	1.450	1.000	1.449	1.449	na	na	na
1997	VIC	1.000	2.664	2.664	1.000	2.652	2.652	1.000	1.000	1.000
1998	VIC	1.000	2.933	2.933	1.000	2.920	2.920	1.000	1.067	1.067
1999	VIC	1.000	3.036	3.036	1.000	3.022	3.022	1.000	1.035	1.035
2000	VIC	1.000	3.089	3.089	1.000	3.075	3.075	1.000	1.057	1.057
2001	VIC	1.000	3.017	3.017	1.000	3.003	3.003	1.000	1.077	1.077

The Result of Decomposition of Total Factor Productivity: Queensland (Part A) Model 1–Model 4

	States	Model1			Model2			Model3			Model4		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	QLD	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	QLD	0.998	1.011	1.009	0.998	1.011	1.009	0.998	1.011	1.009	1.000	1.070	1.070
1982	QLD	0.924	1.068	0.988	0.924	1.068	0.988	0.924	1.068	0.988	1.000	1.164	1.164
1983	QLD	0.917	1.061	0.973	0.917	1.061	0.973	0.917	1.061	0.973	1.000	1.310	1.310
1984	QLD	0.936	1.042	0.976	0.936	1.042	0.976	0.936	1.042	0.976	1.000	1.324	1.324
1985	QLD	0.945	1.054	0.996	0.945	1.054	0.996	0.945	1.054	0.996	1.000	1.375	1.375
1986	QLD	1.032	1.013	1.045	1.032	1.033	1.066	1.032	1.033	1.066	1.000	1.480	1.480
1987	QLD	1.032	1.036	1.068	1.032	1.056	1.090	1.032	1.056	1.090	1.000	1.621	1.621
1988	QLD	1.032	1.073	1.107	1.032	1.091	1.126	1.032	1.091	1.126	1.000	1.764	1.764
1989	QLD	1.032	1.094	1.128	1.032	1.113	1.148	1.032	1.113	1.148	1.000	1.863	1.863
1990	QLD	1.032	1.143	1.179	1.032	1.163	1.199	1.032	1.163	1.199	1.000	1.966	1.966
1991	QLD	1.032	1.177	1.214	1.032	1.194	1.232	1.032	1.194	1.232	1.000	2.010	2.010
1992	QLD	1.032	1.208	1.246	1.032	1.226	1.264	1.032	1.225	1.264	1.000	2.094	2.094
1993	QLD	1.032	1.211	1.249	1.032	1.244	1.284	1.032	1.244	1.283	1.000	2.242	2.242
1994	QLD	1.032	1.192	1.229	1.032	1.223	1.262	1.032	1.223	1.262	1.000	2.270	2.270
1995	QLD	1.032	1.234	1.273	1.032	1.265	1.305	1.032	1.265	1.305	1.000	2.306	2.306
1996	QLD	1.032	1.243	1.282	na	na	na	na	na	na	na	na	na
1997	QLD	1.032	1.285	1.326	na	na	na	na	na	na	na	na	na
1998	QLD	1.032	1.405	1.449	na	na	na	na	na	na	na	na	na
1999	QLD	1.032	1.340	1.382	na	na	na	na	na	na	na	na	na
2000	QLD	1.032	1.411	1.455	na	na	na	na	na	na	na	na	na
2001	QLD	1.032	1.433	1.478	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: Queensland (Part B) Model 5–Model 6

Year	States	Model5 TE-ch	Model5 Tech-ch	Model5 TFP	Model6 TE-ch	Model6 Tech-ch	Model6 TFP	Model7 TE-ch	Model7 Tech-ch	Model7 TFP
1980	QLD	1.000	1.000	1.000	1.000	1.000	1.000	na	na	na
1981	QLD	1.000	1.004	1.004	1.000	1.005	1.005	na	na	na
1982	QLD	1.000	0.986	0.986	1.000	0.986	0.986	na	na	na
1983	QLD	1.000	1.024	1.024	1.000	1.023	1.023	na	na	na
1984	QLD	1.000	1.063	1.063	1.000	1.061	1.061	na	na	na
1985	QLD	1.000	1.114	1.114	1.000	1.112	1.112	na	na	na
1986	QLD	1.000	1.214	1.214	1.000	1.211	1.211	na	na	na
1987	QLD	1.000	1.317	1.317	1.000	1.311	1.311	na	na	na
1988	QLD	1.000	1.408	1.408	1.000	1.401	1.401	na	na	na
1989	QLD	1.000	1.482	1.482	1.000	1.475	1.475	na	na	na
1990	QLD	1.000	1.565	1.565	1.000	1.557	1.557	na	na	na
1991	QLD	1.000	1.605	1.605	1.000	1.597	1.597	na	na	na
1992	QLD	1.000	1.657	1.657	1.000	1.649	1.649	na	na	na
1993	QLD	1.000	1.672	1.672	1.000	1.663	1.663	na	na	na
1994	QLD	1.000	1.781	1.781	1.000	1.771	1.771	na	na	na
1995	QLD	1.000	1.758	1.758	1.000	1.749	1.749	na	na	na
1996	QLD	1.000	1.707	1.707	1.000	1.694	1.694	na	na	na
1997	QLD	1.000	3.223	3.223	1.000	3.197	3.197	1.000	1.000	1.000
1998	QLD	1.000	3.756	3.756	1.000	3.725	3.725	1.000	1.056	1.056
1999	QLD	1.000	3.741	3.741	1.000	3.702	3.702	1.000	1.057	1.057
2000	QLD	1.000	3.726	3.726	1.000	3.693	3.693	1.000	1.152	1.152
2001	QLD	0.990	3.763	3.724	0.999	3.697	3.695	1.000	1.178	1.178

The Result of Decomposition of Total Factor Productivity: South Australia (Part A) Model 1–Model 4

	States	Model1			Model2			Model3			Model4		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	SA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	SA	0.937	0.992	0.930	0.938	0.993	0.931	1.011	1.019	1.031	1.000	1.102	1.102
1982	SA	0.971	0.979	0.951	0.971	0.980	0.952	0.888	1.182	1.050	1.000	1.242	1.242
1983	SA	0.995	0.978	0.972	0.995	0.979	0.974	1.011	1.119	1.132	1.000	1.354	1.354
1984	SA	1.033	0.966	0.998	1.033	0.967	0.999	0.974	1.119	1.090	1.000	1.416	1.416
1985	SA	0.960	1.029	0.988	0.960	1.031	0.989	0.944	1.185	1.118	1.000	1.544	1.544
1986	SA	0.979	1.016	0.994	0.979	1.017	0.996	0.928	1.228	1.139	1.000	1.567	1.567
1987	SA	1.022	1.025	1.048	1.023	1.026	1.050	0.933	1.245	1.162	0.987	1.628	1.606
1988	SA	1.016	1.043	1.060	1.017	1.044	1.061	0.928	1.266	1.175	0.997	1.683	1.678
1989	SA	1.039	1.040	1.080	1.039	1.041	1.081	0.947	1.250	1.184	0.994	1.721	1.711
1990	SA	1.077	1.056	1.137	1.078	1.057	1.139	0.987	1.276	1.260	1.000	1.811	1.811
1991	SA	1.105	1.222	1.351	1.105	1.219	1.348	1.011	1.473	1.489	1.000	2.084	2.084
1992	SA	1.105	1.123	1.242	1.105	1.121	1.239	1.011	1.357	1.373	1.000	2.073	2.073
1993	SA	1.105	1.169	1.292	1.105	1.166	1.289	1.011	1.409	1.425	1.000	2.185	2.185
1994	SA	1.105	1.188	1.313	1.105	1.185	1.310	1.011	1.437	1.453	1.000	2.349	2.349
1995	SA	1.105	1.337	1.477	1.105	1.334	1.474	1.011	1.582	1.599	1.000	2.539	2.539
1996	SA	1.105	1.456	1.609	na	na	na	na	na	na	na	na	na
1997	SA	1.105	1.481	1.637	na	na	na	na	na	na	na	na	na
1998	SA	1.105	1.543	1.706	na	na	na	na	na	na	na	na	na
1999	SA	1.105	1.474	1.629	na	na	na	na	na	na	na	na	na
2000	SA	1.105	1.509	1.668	na	na	na	na	na	na	na	na	na
2001	SA	1.105	1.477	1.632	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: South Australia (Part B) Model 5–Model 6

	States	Model5			Model6			Model7		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	SA	1.000	1.000	1.000	1.000	1.000	1.000	na	na	na
1981	SA	1.000	1.027	1.027	1.000	1.022	1.022	na	na	na
1982	SA	1.000	1.047	1.047	1.000	1.047	1.047	na	na	na
1983	SA	1.000	1.083	1.083	1.000	1.072	1.072	na	na	na
1984	SA	1.000	1.066	1.066	1.000	1.062	1.062	na	na	na
1985	SA	1.000	1.095	1.095	1.000	1.069	1.069	na	na	na
1986	SA	0.927	1.195	1.108	1.000	1.047	1.047	na	na	na
1987	SA	0.946	1.205	1.140	1.000	1.057	1.057	na	na	na
1988	SA	0.927	1.232	1.143	1.000	1.052	1.052	na	na	na
1989	SA	0.926	1.242	1.151	1.000	1.078	1.078	na	na	na
1990	SA	0.909	1.254	1.139	0.988	1.081	1.068	na	na	na
1991	SA	0.902	1.257	1.134	0.974	1.081	1.052	na	na	na
1992	SA	0.904	1.253	1.133	0.976	1.089	1.063	na	na	na
1993	SA	0.926	1.248	1.156	1.000	1.091	1.091	na	na	na
1994	SA	0.927	1.250	1.159	1.000	1.143	1.143	na	na	na
1995	SA	0.936	1.243	1.164	1.000	1.132	1.132	na	na	na
1996	SA	1.000	1.280	1.280	1.000	1.188	1.188	na	na	na
1997	SA	0.907	1.574	1.427	0.976	1.354	1.321	1.000	1.000	1.000
1998	SA	0.935	1.541	1.440	0.993	1.342	1.333	1.017	0.998	1.015
1999	SA	0.889	1.574	1.400	1.000	1.352	1.352	1.024	1.006	1.030
2000	SA	0.941	1.565	1.473	1.000	1.451	1.451	1.038	1.015	1.054
2001	SA	0.917	1.596	1.463	1.000	1.448	1.448	1.038	1.111	1.154

The Result of Decomposition of Total Factor Productivity: Western Australia (Part A) Model 1–Model 4

	States	Model1			Model2			Model3			Model4		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	WA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	WA	0.972	0.995	0.968	0.972	0.995	0.968	0.972	0.995	0.968	1.000	1.136	1.136
1982	WA	0.971	0.988	0.959	0.971	0.988	0.959	0.971	0.988	0.959	1.000	1.265	1.265
1983	WA	1.051	0.932	0.980	1.051	0.932	0.980	1.051	0.932	0.980	1.000	1.416	1.416
1984	WA	1.041	0.910	0.946	1.041	0.910	0.946	1.041	0.910	0.946	1.000	1.528	1.528
1985	WA	1.002	0.956	0.958	1.002	0.956	0.958	1.002	0.956	0.958	1.000	1.617	1.617
1986	WA	1.015	0.962	0.976	1.015	0.962	0.976	1.027	0.973	0.999	1.000	1.719	1.719
1987	WA	1.006	0.976	0.982	1.006	0.976	0.982	1.035	0.983	1.018	1.000	1.892	1.892
1988	WA	1.002	0.983	0.985	1.002	0.983	0.985	1.013	1.004	1.016	1.000	2.016	2.016
1989	WA	1.040	0.991	1.031	1.040	0.991	1.031	1.059	1.007	1.066	1.000	2.196	2.196
1990	WA	1.024	1.020	1.044	1.024	1.020	1.044	1.024	1.055	1.080	1.000	2.316	2.316
1991	WA	1.006	1.047	1.053	1.006	1.047	1.053	1.013	1.077	1.091	1.000	2.385	2.385
1992	WA	1.030	1.014	1.045	1.030	1.014	1.045	1.030	1.047	1.078	1.000	2.447	2.447
1993	WA	1.041	1.027	1.070	1.041	1.027	1.070	1.056	1.046	1.105	1.000	2.478	2.478
1994	WA	1.064	1.005	1.070	1.064	1.005	1.070	1.069	1.021	1.092	1.000	2.592	2.592
1995	WA	1.071	1.045	1.119	1.071	1.045	1.119	1.079	1.061	1.144	1.000	2.550	2.550
1996	WA	1.050	1.069	1.122	na	na	na	na	na	na	na	na	na
1997	WA	1.002	1.090	1.093	na	na	na	na	na	na	na	na	na
1998	WA	1.007	1.116	1.124	na	na	na	na	na	na	na	na	na
1999	WA	1.018	1.100	1.119	na	na	na	na	na	na	na	na	na
2000	WA	1.045	1.068	1.116	na	na	na	na	na	na	na	na	na
2001	WA	1.048	1.110	1.164	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: Western Australia (Part B) Model 5–Model 6

	States		Model5			Model6			Model7	
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	WA	1.000	1.000	1.000	1.000	1.000	1.000	na	na	na
1981	WA	1.027	1.001	1.028	1.024	1.002	1.026	na	na	na
1982	WA	1.074	0.987	1.060	1.072	0.987	1.058	na	na	na
1983	WA	1.067	0.986	1.052	1.065	0.986	1.049	na	na	na
1984	WA	1.041	0.996	1.037	1.038	0.996	1.034	na	na	na
1985	WA	1.042	1.013	1.055	1.044	1.011	1.055	na	na	na
1986	WA	0.996	1.063	1.059	1.047	1.044	1.093	na	na	na
1987	WA	1.017	1.055	1.072	1.041	1.066	1.110	na	na	na
1988	WA	0.982	1.092	1.072	1.070	1.073	1.148	na	na	na
1989	WA	0.971	1.092	1.061	1.034	1.105	1.143	na	na	na
1990	WA	0.975	1.086	1.059	1.005	1.135	1.140	na	na	na
1991	WA	0.952	1.109	1.056	0.987	1.144	1.129	na	na	na
1992	WA	0.971	1.106	1.073	1.028	1.125	1.156	na	na	na
1993	WA	0.995	1.101	1.096	1.033	1.142	1.180	na	na	na
1994	WA	0.993	1.097	1.089	1.023	1.147	1.173	na	na	na
1995	WA	0.995	1.104	1.098	1.082	1.129	1.221	na	na	na
1996	WA	0.943	1.089	1.027	1.016	1.122	1.140	na	na	na
1997	WA	0.965	1.102	1.064	1.024	1.152	1.179	na	na	na
1998	WA	0.977	1.079	1.054	1.025	1.143	1.172	na	na	na
1999	WA	1.007	1.102	1.110	1.083	1.144	1.239	na	na	na
2000	WA	0.978	1.096	1.072	1.011	1.181	1.194	na	na	na
2001	WA	0.968	1.117	1.081	1.012	1.190	1.205	na	na	na

The Result of Decomposition of Total Factor Productivity: Tasmania (Part A) Model 1–Model 4

	States	Model1			Model2			Model3			Model4		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	TAS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	TAS	1.000	0.964	0.964	1.000	0.939	0.939	1.000	0.365	0.365	1.000	0.388	0.388
1982	TAS	1.000	0.965	0.965	1.000	0.892	0.892	1.000	0.236	0.236	1.000	0.267	0.267
1983	TAS	1.000	0.949	0.949	1.000	0.820	0.820	1.000	0.216	0.216	1.000	0.259	0.259
1984	TAS	1.000	0.946	0.946	1.000	0.770	0.770	1.000	0.208	0.208	1.000	0.269	0.269
1985	TAS	1.000	0.881	0.881	1.000	0.730	0.730	1.000	0.260	0.260	1.000	0.354	0.354
1986	TAS	1.000	0.878	0.878	1.000	0.728	0.728	1.000	1.201	1.201	1.000	1.683	1.683
1987	TAS	1.000	0.836	0.836	1.000	0.666	0.666	1.000	1.098	1.098	1.000	1.644	1.644
1988	TAS	1.000	1.106	1.106	1.000	0.866	0.866	1.000	0.583	0.583	1.000	0.884	0.884
1989	TAS	1.000	1.104	1.104	1.000	0.866	0.866	1.000	0.549	0.549	1.000	0.857	0.857
1990	TAS	1.000	1.058	1.058	1.000	0.807	0.807	1.000	0.177	0.177	1.000	0.278	0.278
1991	TAS	1.000	0.979	0.979	1.000	0.746	0.746	1.000	0.153	0.153	1.000	0.241	0.241
1992	TAS	1.000	1.013	1.013	1.000	0.770	0.770	1.000	1.018	1.018	1.000	1.667	1.667
1993	TAS	1.000	1.038	1.038	1.000	0.737	0.737	1.000	1.131	1.131	1.000	1.877	1.877
1994	TAS	1.000	1.065	1.065	1.000	0.756	0.756	1.000	1.157	1.157	1.000	1.942	1.942
1995	TAS	1.000	1.054	1.054	1.000	0.752	0.752	1.000	1.142	1.142	1.000	1.961	1.961
1996	TAS	1.000	1.158	1.158	na	na	na	na	na	na	na	na	na
1997	TAS	1.000	1.257	1.257	na	na	na	na	na	na	na	na	na
1998	TAS	1.000	1.139	1.139	na	na	na	na	na	na	na	na	na
1999	TAS	1.000	1.123	1.123	na	na	na	na	na	na	na	na	na
2000	TAS	1.000	1.186	1.186	na	na	na	na	na	na	na	na	na
2001	TAS	1.000	1.186	1.186	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: Tasmania (Part B) Model 5–Model 6

	States	Model5			Model6			Model7		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	TAS	na	na	na	na	na	na	na	na	na
1981	TAS	na	na	na	na	na	na	na	na	na
1982	TAS	na	na	na	na	na	na	na	na	na
1983	TAS	na	na	na	na	na	na	na	na	na
1984	TAS	na	na	na	na	na	na	na	na	na
1985	TAS	na	na	na	na	na	na	na	na	na
1986	TAS	na	na	na	na	na	na	na	na	na
1987	TAS	na	na	na	na	na	na	na	na	na
1988	TAS	na	na	na	na	na	na	na	na	na
1989	TAS	na	na	na	na	na	na	na	na	na
1990	TAS	na	na	na	na	na	na	na	na	na
1991	TAS	na	na	na	na	na	na	na	na	na
1992	TAS	na	na	na	na	na	na	na	na	na
1993	TAS	na	na	na	na	na	na	na	na	na
1994	TAS	na	na	na	na	na	na	na	na	na
1995	TAS	na	na	na	na	na	na	na	na	na
1996	TAS	na	na	na	na	na	na	na	na	na
1997	TAS	na	na	na	na	na	na	na	na	na
1998	TAS	na	na	na	na	na	na	na	na	na
1999	TAS	na	na	na	na	na	na	na	na	na
2000	TAS	na	na	na	na	na	na	na	na	na
2001	TAS	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: Northern Territory (Part A) Model 1–Model 4

	States	Model1			Model2			Model3			Model4		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	NT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	NT	1.097	0.979	1.075	1.097	0.979	1.075	1.097	0.979	1.075	1.000	1.007	1.007
1982	NT	1.101	0.999	1.100	1.101	0.999	1.100	1.101	0.999	1.100	1.000	1.135	1.135
1983	NT	1.084	0.999	1.083	1.084	0.999	1.083	1.084	0.999	1.083	1.000	1.252	1.252
1984	NT	1.106	0.993	1.097	1.106	0.993	1.097	1.106	0.993	1.097	1.000	1.353	1.353
1985	NT	1.102	0.992	1.093	1.102	0.992	1.093	1.102	0.992	1.093	1.000	1.389	1.389
1986	NT	1.129	0.992	1.120	1.129	0.992	1.120	1.129	0.992	1.120	1.000	1.716	1.716
1987	NT	1.077	0.975	1.050	1.077	0.975	1.050	1.077	0.975	1.050	1.000	1.647	1.647
1988	NT	1.117	0.973	1.086	1.117	0.973	1.086	1.200	0.936	1.124	1.000	1.896	1.896
1989	NT	1.338	0.962	1.287	1.338	0.962	1.287	1.389	1.117	1.552	1.000	2.363	2.363
1990	NT	1.207	0.955	1.152	1.207	0.955	1.152	1.314	1.123	1.475	1.000	2.091	2.091
1991	NT	1.170	0.983	1.150	1.170	0.983	1.150	1.298	1.160	1.506	1.000	2.156	2.156
1992	NT	1.156	0.964	1.114	1.156	0.964	1.114	1.265	1.151	1.456	1.000	2.405	2.405
1993	NT	1.205	0.970	1.169	1.205	0.970	1.169	1.291	1.167	1.507	1.000	2.461	2.461
1994	NT	1.226	0.970	1.188	1.226	0.970	1.188	1.236	1.184	1.463	1.000	2.597	2.597
1995	NT	1.207	0.966	1.167	1.207	0.966	1.167	1.263	1.175	1.484	1.000	2.635	2.635
1996	NT	1.205	0.993	1.196	na	na	na	na	na	na	na	na	na
1997	NT	1.223	1.018	1.245	na	na	na	na	na	na	na	na	na
1998	NT	1.286	1.050	1.350	na	na	na	na	na	na	na	na	na
1999	NT	1.225	1.056	1.294	na	na	na	na	na	na	na	na	na
2000	NT	1.283	1.043	1.337	na	na	na	na	na	na	na	na	na
2001	NT	1.225	1.054	1.292	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: Northern Territory (Part B) Model 5–Model 6

Year	States	Model5			Model6			Model7		
		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	NT	1.000	1.000	1.000	1.000	1.000	1.000	na	na	na
1981	NT	1.025	1.007	1.031	1.029	1.003	1.032	na	na	na
1982	NT	1.045	0.985	1.030	1.023	1.006	1.030	na	na	na
1983	NT	1.040	0.984	1.023	1.012	1.011	1.023	na	na	na
1984	NT	1.025	0.993	1.018	0.995	1.024	1.018	na	na	na
1985	NT	0.997	1.021	1.017	1.007	1.014	1.021	na	na	na
1986	NT	0.995	1.047	1.041	1.071	1.003	1.074	na	na	na
1987	NT	0.905	1.054	0.954	0.975	1.024	0.999	na	na	na
1988	NT	0.905	1.078	0.975	1.139	1.061	1.208	na	na	na
1989	NT	1.009	1.086	1.096	1.139	1.170	1.332	na	na	na
1990	NT	1.003	1.096	1.100	1.139	1.204	1.371	na	na	na
1991	NT	1.004	1.099	1.104	1.139	1.223	1.393	na	na	na
1992	NT	1.004	1.096	1.100	1.139	1.288	1.467	na	na	na
1993	NT	0.990	1.092	1.081	1.139	1.261	1.436	na	na	na
1994	NT	0.995	1.094	1.088	1.139	1.332	1.517	na	na	na
1995	NT	0.979	1.094	1.071	1.139	1.320	1.503	na	na	na
1996	NT	0.925	1.104	1.021	1.139	1.287	1.466	na	na	na
1997	NT	0.986	1.318	1.299	1.139	1.611	1.835	1.000	1.000	1.000
1998	NT	1.021	1.290	1.317	1.139	1.644	1.872	1.014	1.011	1.024
1999	NT	0.978	1.318	1.289	1.139	1.753	1.996	1.014	0.988	1.001
2000	NT	1.057	1.310	1.385	1.139	1.839	2.094	1.014	0.979	0.992
2001	NT	1.001	1.477	1.479	1.139	2.047	2.331	1.014	0.976	0.990

The Result of Decomposition of Total Factor Productivity: Australia (Part A) Model 1–Model 4

	States	Model1			Model2			Model3			Model4		
Year		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	Australia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	Australia	0.960	1.017	0.972	0.966	1.004	0.967	0.976	0.925	0.899	1.000	0.984	0.984
1982	Australia	0.963	1.009	0.971	0.963	1.009	0.970	0.951	0.952	0.897	1.000	1.058	1.058
1983	Australia	0.979	0.998	0.974	0.975	1.000	0.970	0.978	0.941	0.914	1.000	1.184	1.184
1984	Australia	0.976	0.991	0.964	0.977	0.979	0.950	0.982	0.920	0.896	1.000	1.241	1.241
1985	Australia	0.975	0.998	0.968	0.975	0.993	0.963	0.973	0.966	0.932	1.000	1.302	1.302
1986	Australia	1.002	0.983	0.983	1.002	0.983	0.983	0.996	1.102	1.093	1.000	1.589	1.589
1987	Australia	1.000	0.982	0.980	1.000	0.982	0.980	0.991	1.096	1.083	0.998	1.646	1.643
1988	Australia	1.018	1.029	1.047	1.018	1.019	1.037	1.019	1.028	1.043	1.000	1.646	1.645
1989	Australia	1.061	1.036	1.095	1.061	1.027	1.086	1.058	1.054	1.116	0.999	1.770	1.768
1990	Australia	1.049	1.048	1.097	1.049	1.038	1.086	1.051	1.029	1.086	1.000	1.710	1.710
1991	Australia	1.045	1.084	1.132	1.045	1.076	1.124	1.050	1.081	1.140	1.000	1.792	1.792
1992	Australia	1.046	1.073	1.121	1.046	1.063	1.111	1.048	1.187	1.243	1.000	2.067	2.067
1993	Australia	1.055	1.095	1.152	1.055	1.076	1.134	1.056	1.222	1.287	1.000	2.180	2.180
1994	Australia	1.061	1.112	1.176	1.061	1.091	1.155	1.050	1.241	1.299	1.000	2.309	2.309
1995	Australia	1.059	1.154	1.219	1.059	1.135	1.200	1.055	1.280	1.344	1.000	2.357	2.357
1996	Australia	1.048	1.197	1.253	na	na	na	na	na	na	na	na	na
1997	Australia	1.052	1.230	1.291	na	na	na	na	na	na	na	na	na
1998	Australia	1.062	1.265	1.338	na	na	na	na	na	na	na	na	na
1999	Australia	1.054	1.250	1.315	na	na	na	na	na	na	na	na	na
2000	Australia	1.066	1.276	1.354	na	na	na	na	na	na	na	na	na
2001	Australia	1.059	1.288	1.358	na	na	na	na	na	na	na	na	na

The Result of Decomposition of Total Factor Productivity: Australia (Part B) Model 5–Model 6

Year	States	Model5			Model6			Model7		
		TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP	TE-ch	Tech-ch	TFP
1980	Australia	1.000	1.000	1.000	1.000	1.000	1.000	na	na	na
1981	Australia	1.009	1.006	1.014	1.009	1.004	1.013	na	na	na
1982	Australia	1.019	0.995	1.014	1.016	0.998	1.014	na	na	na
1983	Australia	1.018	1.003	1.020	1.013	1.005	1.018	na	na	na
1984	Australia	1.011	0.999	1.010	1.006	1.002	1.008	na	na	na
1985	Australia	1.006	1.045	1.052	1.008	1.041	1.049	na	na	na
1986	Australia	0.986	1.091	1.075	1.020	1.057	1.077	na	na	na
1987	Australia	0.978	1.119	1.094	1.003	1.090	1.093	na	na	na
1988	Australia	0.961	1.166	1.122	1.027	1.129	1.158	na	na	na
1989	Australia	0.984	1.188	1.169	1.028	1.176	1.209	na	na	na
1990	Australia	0.981	1.215	1.192	1.022	1.212	1.239	na	na	na
1991	Australia	0.971	1.238	1.204	1.017	1.233	1.254	na	na	na
1992	Australia	0.980	1.246	1.221	1.024	1.255	1.285	na	na	na
1993	Australia	0.985	1.240	1.222	1.029	1.250	1.285	na	na	na
1994	Australia	0.986	1.284	1.266	1.027	1.314	1.349	na	na	na
1995	Australia	0.985	1.293	1.274	1.037	1.316	1.362	na	na	na
1996	Australia	0.978	1.287	1.263	1.025	1.309	1.340	na	na	na
1997	Australia	0.976	1.973	1.939	1.022	1.991	2.027	1.000	1.000	1.000
1998	Australia	0.989	2.086	2.070	1.026	2.120	2.161	1.006	1.030	1.036
1999	Australia	0.979	2.124	2.091	1.037	2.161	2.218	1.007	1.024	1.031
2000	Australia	0.996	2.127	2.120	1.025	2.207	2.252	1.010	1.043	1.054
2001	Australia	0.979	2.200	2.166	1.025	2.274	2.324	1.010	1.072	1.083

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