Economic forecasting, impact analysis and regional planning with a focus on the Illawarra

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Economic Forecasting, Impact Analysis and Regional Planning With a Focus on the Illawarra

Ashkan Masouman

This thesis is presented as part of the requirement for the Award of the Degree of

DOCTOR OF PHILOSOPHY

from the
University of Wollongong

August 2014
I, Ashkan MASOUMAN, state that this thesis, submitted in fulfilment of the requirements for
the award of Doctor of Philosophy, in the School of Accounting, Economics and Finance,
Faculty of Business, University of Wollongong, is wholly my own work unless otherwise
referenced or acknowledged. The document has not been submitted for qualifications at any
other academic institution.

Ashkan MASOUMAN

20 August 2014
Abstract

Purpose – This thesis investigates the Illawarra economy and presents three approaches to conducting policy impact analysis and economic forecasting. The primary focus of the policy analysis and economic forecasting is measuring the changes that occur in regional output, income and employment as a result of different policies and economic activities. This thesis analyses the structural shifts and economic transitions that have taken place in the regional economy over the past two decades to determine the direction of the economy and analyse impacts of different policies and economic activities on the regional economy.

Methodology – There are five methodologies extended from the literature and adopted in this thesis: two standalone traditional models, namely a standalone input-out analysis and a regional econometric model; and three merged models, namely composite, holistic embedded and linked, all of which result from merging the input-output analysis and econometric model. All the aforementioned models are developed considering regional specificities of the Illawarra. The results from the five models are used in two different experiments. The first experiment is a comparative analysis of all the models for an ex-post forecasting of the employment for 2011, using time-series data for 1990-2009 period. The second experiment is an industry significance analysis of 30 sectors with respect to regional output, income and employment.

Findings – The results obtained from the forecasting experiment indicate that the integrated models as a framework produce higher accuracy, less error, and superior performance in comparison to standalone traditional models. Nevertheless, there is a wide variation between the performance and complexity of different integrated methodologies, ranging from highly complex and data intensive as the case for composite to the least data and calibration requirement as the case for the holistic embedded approach. The results obtained from the industry significance experiment indicate that professional and scientific,
administrative services and construction sectors have the highest impacts on regional output. Education and training, health and social services, and administrative services sectors have the highest impacts on the regional economy with respect to income. Most importantly, in terms of employment, personal and other services, health and social services, and education and training sectors have the highest impacts on the regional economy.

Research contributions – The practical contributions of this thesis are fourfold. This thesis emphasises the importance of the Illawarra economy as the microcosm of the national economy. Employing the aforementioned methodologies, this thesis forecasts structural changes that are likely to happen in employment, regional output, and income as a result of economic transformation. This thesis investigates the industries that were most important in prompting major shifts in employment, regional output, and income in the past 20 years. Finally, this thesis provides a framework to better analyse the impacts that different policies have on economic structure with respect to regional employment, regional output, and income. The theoretical contributions of this thesis are fivefold. This thesis provides inference that integrated models as a framework, offer more advantages, in comparison with traditional models, in terms of accuracy, dynamic, forecasting, impact analysis, price responsiveness, sectoral disaggregation. This thesis provides empirical results of different integration methodologies compare and contrast when all are applied to a single region. this thesis concludes which integration methodology is appropriate for forecasting and which integration methodology is appropriate for impact analysis. And, finally, it uses empirical evidence to measure fitness of each integration methodology for any region with respect to its socioeconomic specificities.
Acknowledgements

First and foremost, I wish to express my deepest appreciation to my principal supervisor and my mentor, Associate Professor Charles Harvie, for his continuous efforts and hear-warming support and all that he has done for me during the course of my PhD program. His unswerving encouragements and profound interest in my research were truly constructive and inspiring; I owe a significant part of my success in academia to his support. I’d like to extend many appreciations to Dr. Corinne Cortese for her unfailing support and remarkable guidance during the final year of my research. I’d also like to thank Associate Professor Mark Nelson for his feedback, assistance and suggestions on several chapters of my thesis. Last but not the least; I would like to thank Professor Abbas Valadkhani for the initial arrangement and support of PhD program.

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I’d like to extend my heartfelt appreciations to my loving parents and my beautiful sisters for putting much faith and trust in me and for always unconditionally believing in me. And my special thanks to my kind and gorgeous soul mate, Sara, who patiently stood by me; fed me; listened to my unending economics talks and theories despite her own specialization in medicine; and kindly supported me in every direction over the past nearly four years.
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<td>AAC</td>
<td>Australian Agricultural Company</td>
</tr>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
</tr>
<tr>
<td>ACIL</td>
<td>ACIL Allen Consulting</td>
</tr>
<tr>
<td>AI &amp; S</td>
<td>Australian Iron &amp; Steel</td>
</tr>
<tr>
<td>AMI</td>
<td>Advanced Manufacturing Industry</td>
</tr>
<tr>
<td>ANZIC</td>
<td>Australian and New Zealand Industry Classification</td>
</tr>
<tr>
<td>AR</td>
<td>Autoregressive</td>
</tr>
<tr>
<td>BEA</td>
<td>Bureau of Economic Analysis</td>
</tr>
<tr>
<td>BHP</td>
<td>Broken Hill Proprietary</td>
</tr>
<tr>
<td>BI</td>
<td>Business Inventories</td>
</tr>
<tr>
<td>BVAR</td>
<td>Bayesian Vector-Autoregressive</td>
</tr>
<tr>
<td>CAF</td>
<td>Cost Adjustment Factor</td>
</tr>
<tr>
<td>CBD</td>
<td>Central Business District</td>
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<tr>
<td>CGE</td>
<td>Computable General Equilibrium</td>
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<tr>
<td>CHARM</td>
<td>Cross-Hauling Adjusted Regionalization Method</td>
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<tr>
<td>COUP</td>
<td>Coupling</td>
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<td>CREIM</td>
<td>Chicago Regional EC-I0 Model</td>
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<tr>
<td>DIA</td>
<td>Dynamic Integration Approach</td>
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<tr>
<td>DIDV</td>
<td>Dynamic Inter-industry Demand Variable</td>
</tr>
<tr>
<td>DIEDV</td>
<td>Dynamic Inter-industry Employment Demand Variable</td>
</tr>
<tr>
<td>DIISRTE</td>
<td>Department of Industry, Innovation, Science, Research and Tertiary Education (abolished)</td>
</tr>
<tr>
<td>DITP</td>
<td>Disposable Income Net of Transfer Payments</td>
</tr>
<tr>
<td>DRA</td>
<td>Department of Regional Australia (abolished)</td>
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<tr>
<td>DS</td>
<td>Direct Sales</td>
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<tr>
<td>EC</td>
<td>Econometric</td>
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<td>EDFS</td>
<td>Economic-Demographic Forecasting and Simulation</td>
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<td>EMB</td>
<td>Embedding</td>
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<td>EX</td>
<td>Exports</td>
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<td>FGLS</td>
<td>Feasible Generalized Least Squares</td>
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<td>FTE</td>
<td>Full-Time Equivalent</td>
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<td>GDP</td>
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<td>GFC</td>
<td>Global Financial Crisis</td>
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<td>Generation of Regional Input-Output Tables</td>
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<td>Gross Regional Product</td>
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<td>GSP</td>
<td>Gross State Product</td>
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<td>HSRL</td>
<td>High Speed Rail Link</td>
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<tr>
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<td>Description</td>
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<td>I</td>
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<td>IBC</td>
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<td>IEDR</td>
<td>Intermediate Employment Demand Requirement</td>
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<td>Intermediate Employment Demand Variable</td>
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<td>IEIOM</td>
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<td>ILAF</td>
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<td>IM</td>
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<td>Illawarra Regional Airport</td>
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<td>IRIIF</td>
<td>Illawarra Region Innovation and Investment Fund</td>
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<td>IUDP</td>
<td>Illawarra Urban Development Program</td>
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<td>KEES</td>
<td>Kiama Economic and Employment Strategy</td>
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<td>KLEM</td>
<td>Capital, Labour, Energy and Materials</td>
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<td>Kiama Municipal Council</td>
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<td>LC</td>
<td>Letter of Credit</td>
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<td>Local Government Area</td>
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<td>Labour Market Information Portal</td>
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<td>Location Quotient</td>
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<td>MAPE</td>
<td>Mean Absolute Percentage Error</td>
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<td>Metal Manufacturers</td>
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<td>MPC</td>
<td>Marginal Propensity to Consume</td>
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<tr>
<td>MRCIO</td>
<td>Closed Multiregional IO</td>
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<td>MREC</td>
<td>Multiregional EC</td>
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<tr>
<td>MRIO</td>
<td>Multiregional IO</td>
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<td>MSA</td>
<td>Metropolitan Statistical Area</td>
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<td>MSA</td>
<td>Manufacturing Skills Australia</td>
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<tr>
<td>NFS</td>
<td>National Forest Service</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>NIPA</td>
<td>National Income and Product Accounts</td>
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<td>NRIES</td>
<td>National Research Institute for Education Sciences</td>
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<td>NSW</td>
<td>New South Wales</td>
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<td>NSW DII</td>
<td>New South Wales Department of Industry &amp; Investment</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-Operation and Development</td>
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<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
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<tr>
<td>O-O</td>
<td>Output-Output</td>
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<td>OPSM</td>
<td>Ohio Projection and Simulation Model</td>
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<td>PCE</td>
<td>Personal Consumption Expenditures</td>
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<td>PIR</td>
<td>Prime Interest Rate</td>
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<tr>
<td>QIM</td>
<td>Queensland Integrated Model</td>
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<td>QUIP</td>
<td>Queensland Impact and Projection</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>RAAF</td>
<td>Royal Australian Air Force</td>
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<td>RDA</td>
<td>Regional Development Australia</td>
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<td>Regional Development Australia Fund</td>
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<td>REMI</td>
<td>Regional Economic Model Inc.</td>
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<td>RIMS</td>
<td>Regional IO Modelling System</td>
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<td>RPC</td>
<td>Regional Purchase Coefficient</td>
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<td>SA</td>
<td>Statistical Area</td>
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<td>SCC</td>
<td>Shellharbour City Council</td>
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<tr>
<td>SCG</td>
<td>Southern Council Group</td>
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<td>SD</td>
<td>Statistical Division</td>
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<td>SDA</td>
<td>Structural Decomposition Analysis</td>
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<td>SGSEP</td>
<td>SGS Economics &amp; Planning Pty Ltd</td>
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<td>SIDV</td>
<td>Static Inter-industry Demand Variable</td>
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<td>SIEDV</td>
<td>Static Inter-industry Employment Demand Variable</td>
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<td>SLGE</td>
<td>State and Local Educational Expenditures</td>
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<tr>
<td>SLGM</td>
<td>State and Local Miscellaneous Expenditures</td>
</tr>
<tr>
<td>SMART</td>
<td>Simulation, Modelling, Analysis, Research and Teaching</td>
</tr>
<tr>
<td>SRCIO</td>
<td>Closed Single Region IO</td>
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<tr>
<td>SRIIO</td>
<td>Single Region IO</td>
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<tr>
<td>TAFE</td>
<td>Technical and Further Education</td>
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<tr>
<td>TEU</td>
<td>Twenty-Food Equivalent Unit</td>
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<tr>
<td>TP</td>
<td>Transfer Payments</td>
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<tr>
<td>UNPLR</td>
<td>Regional Unemployment Rate</td>
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<tr>
<td>UOW</td>
<td>University of Wollongong</td>
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<tr>
<td>US</td>
<td>United States of America</td>
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<tr>
<td>VET</td>
<td>Vocational Education and Training</td>
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<td>WPSM</td>
<td>Washington Projection and Simulation Model</td>
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<td>WSV</td>
<td>Weighted Shapely Value</td>
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<tr>
<td>WWII</td>
<td>World War II</td>
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</table>
List of Candidate’s Awards and Publications

Awards

May 2013 Faculty of Business Three-Minute Thesis (3MT) People’s Choice Winner for presenting “Economic Modelling with a View to Redefining the Regional Economy” presented at Faculty of Business, University of Wollongong

Dec 2012 Highly Commended Award for a Conference Paper by a Current or Recent Student, for “Regional Economic Modelling: a Comparison of Econometric, Input-Output and Integrated Modelling of the Illawarra Economy” presented at the Australia and New Zealand Regional Science Association International (ANZRSAI) conference held at the University of Wollongong

Feb 2011 International Postgraduate Tuition Award

Higher Degree Research SMART Award (the only student from Faculty of Business to win this award in 2011)

Refereed Journal Articles


Refereed Conference Proceedings


Seminar Presentations and Discussions


Chapter 1

Introduction

1.1 Background of the Study

One of the continuing areas of focus in regional science since its inception, which dates back to nearly 70 years ago (Isard, 1949), has been on the development of tools for regional policy analysis. A significant emphasis in this regard has been placed on regional socioeconomic models, which provide a set of value systems associated with the structure of a regional political economy. Such models tend to analyse public policies that affect the structure of a regional economy. Socioeconomic models constitute an important element in the area of regional economic analysis.

Numerous studies related to regional economic analysis and regional policy related modelling have appeared in the literature (Cruz & Teixeira, 2010; Meyer et al., 2011; Schaefer et al., 2011; Mulligan et al., 2012; Newbold, 2012; Plane, 2012). Nonetheless, presenting a comprehensive chronicle of this account – except for the most relevant studies which are presented in the subsequent sections – is beyond the scope of this thesis. In comparison, the objective of this thesis is to highlight the major contributions in the field of regional economic analysis and present an innovative analytical tool inspired by these major contributions.

This thesis focuses on one of the most recent modelling developments, the integration of regional input-output (hereafter referred to as IO) modelling with regional econometric (henceforth referred to as EC) modelling. In the past three and a half decades, integrated models have been investigated by a number of economists to capture the benefits of both the inter-sectoral details of IO modelling and the dynamics of EC modelling (Isard & Anselin, 1982; Moghadam & Ballard, 1988; Anselin & Madden, 1990; Bertuglia et al., 1990; Conway,
A thorough analysis of the studies in the literature reveals that there is an emerging consensus on the motivations for implementing integrated models into regional planning. It is a common credence among integrated modellers that the traditional tools for regional analysis are inadequate to deal with the complexity of the issues that are of interest to regional analysts (Batey & Madden, 1986; Lakshman, 1982).

To analyse the structure of an economy at the regional level and to examine the potential impacts of policies on the future economy of a region, regional analysts frequently apply one of the two popular methods, namely IO and/or EC alone (Milne et al., 1980; Patterson, 1991; Fik et al., 1991; Fingleton, 2001; Henry at al., 2001; Kim et al., 2001; Agha et al., 2013; Dietzenbacher, 2013). The first method, IO analysis, is a detailed table of matrices, through which the interactions between economic sectors are examined and the impacts of exogenous shocks on the economy are analysed (West & Jackson, 1998; Miller & Blair, 2009). The multipliers in IO analysis enable analysts to calculate the direct and indirect effects of any shifts among various economic sectors and to trace the impacts of inter-sectoral transactions within an economy. The other method, EC modelling, is the most popular component of an economist’s toolkit. Regional economists have widely applied EC modelling, through which the growth rate of each sector is forecasted and the effects of a policy on high growth rate industries are evaluated. EC modelling provides dynamic characteristics and enables regional economists to track adjustments in variables of choice through time.

Having said that, each model applied alone ensues some drawbacks¹. For instance, IO models lack the dynamics of EC models whilst EC models do not provide a detailed snapshot of inter-sectoral interactions among economic sectors of a region (Bullard, 1978; Klein, 1978; Kim & Hewings, 2012). The drawbacks of each standalone model in application will be discussed in detail later in the chapter.
West, 1991; Israilevich, 1996). Given the two methods with their limitations when applied alone in analysis, the question is how accurate are the results of evaluating the potential effects of an economic shock such as shutdown of a large employer, a noticeable budget increase in an industry, a construction project and establishment of a new business, on other industries? What about the impacts of a potential policy such as adjustment of the overall rate of inflation or adjustment of relative prices of household expenditure commodities on employment, income, regional output and value added? Considering the features and the limitations of each method in isolation, a confident answer to this sort of question is highly doubtful.

Moreover, a number of studies suggest that there is a degree of uncertainty in traditional IO models despite their claimed deterministic character (Gerking, 1976; Bullard & Sebald, 1977; West, 1982; Schumann, 1990). The uncertainty is due to two factors: a) the unpreventable occurrence of statistical errors while collecting large data sets from various sectors; b) the time lag between the data collection time and the time that the collected data is applied in constructing the table, which usually is about one year (West, 1982). This time lag leads to adjustment of coefficients during periods of structural and technological changes. Nevertheless, despite these setbacks, IO offers a detailed snapshot of the transactions among various sectors of the economy. Conversely, the regional EC model avoids the time lag drawback by offering a dynamic analysis of industry variables over time, which is its main competence for forecasting purposes. However, the EC model does not provide an exhaustive picture of the economic structure and its inter-sectoral interactions for regional impact analysis (West, 1991). As a result, researchers have attempted to solve the quandary by integrating the two models to gain the merits of the inter-sectoral disaggregation of IO with the forecasting qualities of EC. The earliest works on integrating the two models dates back
to the 1970s, where a study by Klein (1978) suggested it was a useful exercise to reduce the restrictive assumptions of each model applied alone.

As mentioned earlier, an integrated IO and EC (hereafter referred to as IO-EC) model combines the advantages of both types of modelling. This in turn leads to relaxing the restrictive assumptions\(^2\) of IO analysis and adds the detailed inter-industry linkage to an EC model. Therefore we will benefit from increased accuracy in forecasting and improved capabilities in our model in impact analysis, which are highly advantageous in regional planning and economic analysis.

To date a significant number of studies have focused on applying the integrated framework in several regions within the U.S (Moghadam & Ballard, 1988; Conway, 1990; Coomes et al., 1991a; Israilevich et al., 1996; Rey, 1998; Motii, 2005). However, in the Australian context, except for West (1991; 1995), no studies have been found in the literature focusing on the integrated IO-EC model to conduct regional analysis. The lack of studies in the literature on regional analysis is especially noticeable on the Illawarra region, which is an important region within the New South Wales\(^3\) economy. The Illawarra economy is a microcosm of the Australian economy; adjustments in the Illawarra economy can represent adjustments in the national economy. Investigating the Illawarra economy is highly interesting due to the economic transitions and structural adjustments that have occurred in the Illawarra economy as a result of globalization. The Illawarra economy is not the only regional economy that has been impacted by globalization. Globalization has impacted regional economies around the globe. There are numerous other regions around the globe that face structural adjustments as a result of globalization and need economic planning and a clear direction for development. Hence, the integrated IO-EC framework developed in this

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\(^2\) This will be fully explicated in Chapter 3.

\(^3\) The economic importance of Illawarra as a region is discussed in detail in the following subsections of this chapter and Chapter 2 is wholly dedicated to analysing the Illawarra region.
study could be applied to other regions around the globe that are similarly in a transitional phase.

As pointed out, in the case of the Illawarra, there have been several shifts in the regional economy over the past few decades. A number of major key industries play a vital role in sustaining the economic welfare of the region. In regional economic development, inter-sectoral economic transactions, output demand, and employment are all influential factors in balancing the regional economy (Isard & Anselin, 1982). Thus it is of vital importance to gain more accuracy in terms of forecasting the major inter-sectoral shifts within the regional economy. To achieve this objective it is required to conduct a methodical impact analysis on the potential effects of new policies and structural changes to maintain a sound balance within the regional economy.

The main motivation of this thesis is drawn from four objectives, two theoretical and two practical. From a theoretical perspective, firstly, studies in the literature suggest that an integrated IO-EC strategy offers higher levels of accuracy in impact analysis and improved performance in forecasting for regional planning and economic analysis. Secondly, Rey (1998) suggests a classification of different integration strategies by applying them to five regions of Southern California and highlighting their competencies. Based upon Rey’s (1998) classification, this research aims to examine the properties of different integration approaches with a focus on the Illawarra region. The focus on the Illawarra is justified because of the region’s economic transitions over the past three decades, in particular the current shift from a heavy industry and mining based economy to a business service, knowledge and innovation based economy.

From an applied perspective, firstly, no studies have been conducted applying an integrated framework to a region in economic transition such as the economy of the Illawarra. The integrated framework developed in this study is applicable to any region where major
structural shifts have been occurring as a result of globalization. Secondly, the integrated model examines the Illawarra economy to forecast employment and analyse the potential impacts of new policies and structural changes on the economy of the region. The Illawarra economy plays a critical role in the Australian economy because it is considered a microcosm of the overall Australian economy and this is the first attempt to apply an integrated model to investigate the Illawarra economy. A brief overview on the choice of region is provided in Section 1.3 and a detailed account of the chosen region will be presented in Chapter 2.

1.2 Significance of the Study

In pursuing much of the literature on regional economic development it is surprising to find how authors have diversely and often imprecisely defined the term regional economic development. Regional economic development has been seen as both a product and a process. It is the product of economic development – for example, measured jobs, wealth, investment, standard of living and working conditions, things with which people living, working and investing in regions tend to be most concerned about. Generally increases or improvements in these measures are equated with economic development. It is the process – for example, industry support, infrastructure, labour force and market development with which economists and economic planners tend to be most concerned.

The significance of modelling in a regional economy context is emphatically justified due to the lack of attention given to policy analysis on a regional level, which in turn results from the lack of data availability at the regional level. The importance of this thesis is attributed to analysing the intensification of globalization on regional level and the applicability of its modelling to other regions in economic transition. The twofold modelling (impact analysis and forecasting) attribute of this thesis highlights and forecasts the impacts of regional transformation, which addresses policy implications to increase employment, household income, household consumption, and consequently gross regional product (GRP).
Although the methodology is not unique as such, the novelty of this thesis is the holistic comparison of the three integration strategies in merging IO and econometric models, as well as its generalizability to other regions in a transitional phase.

Moreover, when the objective of a modeller is to obtain highly accurate results from conducting a regional economic analysis, reducing the measurement errors in forecasting and impact analysis are key concerns. Applying different regional planning strategies, understanding their strengths and weaknesses, and improving the accuracy of forecasts and impact analyses are thus crucial. This thesis examines three different approaches in combining IO modelling and EC modelling, based on Rey’s (1998) classification, to highlight the characteristics of each approach and compare and contrast their results. The threefold modelling in this thesis provides different levels of accuracy in the results of forecasting and impact analyses for the Illawarra region with each approach. It also presents new insights into the effects of integration strategy on regional planning. Through this thesis, the power of using integrated IO-EC models to quantitatively forecast development in a regional economy context and analyse the impacts of different exogenous and endogenous shifts in the economy is demonstrated.

1.2.1 Contribution of the Study to the Literature

A large number of studies in the literature have focused on highlighting the merits of an integrated framework compared to either a traditional IO model or an EC model. On account of the comparative advantages of the integrated framework over stand-alone IO and EC models, studies on the application of an integrated approach have proliferated over the past two decades. However, a comparative analysis of different integrating methodologies is lacking in the literature. With the exception of Rey’s (1998) comparison of alternative integrating methodologies for six regions in Southern California; all studies have applied a single integration approach for a certain region at a time. At the same time, considering the
location specifics of regions under the available studies, the literature shows that except for a few studies conducted for the state of Queensland (West, 1991; West, 1995; West & Jackson, 1998) most studies have been performed for relatively urban areas within the states of California, Chicago, Kentucky, Missouri, Oklahoma, Washington in the US.

Therefore, the significant dual gap which appears in the literature is that firstly we do not know how each integration approach works when applied to a single region, secondly we have not seen studies applied to less urbanised regions where economic diversity is not advanced and data availability could be an issue. This thesis aims to fill this twofold gap by applying three integration methods and comparing them with the original regional IO table of the Illawarra. Accordingly, we apply all three integration approaches to the Illawarra region; examine how their results compare when applied to one regional economy. Although the framework developed in this thesis is applied to the Illawarra regional specificities, each of the three integrating methodologies is applicable to other regions around the globe.

The three integrating methodologies developed in this study would be of particular interest to regional economists investigating regions in an economic transition, such as the Illawarra. This is because the results from the comparative analysis shows which integrating approach is more suited to any particular region with respect to industrial linkages, economic diversity, data intensity, and whether the region is rural or urban in character. This framework can be a stepping stone to future studies that aim to address the problem of data dearth in regions that have not been the focus of economic analysis to date. As mentioned earlier, most studies have been conducted on the regions in the US, where sectoral data availability at the regional level is not an issue. Also, the three integrating approaches are compared to analyse how well they perform subject to cost and modelling complexity and observe how the results of each approach realistically compare for the Illawarra economy. This research adds to the literature by highlighting the advantages and issues and the strengths and weaknesses
associated with each approach. This research is intended to lead the way for future studies on the integration framework with a view to building models that fit a more diverse range of applications.

1.2.2 Research Questions

The questions that this thesis aims to address are twofold, based on the following arrangement.

A: Questions on the Illawarra:

1) What changes are likely to happen to regional income, employment, output and value added in the future?

2) Which industries were most important in prompting significant shifts to the regional economy in terms of income, employment, and output over the past three decades, and will they continue to be prominent in future transformations?

3) What impacts will different exogenous shocks such as a BlueScope Steel shutdown, a construction project, or surge of funds into a sector ensue on other sectors and/or on sectoral and regional employment, output, income and value added?

4) What impacts will different policies, such as adjustment of the overall rate of inflation; household expenditure relative commodity prices; average wage rates; taxation rates; and government expenditure have on regional employment, regional output, income and value added?

5) How might these impacts affect each local government area’s (LGA)\(^4\) economy within the Illawarra?

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\(^4\) According to the Australian Bureau of Statistics, every state and territory is composed of different statistical divisions (SD’s), which in turn are broken down to statistical sub-divisions (SSD’s), composed of local government areas (LGAs).
6) What impacts have globalization had on different sectors within the region in terms of income, employment, regional output and value added?

B: Questions on application of integration strategies to the Illawarra as a case study:

1) Do integrated IO-EC models as a framework offer more advantages, in terms of accuracy of results, economic forecasting, dynamic features, impact analysis, sectoral disaggregation, price responsiveness, over standalone IO or EC models?

2) How do the results of the different integration approaches compare and contrast when all are applied to a region in economic transition?

3) Which integration approach is more appropriate for forecasting?

4) Which integration approach is more appropriate for impact analysis?

5) Which integration approach is more appropriate for a region in economic transition with the specificities of that of the Illawarra?

1.2.3 Anticipated Outcomes

This research implements three methodologies in combining IO with EC models at the regional scale. These recognize Rey’s (1998) taxonomy of integrated methodologies. The properties of different integration approaches are then examined from a theoretical perspective, based on the treatment of model closure, dynamic representation, interregional linkages, sectoral aggregation, and estimation issues. Initial empirical insight as to the simulation and impact analysis capabilities of the alternative integration strategies is provided through a series of experiments employing integrated strategies for the Illawarra region. The projected results suggest that the integrated framework as a group provides increased accuracy in forecasting and improved impact analysis capabilities over traditional IO or non-integrated EC models. Additional insights are likely to be provided with regard to the sensitivity of model performance to the choice of integration strategy.
From a practical perspective, the findings of this research can be used to calculate the fiscal impacts for the three main local governments of the Illawarra, namely Wollongong, Shellharbour and Kiama. The findings can be used to determine how much the local government is willing to sacrifice to draw new businesses into the region. The framework built in this thesis can also be applied to a state or national level of study for other locations to determine the federal government’s end product tax concession. It can be used to calculate the direct and indirect impacts of expansion or shutdown of major businesses in each sector within the region, specifically with regard to employment, gross regional output, and household consumption.

The methodology is adaptable for other regions, in particular regions facing economic transformation like the Illawarra, under economic transition and structural shifts. It can be implemented to investigate the impacts of regional transformation and to analyse the intensification of globalization on a region. It also can be used as a guideline for regional analysts conducting studies on different geographical scopes and with different objectives for modelling. Based on the choice of variables and sectoral data availability in the region of choice, the framework developed in this study requires some adjustments to adapt to the specificities of the location and objectives of the modeller.

Lastly, the empirical model applied in this study can be used to evaluate the advantages and disadvantages of each integration methodology based on their accuracy and performance capabilities. Based on the nature of data that is available for a particular region, the results of each methodology can be gauged and evaluated to fit the nature and availability of data for that region and any other region in future studies.
1.3 Geographical Scope of the Study

The importance of choosing the Illawarra as a region in this research is reflected in two paths. First, the Illawarra is a microcosm of the Australian economy. Structural adjustments in the Illawarra are also important to the national economy as is the need to diversify the region’s economic base. Parenthetically yet importantly, the Illawarra economy is currently going through a structural change, which makes it highly interesting to regional economists and policy makers around the globe.

Second, what adds to the significance of this research in terms of its pertinence to the global context is the application of the methodology in this thesis to other regions that are in a transitional mode both inside and outside Australia. There are several regions with characteristics similar to those of the Illawarra’s, such as old industrial regions like Newcastle in Australia; Lille in France; Liverpool in the UK; and Cleveland, Detroit and Pittsburgh in the US that have experienced economic decline as a consequence of globalization, requiring major structural shifts to address (Stimson et al. 2006). Some successful regions, such as Waterloo, Ontario in Canada have adopted global learning skills and employment cross training schemes that heavily rely on skilled labour and knowledge workers to adapt to the impact of globalization.

As a result of globalization, many regions in member nations of the Organisation for Economic Co-operation and Development (OECD) are in an economic transitional phase. Concepts of competitive advantage and core competency are becoming the central focus in thriving regional economies (Guhathakurta & Stimson, 2007). Such concepts require economies to focus on their competitive advantage and competency strengths in the context of the global economy. This indicates that regional economies play a far more important role in the economic prosperity of national economies (Schaefer et al., 2011). The notion of globally competitive regions has been recognized by several scholars (Guhathakurta &
Stimson, 2007; Wiedmann et al., 2007; Kronenberg, 2009; Stimson et al., 2009; Cruz & Teixeira, 2010). Hence, regional economies have become more and not less important as a result of globalization. According to the data available on Australian Bureau of Statistics (ABS) and the results of this study, the emphasis of the Illawarra economy is increasingly shifted from steel manufacturing and mining to knowledge sectors and technological advancement (ABS, 2013). Following construction of University of Wollongong’s Innovation Campus, a 500-million-dollar precinct dedicated to research, development and technology; SMART Infrastructure Facility, a research institution with a vision to be intellectual leader and educator; and the growing number of jobs in the education sector; the corporate motto of Illawarra’s largest city, Wollongong, is to be regarded as a “city of innovation” (Wollongong City Council, 2014).

The framework developed in this study is applicable to regions with various demographics and economy size, in particular the regions with data intensity and economic diversity commensurate with that of the Illawarra. In the case of the Illawarra, such a threefold framework can help regional economic planners and policy analysts to provide clear direction for the Illawarra economy that is intended to adapt to structural shifts in the past three decades. Similarly, regional economic planners and policy analysts in other regions can apply one of the three integrating methodologies developed in this study that is most suited to the characteristics of their region of choice. Bottom line is that the primary emphasis of this framework is to investigate an economic structure that has been impacted by globalization and increased global competition.

As mentioned earlier, the impact of globalization and subsequently the critical role of regional economies in affecting national economies in a globally competitive environment have changed the structure of regional economies over the past three decades. This structural change has also led to a change in the process of regional planning. This is because in the
past factors such as economic diversity, industrial linkages and international competition were not as intense as they have become during the post-globalization era. Thus if regional planning is to produce an effective positive agenda and set a clear direction for the economy, such factors need to be taken into consideration by employing an accurate analysis of the regional economy. Due to the complexity of the current global economy and the interconnectedness of regional economies and national economies, standalone traditional models may fall short in delivering such required accuracy. Mere quantitative analysis of the economic process through standalone traditional IO analyses or through qualitative socio-economic models is not enough to meet the level of performance and accuracy required to investigate regional economies. Modelling linkages between sectors; analysing impacts of adjustments between interconnected industries; or forecasting the direction and magnitude of changes, such as shutdown of major businesses that affect the whole economy, require a consolidation of standalone analytic tools.

A consolidation, or integration as it will be referred to in this context, of traditional analytic tools provide us with the qualitative, quantitative and dynamic merits of investigation from both micro (IO) and macro (EC) perspectives. Such a regional economic development matrix provides regional economists with an integrated analytic tool to quantify the linkages and impacts of economic processes and products within the region, in addition to taking into account the socio-economic, demographic, and dynamic analysis of adjustments that occur in the regional economy. Thereby, meeting the level of accuracy and performance required to deal with the complex issues that stem from globalization and interconnectedness of industries prevalent in a regional economy. Figure 1.1 illustrates the four dimensions of the regional economic development matrix.
The importance of the Illawarra as a region is reflected in several attributes that are discussed in detail in Chapter 2. However, a brief snapshot of the current economic strengths and weaknesses is now provided. The Illawarra contributes considerable resources to the economy of Australia as a leading grain and coal exporter through its port facilities in Port Kembla. The major portion of New South Wales grain export activities was transferred from Glebe Island to Port Kembla during the 1980’s (Wilkinson, 2011). With 28,882,422 revenue tonnes and 2,126,268 TEU\(^5\)s, Port Kembla is currently ranked Australia’s largest vehicle import centre, the largest hub for grain exports and the second largest coal export port in the state (NSW-Ports, 2013). The Illawarra features the largest plant for steel production in the southern hemisphere (IRIS, 2008). It is nationally acclaimed for metal fabrication and engineering, a recognized centre for information and communication technology (ICT),

\(^5\) The twenty-foot equivalent unit (often TEU) is a conventional inexact unit of cargo capacity often used to describe the capacity of container ships and container terminals.
financial services and research and development (BusinessNSW, 2014), playing an integral role in engineering and manufacturing technological advancement. Livestock, maritime enterprises, and wood and paper products are among the regions other significant resources. This is in addition to being a globally renowned provider of tertiary education and boasting a substantial tourism capacity.

According to the Australian Bureau of Statistics (ABS, 2012) the Illawarra statistical area (SA)\(^6\)\(^7\) has an unemployment ratio of 6.7%. With a population of 292,190 and a labour force of 128,020, this indicates that nearly 8,597 of the current labour force are unemployed. This is explained by the economic shifts that have taken place in the regional economy, as major businesses in the heavy industry manufacturing sector are deserting the market due to high labour cost and a lack of competitive advantage in manufacturing compared to lower cost labour in east Asian heavy industry and technological advancement and economies of scale in European and American heavy industry manufacturers. On the whole, the current above the state average unemployment is due to the economic transition from heavy industry manufacturing and mining toward highly skilled labour orientation and inclination towards a knowledge based economy. More specifically, as a result of the economic transition, there is a disparity between the labour demand curve and labour supply curve. This is because industries that were once capable of employing a large labour supply cannot afford large employment due to strong global competition and losing market share.

Furthermore, analysis of the type of unemployment is useful to address the high unemployment rate in the Illawarra. An important factor addressing the regional high

\(^6\) The geographical scope of this thesis only encompasses the Illawarra SA, also known as (AKA) the Illawarra economy (ABS, 2011; RDA-Illawarra, 2012), which consists of the three LGAs of Wollongong, Shellharbour and Kiama. ABS also defines a region known as the Illawarra statistical division (SD), which includes Shoalhaven and Southern Highlands, in addition to the three aforementioned LGAs in the Illawarra SA, with an overall population of 436,117.

\(^7\) The difference between the Illawarra SD and the Illawarra SA is discussed in detail in Chapter 2.
The structural unemployment rate is changes in technology and changes in consumer taste. The former is explained by European and Asian steel manufacturers’ use of advanced technology in reducing the cost of production, thus providing steel supply at a significantly lower cost. The latter structural unemployment is explained by the increase in demand for Asian products, due to lower cost. There is also the issue of frictional unemployment, as steel manufacturers and mines have to downsize due to losing market share and their former employees are forced to move between jobs and locations. A major seasonal unemployment is also evident in the Illawarra tourism industry due to sudden increase in tourism during December to February and lack of tourism during May to August. Lastly, the impact of globalization which led to downsizing and, in some severe cases, shutdown of the former major industries led to cyclical unemployment. The cyclical unemployment addresses the major issue of considerable youth unemployment in the region.

Having said that, the estimated population of the Illawarra SA was reported to be 292,190 people in June 2011, up from 269,597 in June 2001 (ABS, 2011). This indicates that there has been a nearly 8.38% increase in population within a timespan of ten years. The noticeable increase in the regional population is indicative of the high potential that the region has in reducing unemployment and improving industrial development. However, it is important to note that the high potential is dependent upon the demographics and skill profiles of new migrants to the region.

This thesis provides an aggregate regional investigation on the economy of the Illawarra with a view to analysing policies that are intended to boost the regional economy by increasing employment and regional gross output. Subject to availability of data, significant strengths and weaknesses of key industries are described at the LGA level in the following chapters.
1.4 Methodological Scope of the Study

The overall methodological purpose of this study reflects two main concerns. The first relates to the methodological issues involved in the practice of integrating regional modelling as a whole. The second focuses on the issues arising from the implementation of these models into a small region with the characteristics of the Illawarra. Although there are substantial details underlining these two broad concerns, for the time being we outline the key aspects of each concern.

As mentioned earlier, the most recent innovative trends and methodologies in regional analysis centre on integration of traditional tools, particularly IO analysis and EC modelling, due to their comparative higher accuracy. Studies that combine EC and IO modelling in an integration framework are isolated for further analyses in this research. The methodological choice for this thesis is motivated on three bases. First, the use of integrated IO-EC modelling has gained in popularity in the regional analysis literature (Conway, 1990; Coomes et al., 1991b; West, 1991; Israilevich & Mahidhara, 1991; West & Jackson 1995; Rey, 1998; Motii, 2005); however, theoretical issues underlying the integrated framework have not been applied to regional economies and explored in the literature. Second, the two modules composing the integrated framework, EC and IO, are two of the most frequently implemented tools in regional analysis. Therefore, there is a plethora of information that pertains to the issues involved in integrating the two tools. Finally, three different approaches to integrated IO-EC modelling, namely composite, embedding, and linking, can be regarded as the bases for examination of the methodological issues and deficiencies connected to the usage of stand-alone IO models.

As mentioned in previous sections, there are a large number of studies in the literature that apply a composite or an embedded modelling methodology to the analysis of a particular region. There are also a small number of studies in the literature that apply linked
methodology to analyse a particular economy. Nonetheless, there are no studies that apply all the three different integrating methodologies to one region and compare their pros and cons. A review of the literature shows that except for Rey’s (1998) comparative analysis of different integrating methodologies, which was conducted on five regions of Southern California, none of the studies in the literature has conducted a comparative analysis of different integrating methodologies for one particular region. Therefore, a significant contribution to the literature would be to build a three-component model to investigate a regional economy, where each component applies one integrating methodology. Comparing different integrating methodologies, we are then able to point out the differences in the results obtained from each integrating methodology. This is a useful practice to pinpoint and match the suitability of each integrating methodology to the characteristics of different types of regional or even urban economies.

Furthermore no study has been found in the literature applying the integrated method to a region with the characteristics of the Illawarra. Most of the studies of regional planning have been applied to highly industrial and urbanised regions of the US. Therefore, building upon Rey (1998; 2000), West (1991; 1995), and Motii (2005) the main purpose of this research is threefold. First this thesis applies three integration approaches to the same region and then compares and contrasts their results. Second this thesis is intended for forecasting the direction of major industries and analysing the impacts of structural shifts and new policies on the economic structure of the Illawarra with a focus on regional income, employment and output. Finally it aims to provide steppingstones for regional analysts in terms of defining selection criteria for integration approaches to suit the modeller’s objectives and the region under study. By doing so, this thesis aims to contribute to the development of a research agenda in the integrated literature that focuses on a comparison of traditional IO with different integration strategies, suggest methods for improvement of the three approaches,
and achieve more accuracy in results of analysis and forecasting and by doing so provide an invaluable tool for regional planners and policy makers.

1.5 Data

The choice of sectors used in the IO table is determined by the availability of a consistent set of time-series data for a number of variables at the sectoral level, including gross regional product, wages and salaries and employment. The primary data sources include:

A. Federal level:
   1) Australian National Accounts (input-output tables) from Australian Bureau of Statistics (ABS)
   2) Australian System of National Accounts from ABS
   3) Consumer Price Index (CPI) from ABS

B. State level:
   1) Manufacturing Statistics for New South Wales (NSW)
   2) NSW State Accounts
   3) NSW Yearbook

C. Regional level:
   1) Annual publications from the Illawarra Regional Information Service (IRIS)
   2) Illawarra Regional Profile at Statistical Area level four (SA4) available from ABS
   3) Labour Force Statistics on the Illawarra from the Department of Employment at Labour Market Information Portal (LMIP)
   4) Local Government Area (LGA) specific data from .id community (profile, atlas, forecast, and economy)

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8 These variables are fully discussed in Chapter 4.
5) Miscellaneous industry specific publications and economic reports on the region

The input-output table compiled for this study adopts a hybrid method, which is a combination of survey and estimated data.

1.6 Structure of the Study

The thesis contains eight chapters. The chapters are organized as follows. Chapter 1 provides an introduction to the thesis, which includes the significance, scope, and objectives of it. Chapter 2 provides an overview of the Illawarra region and its economy while Chapter 3 provides a review of the literature. The literature in Chapter 3 is categorized into five main sections: studies on the comparison of traditional IO and IO-EC; studies on the comparison of the different integration strategies; studies on the embedding approach; studies on the composite approach; and studies on the linking approach. Chapter 4 covers the theoretical framework of the models including the structure of each model, the variables, the data, and so forth. Chapter 5 describes the specific modelling of and the IO table for the Illawarra while Chapter 6 provides the empirical results and scenario analysis. Chapter 7 presents the key policy implications. The final chapter – Chapter 8 provides the main conclusions encompassing limitations of the thesis and identifies areas for future research.

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9 This is a useful source for regional statistics on population, demographic forecast, economic profile, and housing data. The main website is linked here [http://home.id.com.au/](http://home.id.com.au/) and detailed reference is provided in the Bibliography.
Chapter 2

Overview on the Illawarra

2.1 Introduction

The purpose of this chapter is to present a prelude to the Illawarra region; a review of related theories in regional economic development; an overview of the Illawarra economy; a brief history of the major events that occurred in the Illawarra economy since the 19th century; and the current economic structure of the Illawarra. These criteria represent separate aspects of the regional economy yet each plays a paramount role in understanding the current difficulties faced by the region and what needs to be done to improve the performance of the regional economy.

The Illawarra is a region in the state of New South Wales in Australia. It is a coastal region located south of Sydney and north of the Southern Highlands and Shoalhaven. It comprises the cities of Wollongong, Shellharbour, and the municipality of Kiama. The region is composed of three distinct districts; the north-central district, which is an urban sprawl adjacent to Lake Illawarra; the western district defined by the Illawarra escarpment, which is adjacent to the south-west fringe of Greater Metropolitan Sydney; and the southern district that is historically semi-rural, albeit now being defined by increasing urbanisation.

The Illawarra region is defined in four different contexts. First, in the context of Australian federal elections for the House of Representatives the Illawarra region is defined by the electoral Divisions of Cunningham, Throsby and Gilmore. Second, in the context of New South Wales elections for the NSW Legislative Assembly the Illawarra region is defined by the electoral Districts of Wollongong, Keira, Shellharbour, Heathcote, and Kiama. Third is the context of local government administrations (LGA), in which the Illawarra region is contained within the cities of Wollongong, Shellharbour and Shoalhaven, the Municipality
of Kiama, and the Wingecarribee Shire. Finally, in the context of statistical analysis and economic planning the Illawarra statistical area (SA) is contained within Dapto-Port Kembla SA, Illawarra Catchment Reserve SA, Kiama-Shellharbour SA, and Wollongong SA. In this context it encompasses the three LGAs of Wollongong, Shellharbour and Kiama. The focus of this research is on the Illawarra SA, which has an overall population of 288,036, of which 128,020 are in the labour force, of which 8,597 are unemployed (ABS, 2011).

The importance of investigating structural shifts, analysing the impacts of inter-sectoral interactions, and forecasting economic changes in the Illawarra is justified by the major economic shifts (which will be thoroughly discussed in the following sections) in the Illawarra over the past three decades. In the early 20th century the Illawarra economy was concentrated mainly on agriculture, fishing, heavy industry manufacturing and mining (Rittau, 2005). Over the past three decades, however, a number of shutdowns and expansions of major businesses in certain sectors caused noticeable shifts in the economic structure of the region (IRIS, 2009). As a result of globalization and the follow-on focus of regional economies on their competitive advantage since the late 1990s, the focus of the Illawarra economy has been gradually shifted to other economic activities such as business services, knowledge and innovation generation, education and tourism (Wilkinson, 2011).

The global recession of the early 1980s, the closure of BHP in 1999 and BlueScope Steel shutdown of one of the only two blast furnaces in Port Kembla in 2012, which resulted in redundancy of 800 direct employees, have been major shocks to the regional economy. These substantial economic readjustments led the regional unemployment rate to trend around 6.7%, which is above the state average of 5.7% (Labour Market Information Portal, 2014). There is also a noticeable youth (15-24 years of age) unemployment rate of 17.5% in the Illawarra, which is well above the state average of 11.8% (Labour Market Information Portal,
2014). As of April 2012, the Illawarra’s\(^{10}\) unemployment rate was 6.7%, ranking it the ninth region out of 28 regions (at SA4 level) in NSW with the highest unemployment rate\(^{11}\) (ABS, 2014). The region has focused on diversifying economic activities, inclining towards improvement of service sectors such as education and information and communication segments as the key sectors.

Following the aforementioned brief record of economic events in the region, the significance of this thesis, in relation to the Illawarra, is to identify changes that are likely to happen in the future and the industries that are going to be important in bringing about these changes. This research aims to highlight the industries that were central to bringing about structural shifts in the regional economy over the past 20 years, and to forecast their future development. Using impact analysis, we analyse the potential impacts of different policies and structural adjustments on regional employment, regional output, income and other key elements of the regional economy. The direct and indirect effects of policies and inter-sectoral shifts will be further analysed through multipliers and an embedding approach to identify the effects of these impacts on the overall regional economy.

This chapter is organized as follows: Section 2.2 presents an overview of related theories in a regional economic development context. Section 2.3 provides an overview of the Illawarra economy, history of the Illawarra economy, and the major industries that have shaped the regional economy over a number of years. Section 2.4 discusses and analyses the new economic era, the new key industries and an overview of the issues, opportunities and challenges facing the regional economy. Finally section 2.5 provides some concluding remarks.

\(^{10}\) Here we refer to the economy of Illawarra as being composed of Wollongong, Shellharbour and Kiama LGAs.

\(^{11}\) The highest being Coffs Harbour – Grafton with an 8.5% unemployment rate, the lowest being Sydney – Sutherland with a 3.5% unemployment rate, and the median regional unemployment rate of 5.55% which lies between Sydney – City & Inner South with 5.6% and Newcastle & Lake Macquarie with 5.5% (ABS, 2014).
2.2 Regional Economic Development

The role that regions play in shaping national economies has heightened considerably in magnitude and become more central since major waves of globalization rippled across the globe during the 1980s and 1990s. A brief exploration of the adjustments in the role of regional economies is essential here before we can conduct an impact analysis and planning towards regional economic development. In this respect it is useful to explicate how regional economies work and how they should function in the current competitive global economy. Figure 2.1 depicts a model conceptualized by Scarbrough & Lannon (2010) for an ideal process in which regional economies function in an open market and the components involved in the process.

The model indicates that development of regional market economies is driven by gaining efficiency and control in the following seven primary factors.

1) Value added
2) Effective management
3) Productivity and performance
4) Investment
5) Asset optimization
6) Apt rate of consumption
7) Apt rate of population growth

According to Scarbrough & Lannon (2010) there are two major sources, namely external and internal capital flows that generate investment capital. External capital flows are derived from external investors, exports, grants, and repatriated earnings; while internal capital flows are derived from assets, dividends, labour market profits, savings and social capital. Internal capital flows also encompass non-monetary human capital to production or service sectors.
Repatriated earnings are becoming increasingly important in supporting regional development in many Asian countries (Scarborough & Lannon 2010). In contrast, domestically repatriated earnings, such as that earned by family or relatives who migrate to the larger cities, are becoming important in supporting regional development investment and private consumption in regions in developing countries, particularly nations in the African continent (Fafchamps, 2006).

As depicted in Figure 2.1, government at the regional level contributes to growth of regional development by designing policies on workplace capabilities, financing and planning aspects of organizations, and developing strategic infrastructure with respect to services, facilities and information. Firms contribute to growth of regional development by maintaining proficiency in management of capital, innovation and catalysis. In summary, managing adequate sources of external and internal capital, in addition to maintaining apt levels of contribution from firms and regional government to the seven factors driving regional development growth will subsequently lead to development of regional capital stock, which subsequently increases exports, which then results in efficient management of risk at the regional level. Effective management of driving factors of regional development growth also results in reduction in leakage of capital in the form of dividends to external investors, reduction in imports of production and consumption inputs to the region, and finally reduction in expatriated investment of savings earned in the region.
FIGURE 2.1
REGIONAL ECONOMIC DEVELOPMENT PROCESS

Source: configured by the author and inspired by a model built by Scarbrough & Lannon (2010).
Furthermore, according to Johansson (2014), government and business sectors need to issue and apply policies and strategies for nations and regions in order to obtain sustainable development outcomes and growth. Such policies and strategies may include an emphasis on increasing productivity; a focus on decreasing inputs to production; development of logistic systems; emphasis on recycling which leads to a decline in waste; more efficiency in leveraging and employing resources; and improvement of economies that focus on exporting and are demand-driven.

Nevertheless, it is not only economic systems that should be a priority to support regional development. It is argued by both Scarbrough & Lannon (2010) and Johansson (2014) that there is also a need to focus on the development and maintenance of cultural, knowledge and social capital, development of risk management strategies, and improvement of regional governance. These factors are equally essential to achieve regional sustainability and to grow regional development.

2.2.1 Post-Globalization Era: Key Factors for Regional Economic Prosperity

The modern global economy is progressively driven by financial and information sectors that support production processes. Production processes are networked to each other in different parts of the world. Such a multinational production process network facilitates mutualisation of capital, innovation and catalysis at the firm level in order to drive regional development. Multinational corporations have a key role to play in organizing and coordinating production systems that stretch over multiple regions of the world and that have competitive advantage in the production and distribution of goods and services (Korten, 1995). Information technology (IT) keeps swiftly penetrating into every domain of the national and regional economy, prompting new product creation and market integration. Meanwhile producing sectors are prompted to adopt new skills and strategies in order to adapt to the radically fast-
tracking change stemming from globalization. Therefore the main challenge for a region in pursuing a strategy for economic development is to “think global” while “acting local” (McKinsey & Company, 1994).

Such adjustments in the nature of employment, information, production and trade that affect firms and regions indicate major challenges in maintaining and improving regional economic development. Economic development can have a substantial impact on investment location decisions. The current level of restructuring and development in the global economy has changed four important dimensions of economic development, namely, economic inputs, geographic dimension, sectoral profile and sustainability as discussed in the following paragraphs.

Economic inputs represent the changes in the types and location of input factors required for the attraction, expansion and formation of industry to a region. Labour, land, material costs and taxes have traditionally been recognized as factors based on which comparative advantage was measured. Nevertheless, the focus today is on competitive advantage which emphasises value adding factors associated with applications, efficiency, leadership and technology skills placement. There is an additional emphasis on collaborative advantage through strategic alliances and networks.

Geographic dimension represents adjustments that can occur in geographic scale of economic development. Economic development strategy has traditionally been focused on geographic dimensions that were under jurisdictions of local government. Nevertheless, the focus today is expanding towards city regions that include several jurisdictions. The focus is on understanding how sectors located throughout a region operate related to their inter-sectoral and inter-firm linkages across the entire region. This can also include – subject to data availability – their linkages with industries outside the region.
Sectoral profile of economic structure of a region represents the interdependence among industries within the region. This inter-industry interdependence is required to analyse linkages across firms and businesses and to see how they affect one another and how they impact the economy as a whole. Traditionally, policy makers aimed to design policies that were solely focused on a solitary industry and strategies were tailored to improve one business in one region (Hall & Markusen, 1985; Saxenian, 1994; Stimson et al., 2006). Nevertheless, single-industry policies and solitary firm-level strategies cannot recognize the growing significance of inter-sectoral and interregional dependencies that exist between firms across sectors, regions and nations. This is particularly important in the context of the operation of trans-national operations and the strategic linkages and alliances that develop between firms in a global production process.

Sustainability signifies that purely economic outcomes can no longer be the only factors by which regional economic performance is measured. Maintaining safety and a pleasant living environment, quality of life and resolving social disparities within communities are all now significant factors by which economic development can be measured. There have been major restructuring and other adjustments brought about by globalization. These adjustments are related to the flow of information and to governance systems as well as the paradigm of sustainable development. The paradigm of sustainable development signifies the assimilation of economic viability, social equity and cohesion, and ecologically sustainable development. This paradigm is progressively being adopted as a fundamental principle of regional development strategies and employed for planning practices.

In the Illawarra, the results of the economic investigation conducted in this research indicates that the evolving nature of current economic development is increasingly focusing
on four major objectives, namely, a) job diversity and employment growth; b) development through industrial interdependence; c) enhancement of location inducing factors through locational asset management; and d) shifting the focus of development on to knowledge intensive and information sectors. This shift is consistent with a conceptualization of regional economic development proposed by Jin & Stough (1998), comparing old and modern regional economies with respect to market economy, labour and workforce, production and infrastructure characteristics.

Using data obtained from ABS, IRIS, and, LMIP the inferences from our economic investigation indicate a shift from vertically integrated to horizontal networks in organizational form within the regional economy. The scope of competition has escalated from a national level to a global level in the aftermath of globalization. The global level of competition is particularly evident in heavy industry manufacturing sector by the shutdown of BlueScope Steel blast furnace at Port Kembla. Lay-off of 800 full-time employees (FTE) ensuing the shutdown of the blast furnace signifies the impacts of global competition, in particular from south-east Asian and Chinese steel manufacturers, on the Illawarra economy.

While heavy industry manufacturing sectors are negatively impacted by global competition, education and knowledge related sectors are gaining momentum as a result of global competition. This momentum is signified by enhanced global presence, dynamic geographical mobility of businesses and improved role of government in sectors such as cultural & recreational; education & training; finance & insurance; professional & scientific; and rental, hiring & real estate, to name a few.

12 This objective also addresses labour costs and productivity.
13 The discussion in this subsection is thoroughly explicated and quantified with examples in the subsequent subsections of this chapter.
14 This is further discussed in the subsequent sections of this chapter.
In terms of labour and workforce characteristics, the trend is directed towards collaboration and knowledge leadership. Labour management relations have become increasingly collaborative and businesses focus on global learning skills and cross training programs. The role of education is shifting from single task specialisation to lifelong and pragmatic learning, while the objective of regional policy makers is on increased productivity through highly skilled labour orientation and thus higher wages. The resulting higher wages is because in knowledge related sectors employment growth and higher real wages go hand in hand.

At the same time resource orientation in producing sectors is focused on information and knowledge as key resources. As a result, alliances and collaborations are increasing among both firms that are within the same industry and firms that are in different industries. Increased alliances and collaboration are particularly important where they lead to increased knowledge and information among the collaborating firms; in other words creating a knowledge network. The role of agglomeration as a source of competitive advantage is becoming more important. Agglomeration economies are a key source of competitiveness for firms in regions through spill-over benefits, knowledge, resource and information sharing. Agglomeration is critical in the context of production networks where firms specialise and agglomerate in the production of niche products in a production network (supply chain).

Similarly, cost cutting strategies, innovation, quality, and time to market are becoming the source of competitive advantage for firms. Productivity is shifting from mechanical to digital; innovation, invention and knowledge are replacing capital, labour and land as growth drivers; and the role of research and innovation is gaining momentum in the regional economy. In producing sectors, methodology is shifting from mass to flexible production. Also the government does not merely play the role of infrastructure provider as in the past; it
is now becoming more important in privatization, provision of education and training, network building, better institutions and support services at the regional level.

The objective of regional infrastructure development is shifting from being purely focused on development of a physical network to development of an informational network, in addition to enhancement of quality and organization within the region. In this regard, the goal of transportation development is to reduce travel time by enhancing power generation and applying information technology to the regional infrastructure network. Power distribution is changing from a standard generation plant to a linked power grid. There is increased deregulation in organizational flow within infrastructure related firms. Wireless, fibre and broadband are substituting miles of wire in telecommunication systems. And finally, education and learning are becoming progressively online and taking the form of distance learning. Table 2.1 provides a summary of the aforementioned shifts in the Illawarra economic characteristics and several examples are provided in the following subsections of the chapter, signifying these economic shifts. Although the structural shifts mentioned in the table have taken place in the Illawarra economy, they are applicable to all regions that are similarly in an economic transformation phase and are adapting to the impacts of globalization.
<table>
<thead>
<tr>
<th>Economy Wide Characteristics</th>
<th>Old Economy</th>
<th>New Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organizational Form of Production</strong></td>
<td>Vertically Integrated</td>
<td>Horizontal Networks</td>
</tr>
<tr>
<td><strong>Scope Of Competition in Markets</strong></td>
<td>National and Stable</td>
<td>Global</td>
</tr>
<tr>
<td><strong>Competition Among Sub-National Regions</strong></td>
<td>Medium</td>
<td>Volatile</td>
</tr>
<tr>
<td><strong>Geographical Mobility Of Business</strong></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Role Of Government</strong></td>
<td>Provider</td>
<td>High/Steer/Row/End</td>
</tr>
</tbody>
</table>

**Labour and Workforce Characteristics**

| Labour Management Relations                    | Adversarial                                     | Collaborative                          |
| **Skills**                                     | Job-Specific Skills                             | Global Learning Skills and Cross Training |
| **Requisite Education**                        | Task Specialization                             | Lifelong Learning and Learning By Doing |
| **Policy Goals**                               | Jobs                                            | Higher Wages and Incomes (Productivity) |

**Production Characteristics**

| Resource Orientation                           | Material Resources                              | Information and Knowledge Resources    |
| **Relation With Other Firms**                  | Independent Ventures                            | Alliance and Collaboration             |
| **Source of Competitive Advantage**            | Agglomeration Economies                         | Innovation, Quality, Time To Market and Cost |
| **Primary Source of Productivity**             | Mechanization                                   | Digitization                           |
| **Growth Driver**                              | Capital/Labour/Land                             | Innovation, Invention and Knowledge    |
| **Role of Research and Innovation In The Economy** | Low/-Moderate                                  | High                                   |
| **Production Methodology**                     | Mass Production                                 | Flexible Production                    |
| **Role of Government**                         | Infrastructure Provider                         | Privatization                          |
### Infrastructure Characteristics

<table>
<thead>
<tr>
<th>Economy Wide Characteristics</th>
<th>Old Economy</th>
<th>New Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Form</strong></td>
<td>Hard (Physical)</td>
<td>Soft (Information and Organizations)</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td>Miles of Highway</td>
<td>Travel Time Reduction Via Application of Information Technology</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>Standard Generation Plant</td>
<td>Linked Power Grid (Co-Generation)</td>
</tr>
<tr>
<td><strong>Organizational Flow</strong></td>
<td>Highly Regulated</td>
<td>Deregulation</td>
</tr>
<tr>
<td><strong>Telecommunication</strong></td>
<td>Miles of Copper Wire</td>
<td>Wireless and Fibre</td>
</tr>
<tr>
<td><strong>Learning</strong></td>
<td>Talking Head</td>
<td>Distance Learning</td>
</tr>
</tbody>
</table>

2.3 Overview of Illawarra Economic Development

The Illawarra houses a six-billion-dollar manufacturing sector in the statistical subdivision of Wollongong\(^{15}\) (ABS, 2011). Cultural landscapes and agricultural lands that supply a long-run resource for sustainable food production are aspects of the southern portion of the region (Yin et al., 2004). The Southern Highlands (Wingecarribee) is majorly associated with employment, settlement and transport opportunities among the adjoining regions to the Illawarra economy (NSW-Department of Planning, 2007). In the southern part, Kiama and areas of Shellharbour exemplify cultural landscapes and vast agricultural lands, presenting a long-run resource for food production (NSW-Department of Planning, 2007). The primary opportunities for urban expansion are concentrated in the centre of the region where the coastal plain spans, which represent a slew of prospects to yield new dwellings (NSW-Department of Planning, 2007).

The three LGAs within the Illawarra statistical area as defined by ABS, respective to their population, are: Wollongong, Shellharbour, and Kiama. A brief regional profile for each LGA is presented below:

Wollongong LGA spans an area of 714 km\(^2\), had a population growth rate of 7.5% from 2001 to 2011 and is the third largest LGA in New South Wales, after Blacktown and Sutherland Shire LGAs, and is the tenth largest city in Australia (ABS, 2011; RDA-Illawarra, 2011). 86% of total manufacturing turnover in the Illawarra region is contributed to by Wollongong LGA (Wilkinson, 2011). The majority of the Illawarra’s largest employers, e.g. BlueScope Steel, the University of Wollongong and Wollongong City Council, are located in Wollongong (Wilkinson, 2011). As of 2011, there are 11,864 businesses in Wollongong, which accounts for 42.1% of all the businesses in the Illawarra SD (ABS, 2011).

\(^{15}\) This is also known as the Illawarra economy or the Illawarra SA as explained earlier in the chapter.
The Shellharbour LGA has a population of 68,339, covers an area of 154 km$^2$, from Albion Park Rail in the north to Macquarie Pass in the west and south to Dunmore (RDA-Illawarra, 2011). Shellharbour had a population growth rate of 14.2% from 2001 to 2011 (ABS, 2011). As of 2011, there are 2,895 businesses in the Shellharbour LGA, which accounts for 10.3% of all the businesses in the region (ABS, 2011). The major employers in Shellharbour LGA, namely Coles, Shellharbour Council and Woolworths, are smaller than their counterparts in Wollongong (Wilkinson, 2011).

Kiama has a population of 21,139, covers an area of 256 km$^2$, from the Minnamurra River to the north, Knights Hill in the west and to a point just north of Gerroa in the south (RDA-Illawarra, 2011). The Kiama LGA’s population growth rate in 2001-2011 was only 5.9% (ABS, 2011). As of 2011, there are 1,592 businesses in the Kiama LGA, which accounts for 5.6% of all the businesses in the Illawarra SD (ABS, 2012). The major employer in the Kiama LGA is Kiama Council, employing 330 people as of 2005 (Wilkinson, 2011).

The Illawarra contained 16,889 businesses in 2011 (ABS, 2013). The industry sectors with the highest employment were health care and social assistance with 13.3% of the total labour force, retail trade with 10.5%, and education and training with 10.4% (ABS, 2013). The region’s agricultural industry made significant economic contribution to the region by producing a gross value of AU$101.4 million in 2006, an increase of nearly 14% (AU$12.4 million) from AU$89 million in 2001 (ABS, 2011). Agricultural activity in the region is mainly supplied by dairy and beef cattle grazing and also there is a continuous growth in fruit and wine grape growing industries (IRIS, 2008).

In the early 1980s a global recession caused a decline in the manufacturing sector in the region (Wilkinson, 2011). For instance, the Port Kembla steel works had cut down 14,000 jobs from the early 1980s to the mid-1990s (Wilkinson, 2011). Despite major economic shifts taking place in that period, manufacturing continued to be a major industrial sector within the
Illawarra during the 2000s (IRIS, 2008). Basic and fabricated metal products, non-metallic mineral products, food and beverage products and paper products constituted major production of most manufacturers in the region during the 2000s (IRIS, 2008).

2.3.1 History of Economic Development in the Illawarra

A brief snapshot of historical economic events, which are related and have contributed to the present time key industries and the current economic situation in the region, is presented as follows. During the nineteenth century two of the Illawarra’s major industries were coal mining\textsuperscript{16} and dairying (Kass, 2010). During the 1870s and 1880s, booming conditions and high demand for coal resulted in the opening of a number of collieries in the region (Kass, 2010). During the 1880s and 1890s the district in the south of Wollongong was split by major economic activity. Coal mining was the main activity in the north and dairying remained the main activity in the south (Kass, 2010).

During the First World War, metal manufacturing developed in the Illawarra as copper products, initially imported from Germany, went out of stock (Kass, 2010). As a result, British Insulated and Helsby Cables along with a group of Australian companies formed Metal Manufacturers (MM). MM opened a production plant at Port Kembla in 1918 (Kass, 2010). In 1927, George Hoskins merged Esk Bank Iron & Steel Works with two British companies, Baldwins and Dorman Long to form Australian Iron & Steel (AI&S) (Kass, 2010). AI&S built a blast furnace in 1928 and began its operation (Rittau, 2002). During the 1930s, the first recession of the twentieth century occurred (Great Depression). In 1935, BHP took over AI&S and expanded its own production (Rittau, 2002). During 1940 and 1941,

\textsuperscript{16} It is noteworthy to mention that coal mining was slow to start due to the Australian Agricultural Company’s (AAC) monopoly over coal production from its Newcastle mines. In 1848, the colonial government put an end to the AAC’s monopoly of coal mines. This resulted in coal production in the Illawarra and the first private mine was opened by James Shoobert in 1849 (Kass, 2010).
BHP built an electric steel plant and installed six open-hearth furnaces\textsuperscript{17} used to produce aircraft, ammunition, marine engines, and vessels (Rittau, 2002). Due to the production acceleration at BHP the employment landscape in the Illawarra changed distinctively. During the period from 1921 to 1947, the farming sector’s employment dropped from 8\% to 3\% of the workforce (Rittau, 2003). By 1949 heavy industry manufacturing became the dominant industrial activity with sectoral employment of 43\% of the workforce (of which 49\% was for BHP) and employment in the mining sector was 14\% of total employment in the region (Rittau, 2001).

In the early 1980s the third global recession of the 20\textsuperscript{th} century (the second being the global recession of 1973, triggered by a sudden rise in oil prices) affected employment in the manufacturing sector (Rittau, 2003). The global recession resulted in a gradual loss of around 13,000 jobs at Port Kembla, from 30,347 in 1977 down to 17,658 in 1996 (IRIS, 1990; 2000). This decline in steel production was followed by a decline in coal mining, from 7,557 in 1982 down to 1,574 in 1998, representing a decline in the employment level of 79.2\% in coal and steel production during the 1980’s and mid 1990’s (IRIS, 1990; 2000). In 1999, BHP closed down its production plant at Port Kembla and Newcastle (IRIS, 2008). As a result the state government launched the Illawarra Advantage Fund (ILAF) and provided AU$10m in funding to finance ILAF’s operations\textsuperscript{18} (Martinez-Fernandez, 2001). During the fiscal years of 1999 to 2011 ILAF provided over AU$19m to 170 companies and organizations to establish, expand and create jobs in the region (NSW-DTIRIS, 2011). During this period, 4,292 jobs were created through ILAF assistance, where 63\% was for expansion of existing

\textsuperscript{17} Open-hearth furnaces are one of a number of kinds of furnaces where excess carbon and other impurities are burnt out of pig iron (an intermediate product of smelting iron ore with a high-carbon fuel such as coke) to produce steel.

\textsuperscript{18} The ILAF operations are a) assisting new business establishment in the Illawarra; b) assisting firms located in Sydney, interstate and overseas to relocate to the Illawarra; c) assisting the existing firms to expand their Illawarra operations.
businesses; 25% for establishing start-ups of small and medium businesses; and 12% for relocation of businesses outside the Illawarra to relocate to the region (NSW-DTIRIS, 2011).

In 2002, BHP Steel became an independent steel company and listed its shares publicly on the Australian Stock Exchange (ASX). In 2003, BHP Steel changed its name to BlueScope Steel following shareholder approval at its 2003 Annual General Meeting (BlueScope Steel, 2011). In late 2011, BlueScope decided to shut down its No 6 blast furnace, halving steelmaking capacity to around 2.6m tonnes a year in order to restructure its Australian operations (Paver, 2011). The shutdown resulted in 800 redundancies at Port Kembla (Langford, 2011). As a result the Federal and the State governments, together with BlueScope Steel, declared that they would establish an AU$30m Illawarra Region Innovation and Investment Fund (IRIIF), of which AU$20m is provided by the Commonwealth; AU$5m by the State; and AU$5m by BlueScope Steel (DIISRTE, 2011). The aim of IRIIF is to provide retrenched workers to gain immediate access to the services of Job Services Australia and to assist the workforce with relation to other forms of employment (DIISRTE, 2011). This event, along with the current economic transition toward knowledge sectors and skilled labour orientation, is the key economic justification for selecting the Illawarra as a region for economic investigation. A summary of the important economic events reviewed in this section is provided in Table 2.2.
### Table 2.2
**Summary of Major Economic Events in the Illawarra**

<table>
<thead>
<tr>
<th>Economic Event</th>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colonial government ended the AAC’s monopoly and subsequently coal production</td>
<td>1849</td>
</tr>
<tr>
<td>began in the Illawarra.</td>
<td></td>
</tr>
<tr>
<td>The major economic activity in the north was coal mining and in the south was</td>
<td>1880s and 1890s</td>
</tr>
<tr>
<td>dairying.</td>
<td></td>
</tr>
<tr>
<td>Metal manufacturing developed.</td>
<td>During WWI (1914 to 1939)</td>
</tr>
<tr>
<td>British Insulated and Helsby Cables with Australian companies formed Metal</td>
<td>1918</td>
</tr>
<tr>
<td>Manufacturers that opened a plant in Port Kembla.</td>
<td></td>
</tr>
<tr>
<td>George Hoskins merged with two British companies, Baldwin’s and Dorman Long,</td>
<td>1927</td>
</tr>
<tr>
<td>to form Australian Iron &amp; Steel.</td>
<td></td>
</tr>
<tr>
<td>1st Worldwide recession in the 20th century.</td>
<td>1930</td>
</tr>
<tr>
<td>BHP took over AI&amp;S.</td>
<td>1935</td>
</tr>
<tr>
<td>BHP built an electric steel plant.</td>
<td>1940</td>
</tr>
<tr>
<td>BHP installed six open-hearth furnaces.</td>
<td>1941</td>
</tr>
<tr>
<td>Employment in farming dropped from 8% to 3% of the workforce.</td>
<td>1921 to 1947</td>
</tr>
<tr>
<td>Mining employed only 14% of the workforce.</td>
<td>1921 to 1947</td>
</tr>
<tr>
<td>Heavy industry manufacturing employed 43% of the total regional workforce (BHP</td>
<td>1921 to 1947</td>
</tr>
<tr>
<td>employed 49% of this share).</td>
<td></td>
</tr>
<tr>
<td>2nd Worldwide recession in the 20th century.</td>
<td>1980s</td>
</tr>
<tr>
<td>Employment at Port Kembla dropped by 14,000.</td>
<td>1980s to mid-1990s</td>
</tr>
<tr>
<td>Employment in coal mining was nearly halved.</td>
<td>1980s to mid-1990s</td>
</tr>
<tr>
<td>BHP closure in Port Kembla.</td>
<td>1999</td>
</tr>
<tr>
<td>State government provided AU$19m to 170 companies for assistance in expansion,</td>
<td>1999 to 2011</td>
</tr>
<tr>
<td>establishment and relocation. This helped create 4,292 jobs.</td>
<td></td>
</tr>
<tr>
<td>BlueScope closure of one blast furnace in Port Kembla.</td>
<td>2011</td>
</tr>
<tr>
<td>AU$30m fund for IRIIF.</td>
<td>2012</td>
</tr>
</tbody>
</table>

*Source:* Compiled by the author.
FIGURE 2.2
GRAPHIC ILLUSTRATION OF ECONOMIC ADJUSTMENTS IN THE ILLAWARRA

1849-1914
• Coal Production Begins
• Boom of Coal Mining

1914-1939
• Metal Manufacturing Begins
• Boom of Metal Manufacturing
• Farming Employment Drops 8% to 3%
• Heavy Industry Employment at 43%
• 1st Global Recession of the 20th Century

1939-1980
• BHP Electric Steel Plant
• BHP Six Open-Hearth Furnaces
• Mining Employment at 14%
• BHP Employment at 49% of 43% Heavy Industry

1980-2012
• 2nd Global Recession of the 20th Century
• Port Kembla Employment Dropped by 14,000
• Coal Mining Employment Halved
• BHP Closure
• State Gov. AU$19m to 170 Companies, Creating 4,292 jobs
• BlueScope Blast Furnace Shutdown in Port Kembla
• IRIIF AU$30m Fun

Source: configured by the author.
2.4 The New Era

As mentioned in the previous subsection, significant structural adjustments have occurred in the Illawarra economy during the past few decades. As a result of the global recession in the 1980s the local steel industry and manufacturing base of the regional economy were gravely affected (NSW-Department of Industry & Investment, 2010). Subsequently, a Regional Development Task Force (SGSEP, 2010) reported a second recession in the early 1990s, which resulted in further diversification and restructuring of the regional economy. Since the 1980s the Illawarra has strived to help grow the supply of skilled professionals and specialist experts by matching education and training with the demands of new industries and employers after the occurrence of structural shifts in the regional economy in the 1980s (IRIS, 2008).

The noticeable shrinkage in employment within the steel making and manufacturing sectors has highlighted a need to shift the region’s primary economic activity from a heavy-industry based economy to a globally competitive economy by focusing on advancement in innovation, with knowledge and skill training as the new key sources of domestic and international comparative advantage. During the 1980s to 1990s BHP, which composed 49% of the employment of the manufacturing sector, had a redundancy rate of 70%, indicating a significant loss of 14,305 jobs (Wilkinson, 2011). Table 2.3 shows the employment change in BHP from 1981 to 1996.

### TABLE 2.3
EMPLOYMENT CHANGE IN BHP FROM 1981 TO 1996

<table>
<thead>
<tr>
<th>Year</th>
<th>1981</th>
<th>1993</th>
<th>1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment</td>
<td>20,305</td>
<td>7,700</td>
<td>6,000</td>
</tr>
<tr>
<td>(\Delta t = t_{1993} - t_{1981}, t_{1996} - t_{1993}) &amp; 62% &amp; 22%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Compiled by the author, using data from Wilkinson, 2011.
In the late 2000’s, affected by the global financial crisis (GFC), the Illawarra strived to perpetually implement structural adjustments and benefit from emerging and different economic activities. The Commonwealth, state government and private sectors have come together with the objective to create a ‘roadmap’ to stimulate local economic development (NSW-Department of Planning, 2007). Major setbacks in the local economy during the early 2000s were high structural unemployment and overdrawn reliance on declining industries that were once strong but had begun declining (Buchan, 2003). The heavy reliance on declining industries resulted in a predicament where local government became inattentive to businesses outside the region and therefore overlooked any attempts to attract new investment into the region (IRS 2007). As the business hub and the major city of the region, Wollongong has a significant reserve of latent commercial and geographical advantages to become a city marked by business innovation and advancement in technology and education, provided that the current infrastructure, training and regulatory constraints are mitigated from the local economy (Buchan, 2003; IRS 2007).

The Illawarra region is now intended to develop its current economic foundation by focusing on extension of value-added activities mostly in the areas of education, health and information technology (knowledge and education related sectors) and in the areas of business services, finance and tourism (service sectors) (IRIS, 2013). According to the statistics provided by Australian Bureau of Statistics (ABS) and Labour Market Information Portal (LMIP), tourism, financial and insurance services, education, and retail are, respectively, the sectors that have received significant escalation in terms of employment in the region over the past two decades (ABS, 2013; LMIP, 2014). This can be explained by the gradual decline of heavy industrial manufacturing and the inclination towards a more highly skilled labour orientation and current focus on knowledge leadership. Table 2.4 shows the employment increase in the major sectors within the region from 1991 to 2012.
To summarize the statistics required for the following subsection, the value of gross regional product (GRP) is estimated to be AU$11,128 million, which is 2.98% of the New South Wales economy (RDA-Illawarra, 2011). Household disposable income is estimated to be AU$10,187.6 million, with 16,351 businesses registered in the Illawarra (RDA-Illawarra, 2011). The largest industry sector in terms of employment is currently health care and social assistance, employing 15,690 of the workforce population (RDA-Illawarra, 2011). Due to the need for diversification in regional primary economic activity, it is vital to note and analyse the major economic sectors which have been important in driving structural shifts over the past three decades. Table 2.5 presents a breakdown of the key industry sectors and each sector is discussed in the subsequent subsections.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Employment</th>
<th>% of Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tourism</td>
<td>1,817</td>
<td>3,470</td>
</tr>
<tr>
<td>Financial and Insurance Services</td>
<td>4,302</td>
<td>8,073</td>
</tr>
<tr>
<td>Education</td>
<td>9,701</td>
<td>15,080</td>
</tr>
<tr>
<td>Retail</td>
<td>17,128</td>
<td>20,972</td>
</tr>
</tbody>
</table>

Source: Compiled by the author using data from ABS and LMIP.

<table>
<thead>
<tr>
<th>Key Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Sector</td>
</tr>
<tr>
<td>1) Advanced Manufacturing</td>
</tr>
<tr>
<td>2) Construction</td>
</tr>
<tr>
<td>3) Mining</td>
</tr>
<tr>
<td>4) Green Economy</td>
</tr>
<tr>
<td>5) Agriculture</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Source: Compiled by the author.
2.4.1 Production Sectors

Goods producing sectors have traditionally played an important role in the Illawarra’s economy – with manufacturing being the most prominent one, employing 9.9% of the regional workforce population as of 2012 and ranking the fourth largest sector by employment in the Illawarra SA (LMIP, 2014). Contrary to the overall Australian and NSW economies manufacturing was still considered to be the largest single sector in the region in terms of value added, with AU$1,529 million in added value in 2011 (RDA-Illawarra, 2011). Nonetheless, it is likely that this figure has changed since the closure of the Blue Scope Steel blast furnace at the end of 2011. Manufacturing in the Illawarra has been customarily concentrated in metals, steel and copper in particular and engineering sectors in the twentieth century (Buchan, 2003). Although these industries have endured significant restructuring and employment losses in recent years, they remain important parameters in generating wealth in the region (Buchan, 2003). In addition to these industries there are five other industries that are worthwhile mentioning in this chapter as major contributors to the regional economy (IRIS, 2013; ABS, 2013).

I. Advanced Manufacturing

The advanced manufacturing industry (AMI) includes high-tech companies which, although traditionally supplying goods and services to the mining and metallurgical industries in the region, have expanded to supply these industries on a national and global scale. AMI is considered to have the potential to provide sustainable economic growth in the region by increasing regional employment and output growth, which tourism did in the 1980s according to the New South Wales (NSW) government’s website (2012). Factors hindering the growth of this sector have been in training, infrastructure and a lack of regional coordination and networking (Neto & Potts, 2010).
AMI plays an integral role within the economy of the region. A great number of manufacturers in the region focus on production of heavy industrial goods e.g. fabricated metal, basic metal and non-metallic mineral products. In terms of manufacturing locations, fabricated metal products dominate the manufacturing sector of the region with 235 manufacturers, followed by non-metallic minerals with 84 manufacturers and finally primary (basic) metal products with 62 manufacturers (MSA, 2013). Production of food and beverage products and furniture manufacturing are also noteworthy in terms of manufacturing locations. Food product and beverage and tobacco manufacturing count for 150 manufacturers in the region while furniture and other manufacturing compose 146 manufacturers, ranking the second highest after fabricated metal manufacturing (MSA, 2013).

Illawarra is also noted for being the leading producer of steel and steel products in the Southeast Asian region (IRIS, 2008). As indicated earlier BlueScope Steel dominated manufacturing industry in the mid 2000’s and was a major employer and income generator for the region. The Coated Products Division of Blue Scope Steel is one of the world’s largest producers of coated and rolled steel products (IRIS, 2008). Before the redundancy of 800 direct jobs and 400 contracting jobs at the end of 2011 BlueScope was the largest employer in the manufacturing sector, employing nearly one third of the 18,000 regional manufacturing workforce directly or on a contract basis (Hasham, 2010). Nevertheless, even after shutdown of blast furnace No 6 in 2011 BlueScope Steel still plays a major role in manufacturing sector employment, as they still have 2,200 direct and contract-based employees (Christodoulou, 2012; Verity, 2012; Langford, 2011).

II. Construction

Construction is a significant factor contributing to regional economic growth. It was one of the major employers in the region in 2006, employing 8.5% of the 170,670 labour force
Employment in this sector witnessed a growth of more than 3,000 from 12,196 in 2001 to 15,541 in 2011 (ABS, 2007; LMIP, 2014). Continuing growth in the regional population and recent trends in metropolitan construction are the main factors currently driving this industry. The number of private dwellings in the Illawarra rose from 132,418 in 1996 to 151,616 in 2006, an increase of 13% over the 10 years (ABS, 2011). Regional population growth is partly due to the fact that Wollongong is a relatively low cost residential hub for commuters working in Sydney and for retirees (IRIS, 2008). The construction sector provides a market for local high technology goods and service support companies. There was a significant increase in the construction sector in May 2010 as the outcome of approval of the early stages of the West Dapto project, resulting in land expansion for up to 6,900 new residential homes and 175 ha of employment lands around Wongawilli, West Horsley and Kembla Grange (Hasham, 2010; Paver, 2011). This indicates the potential for increased construction activity relying on residential growth, new infrastructure projects and AMI business start-ups and expansions (Buchan, 2003). Table 2.6 outlines some of the major projects that have been either completed or are in process as of 2011.

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Cost</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aviation Support Facility (Yerriyong)</td>
<td>$9 m</td>
<td>Approved</td>
</tr>
<tr>
<td>Enterprise 1 Building</td>
<td>$31 m</td>
<td>Approved</td>
</tr>
<tr>
<td>Figtree Princess Highway Intersection</td>
<td>$15 m</td>
<td>In progress</td>
</tr>
<tr>
<td>Nan Tien Education And Cultural Facilities</td>
<td>$26 m</td>
<td>Approved</td>
</tr>
<tr>
<td>P &amp; DII Building</td>
<td>$33 m</td>
<td>In progress</td>
</tr>
<tr>
<td>Picton Road Upgrade</td>
<td>$41 m</td>
<td>In progress</td>
</tr>
<tr>
<td>SMART Infrastructure Facility</td>
<td>$40 m</td>
<td>Approved</td>
</tr>
<tr>
<td>WIN Stadium Western Grandstand</td>
<td>$31 m</td>
<td>Approved</td>
</tr>
<tr>
<td>Wollongong 13 Storey Commercial Development</td>
<td>$33 m</td>
<td>In progress</td>
</tr>
<tr>
<td>Wollongong Housing Commission Pensioner Housing</td>
<td>$18 m</td>
<td>In progress</td>
</tr>
</tbody>
</table>

Source: Compiled by the author, using data from Wilkinson, 2011; Paver, 2012; Wollongong City Council, 2012.
III. Mining

The mining sector had been consistently regarded as a paramount industry in the region for a few decades, employing nearly 3,000 people over the past 10 years (ABS, 2011). Nevertheless, ongoing closures of mines and the introduction of labour saving technological advancements have negatively affected employment in the industry. After a decline in the mining industry during the 1980s, as mentioned earlier, the sector recently witnessed improvement due to the resource boom of 2009-2011 arising from strong growth of the Chinese economy and resulting higher commodity prices including that of coal. Regional employment in this sector increased more than 3,000 from 1,523 in 2001 to 4,740 in 2011, with much of the increase concentrated in knowledge and high skilled jobs (ABS, 2013). This increase can be attributed to the prospective projects under development in the Illawarra, namely, the Wongawilli coal seam which accounts for the region’s highest potential for coal; the Bellambi coal mine; and the expansion of the Wongawilli and Appin coal mines (Neto & Potts, 2010). During the period from the end of the global financial crisis to the end of 2013, the availability of skilled labour, infrastructure congestion and environmental limitations were the only drawbacks on this industry. However, since the beginning of 2014 there have been more economic downturns evident in the sector. For example, Gujarat Natural Resources Environment (NRE), one of the major mining companies in the Illawarra, is facing financial difficulties and also there has been shedding of many jobs in the sector from the beginning of 2014\(^{19}\).

Shellharbour has a specialization in mining blue metal and other non-metallic materials (Hodgkinson & Agalewatte, 2005). The three blue metal\(^{20}\) mines in the Shellharbour are expected to last between 20 to 50 years according to Shellharbour City Council (SCC, 2012).

\(^{19}\) Exact figures on this update are not available yet.
\(^{20}\) Blue metal is 10mm graded crushed rock or aggregate, for use in making concrete.
Illawarra’s blue metal mines could receive a significant boost as a result of increased construction projects in South Western Sydney and the Illawarra itself. This is partly due to the importance of blue metal in the construction industry and partly due to the closure of large blue metal mines near Sydney, such as Kurri Kurri and Hillgrove (Neto & Potts, 2010).

Coal mining is also highlighted as primary economic activity in terms of production and exports. The regional coal mining sector has reported an average of 13 million tonnes of raw production annually since 2004, and has accounted for more than 75% of all regional exports since then (IRIS, 2013). During the 1990s the coal mining sector used to be a large employer within the Illawarra, employing more than 5,000 (ABS, 2013). Although sectoral annual production and employment declined in scale from 18 million tonnes and nearly 5,000 employees in the 1990s to 10 million tonnes and 1,700 employees in the early 2000s, it has retained an important role in both the regional and state economies due to the size and value of its exports during this period (IRIS, 2013). However, a steady increase has been noted in sectoral employment and production from 12.1 million tonnes in 2004 to 13 million tonnes in 2010 (ABS, 2011). During 2007-2008 the region’s coal companies produced 13.8 million tonnes of raw coal (Pomfret, 2011). Nevertheless, recent developments have not been encouraging.

**IV. Green Economy (Environment Related Industries)**

This industry includes several sectors ranging from traditional construction and engineering sectors, such as building or equipment maintenance, construction, repairs and retro-fitting, to advanced manufacturing and engineering sectors. In comparison to other Australian regions the Illawarra features a high skill base, through which it can benefit from adopting and developing green technology (IRIS, 2013). The Illawarra has many CO2 emitting sectors. There is an incentive to switch to “green” technology and industries because of the existing skill base. There is a great potential for green technology in sectors such as manufacturing;
metals, machinery and equipment production; construction and transport within the region. This would contribute to the growth of the green economy. As mentioned earlier, due to advancements in labour saving technology, employment in these sectors is in decline as a result of a mismatch of skills, thus the unemployed skills can be shifted to green economy sectors. This can be achieved by retraining and education of the current unemployed skilled labour and can be funded by the state and local government through creation of funds similar to ILAF, which was mentioned earlier.

The primary objective of the NSW government for the Illawarra is to develop the green economy by creating green jobs; therefore there was a consistent effort from the Federal and State Governments to develop policies to support this sector until late 2013\(^\text{21}\) (New South Wales, 2012). According to the Green Jobs Illawarra Project Steering Committee (GJIPSC), the large number of employees, enterprises, and infrastructure that focused on sustainability growth indicated the expertise and qualification of the region in this sector in line with the Green Jobs Illawarra Action Plan (GJIPSC, 2009). Nevertheless, the outcomes from this initiative have been recently limited (GJIPSC, 2009). According to the findings of GJIPSC’s report, the region has a significant long-term potential to develop the green sector because the largest industrial wastewater recycling system in Australia is located in Wollongong\(^\text{22}\).

In 2010, a biodiesel production plant project was approved to be built by National Biodiesel in Port Kembla. The AU$273 million plant is set to have a continuing social and economic impact on the region. There will be 235 permanent full time jobs (direct employment) upon completion of the plant and an estimated 725 jobs (indirect employment)  

\(^{21}\) Nevertheless, the current government appears to be moving away from this.  
\(^{22}\) Sydney Water operates one of the largest industrial water recycling systems in Australia, which supplies BlueScope Steel in Port Kembla. It delivers up to 20 million litres of recycled water per day to BlueScope Steel from Sydney Water's Wollongong Water Recycling Plant. This replaces up to 7.3 billion litres of drinking water per year previously drawn from the local Avon Dam, a 57% reduction of drinking water consumption by Sydney Water's largest customer (Sydney Water, 2012).
in related industry as intermediate impacts of the plant (Thompson, 2009). Premier Barry O'Farrell turned the first sod at the plant site at Port Kembla in 2012 (Daily Examiner, 2012).

V. Agriculture

There has been a steady growth in the regional agriculture sector in terms of employment and production. Sectoral employment in the Illawarra SA increased by more than 1,000 or nearly 43%, from 2,317 in 2001 to 3,323 in 2011 (ABS, 2011; DE, 2012). A number of the best soil grades in Australia are in the Illawarra (Dunlop et al., 1999). This places the region in a unique spot for expanding into niche markets of organic products, increasing value added agriculture, and utilizing high grade soil to achieve high levels of economic income from agricultural activities in accordance with the Southern Council Group (SCG, 2012). However, agricultural expansion creates a conflict with the expansion in residential construction that was mentioned earlier. This is due to lack of land for residential development, which is currently a serious issue in the Illawarra.

The dairy industry in Shellharbour was deregulated in 2000 and there has been a decline in its dairy dominated agriculture industry since then. This sector accounts for only 0.16% of overall employment in the Shellharbour LGA, playing an insignificant role in its economy (IRIS, 2008). Notwithstanding this insignificant contribution, council policy limits further development on agriculture land (SCC, 2012). However, recently there have been cases, such as Calderwood near Albion Park, where state laws and processes have overruled the limited development policy and residential development has continued on prime agricultural land.

Kiama is also facing a quandary on agriculture where the farmlands and country town atmosphere are to be preserved while there is an urgency to obtain economic return from those farmlands to benefit Kiama, as mentioned by Kiama Municipal Council (KMC, 2012). Akin to Shellharbour, Kiama boasts some of the best grades of soil (Dunlop et al., 1999)
which are conducive to the overall development of a boutique food and wine industry in the region (SCG, 2012; KMC, 2012). Kemp (2003) highlights the importance of the Kiama economic and employment strategy (KEES) in improving productive properties in rural areas which promote the rural setting of the LGA. Although this strategy is mainly tourism related, it emphasizes innovative rural use, development of cottage industries in addition to development of viniculture, horticulture and boutique food production (Kemp, 2003).

2.4.2 Service Sectors

I. Business & Knowledge Services

It is important for regional sustainable growth to promote the Illawarra’s competence in the knowledge and business services sector. Wollongong has gained a significant momentum in this sector by having more than 40 businesses in this sector, which in turn employ nearly 4,500 people (New South Wales, 2012). One of the key factors in the long term sustainability of the region in this sector is Information and Communication Technology (ICT), which is noted for its comparatively longstanding performance in the region with 63% of ICT businesses operating for over five years in the region (Coopers & Lybrand, 1997; IRIS, 2013).

II. Post-Secondary Education

Owing to the presence of major institutions, principally the University of Wollongong (henceforth referred to as UOW) and the Illawarra Institute of TAFE, Wollongong has a strong comparative advantage in the post-secondary education sector. This sector is ranked second in the region in terms of increase in employment with more than 2,000 additional jobs over the past ten years (ABS, 2011). The number of onshore students enrolled at UOW\(^2\) was

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\(^2\) This figure only represents onshore students from campuses on Wollongong, Sydney, Shoalhaven, Bega, Southern Highlands, Bateman’s Bay and Innovation Campus. UOW also operates campuses in Dubai,

53
27,107 in 2012, up from 21,448 in 2008, which indicates a more than 26.38% increase in only four years. Staff supporting these students was 2,738 in 2011, up from 2,215 in 2010, indicating a 23% increase in local employment in just one year (IRIS, 2013, Braithwaite et al., 2013). Over the past 10 years, there has been an overall 2,734 (22%) increase in employment within the regional education sector. This 22% increase indicates the significance of this sector in terms of regional development and its contribution to the regional economy (IRIS, 2013).

As a major component of this sector UOW fulfils the education and training of prospective employees in the region in addition to being a major employer, with more than 2,000 skilled workers. There are many graduates and potentially skilled workers, relocating to other regions, states or overseas, that could be employed within the region. It is also important to note that UOW has one of the largest numbers of graduates in information technology, many of who cannot be retained because of an inadequate number of job opportunities. The economic contribution of the education sector is reported to be 5% of the $15.5 billion gross regional product in the financial year 2009-2010 (IRIS, 2013). The flow-on impacts of UOW transactions by students and staff is estimated to yield a daily sum of AU$1.3 million (IRIS, 2013). Furthermore, the Innovation Campus developed by UOW is designed to support industry driven innovation. The university has shown an incontestable focus on research and industry ventures with international corporations and organizations (Netto & Potts, 2010). Construction of the SMART Infrastructure Facility has also contributed to the primary objective of the university in creating new jobs, educating the prospective workforce and facilitating innovative research and development (SMART, 2012). It is reported that UOW generated more than $2.06 billion gross output, $1.1 billion value Singapore and Hong Kong, all of which have an impact on UOW’s operational surplus that may flow back into the region.
added and nearly 8,000 full time equivalent (FTE) jobs overall (direct, indirect and induced) throughout the national economy in 2011 (Braithwaite et al., 2013).

The Illawarra Institute of TAFE provides excellent vocational education and training opportunities to the residents of the region. TAFE offers approximately 630 courses in 14 campuses. With more than 34,000 students, the Illawarra Institute of TAFE is the largest single provider of VET courses in the state of NSW (Neto & Potts, 2010).

The education sector has received a major boost as a result of workforce restructuring and economic diversification over the past two decades. The education and training sectoral employment increased from a 7.6% share of the workforce in 1991 to 9.4% in 2006 and to 10.4% in 2011 (ABS, 2013). With 15,100 jobs, education and training is currently the second largest employer in the region, after health care and social assistance with 19,200 (LMIP, 2014).

III. Retail Trade

The Wollongong central business district (hereafter referred to as CBD) has traditionally dominated the retail sector in the region. Nonetheless, a number of large shopping centres have been built in nearby areas, e.g. Figtree, Kiama, and Shellharbour, which obscure the importance of the CBD (Buchan, 2003). Despite this, retail trade continues being the primary component in this sector in Wollongong with 1,041 businesses employing nearly 15% of the regional workforce (Pomfret, 2011). The General Property Trust (henceforth referred to as GPT) construction group has been working on a AU$200+ million West Keira development project (Crown St. Mall expansion), which would significantly increase the region’s retail sector upon its completion in 2014 (Tonkin, 2011; 2012). The retail sector currently employs 8,230 full-time employees and 7,552 part-time employees, ranking it the third largest full-time employer in Wollongong SD after manufacturing with 10,984 and construction with
8,776 full-time employees (LMIP, 2014). In terms of part-time employment this sector comes second after health care and social assistance with 8,251 part-time employees (LMIP, 2014). Sectoral output increased by $132.8 million, from $881.5 million in 2001 to $1,014.4 million in 2011 (RDA, 2014).

IV. Health & Community Services

This sector is first in terms of employment in the Illawarra, employing more than 16,463 only in the Illawarra SA and 6,697 in the rest of the Illawarra SD (LMIP, 2014). The health care sector has been continuously growing in the local economy, mostly because of an aging population. The Wollongong LGA is providing the region with high-tech health and medical technologies such as that through the Illawarra Health and Medical Research Institute as part of its strategic initiatives scheme based at UOW. As a result, this sector has witnessed an employment increase of 9,204 or nearly 60% over the last ten years (ABS, 2011; LMIP, 2014). Overall in the Illawarra’s major public hospital, 1,918 full-time equivalent (FTE) staff was employed at Wollongong Hospital; 448 FTE staff at Shellharbour Hospital; and 286 FTE staff at Port Kembla Hospital in the year 2008-2009 (NSW Health, 2010). The output and value added of this sector in Wollongong LGA are reported to be respectively $903 million and $719.8 million. The $903 million value added of health and social service sector is 7.2% of the overall value added from all the sectors within the region (RDA, 2014).

V. Tourism

Tourism is attracted to the region due to the scenic natural landscapes and green environment of the Illawarra. This natural asset, together with the region’s geographical propinquity to global Sydney\textsuperscript{24}, provides the Illawarra with a major advantage for the tourism industry. One

\textsuperscript{24} The term “global Sydney” features in the State of the Regions Report produced by economic researcher, National Economics, describing the 220 square kilometre slice of the greater metropolitan area stretching from technology-rich Macquarie Park in the north to Port Botany in the south, embracing twelve local government
of the most picturesque drives in Australia is the Grand Pacific Drive, which is gaining a tremendous popularity in Australian tourism (Visit Wollongong, 2013). This is in addition to other attractions such as the Nan Tien Temple, Illawarra Fly Treetop Walk, Jamberoo Action Park, and the Blue Mile Foreshore promenade which all add to the tourism appeal of the region (Wollongong City Council, 2012).

The University of Wollongong also contributes significantly to the region’s tourism industry, attracting visitors from around NSW, interstate and overseas. Around 60,000 people are reported to visit the University’s Science Centre and Planetarium at the Innovation Campus every year, for exhibitions, observatory, planetarium, and science shows (Visit Wollongong, 2013; Braithwaite et al., 2013). A study has shown that a growing number of visitors come to the region for conferences, graduation ceremonies and visiting friends or family members who are working or studying at UOW (Visit Wollongong, 2013). The education and training sector is the third top contributor to the regional tourism sector, which represents 17.1% of visitors to the Illawarra (Braithwaite at al., 2013). Booking accommodation in Wollongong for educational purposes is also in the top three factors for international visitors, which represents 15.5% of all the nights that are booked by international visitors and accommodation guests within the region (Visit Wollongong, 2013).

VI. Cultural and Recreation Industries

Wollongong has more than 30 developed cultural venues including the WIN Entertainment Centre, Wollongong City Arts Gallery, Illawarra Museum, Australian Motor Life Museum, and the Science Centre and Planetarium, which collectively are becoming increasingly important inputs to the regional economy (Wollongong City Council, 2012). The cultural areas covering Ryde, Hunters Hill, Lane Cove, Willoughby, Mosman, the CBD, South Sydney and the Eastern Suburbs.

25 The Innovation Campus houses a research-quality telescope, which is one of Wollongong’s most popular indoor tourist attractions.
venues manifest the heritage of the city which in turn shapes a sophisticated image for the region, to which tourists gravitate. The cultural venues are deemed to be the region’s economic assets promoting tourism and attracting potential residents to the region (Buchan, 2003). The program set forth by Wollongong LGA for Illawarra museum offers access to resources, training, a museum, and a collection of management programs. Wollongong’s cultural sector is projected to have a significant increase upon implementing the cultural program. The short-range impacts of improvements in Wollongong City Art Gallery in terms of air-conditioning and disabled access would likely see an increase in attracting touring exhibitions (Buchan, 2003). There has been an increase in sectoral employment of 520 FTE over the past six years, from 1,610 in 2006 to 2,130 in 2011 (RDA, 2014). A $271.4 million sectoral output was reported in 2011, a $22.5 million increase from 2006 (RDA, 2014).

Table 2.7 presents regional employment in all sectors for 2001 and 2011; followed by Figure 2.2 that depicts sectoral employment change from 2001 to 2011; followed by Figure 2.3 that presents Wollongong SSD sectoral employment; followed by Figure 2.4 that depicts sectoral employment within the Illawarra SD, excluding Wollongong.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agriculture, Forestry and Fishing</td>
<td>910</td>
<td>922</td>
<td>-1.30%</td>
</tr>
<tr>
<td>2</td>
<td>Mining</td>
<td>2,393</td>
<td>1,053</td>
<td>127.26%</td>
</tr>
<tr>
<td>3</td>
<td>Manufacturing</td>
<td>12,118</td>
<td>15,702</td>
<td>-22.83%</td>
</tr>
<tr>
<td>4</td>
<td>Electricity, Gas, Water and Waste Services</td>
<td>1,697</td>
<td>1,045</td>
<td>62.39%</td>
</tr>
<tr>
<td>5</td>
<td>Construction</td>
<td>10,334</td>
<td>9,140</td>
<td>13.06%</td>
</tr>
<tr>
<td>6</td>
<td>Wholesale Trade</td>
<td>2,134</td>
<td>3,259</td>
<td>-34.52%</td>
</tr>
<tr>
<td>7</td>
<td>Retail Trade</td>
<td>13,029</td>
<td>13,867</td>
<td>-6.04%</td>
</tr>
<tr>
<td>8</td>
<td>Accommodation and Food Services</td>
<td>10,002</td>
<td>8,429</td>
<td>18.66%</td>
</tr>
<tr>
<td>9</td>
<td>Transport, Postal and Warehousing</td>
<td>5,076</td>
<td>4,693</td>
<td>8.16%</td>
</tr>
<tr>
<td>10</td>
<td>Information Media and Telecommunications</td>
<td>1,200</td>
<td>1,785</td>
<td>-32.77%</td>
</tr>
<tr>
<td>11</td>
<td>Financial and Insurance Services</td>
<td>4,476</td>
<td>3,412</td>
<td>31.18%</td>
</tr>
<tr>
<td>12</td>
<td>Rental, Hiring and Real Estate Services</td>
<td>1,371</td>
<td>1,754</td>
<td>-21.84%</td>
</tr>
<tr>
<td>13</td>
<td>Professional, Scientific and Technical Services</td>
<td>5,777</td>
<td>5,049</td>
<td>14.42%</td>
</tr>
<tr>
<td>14</td>
<td>Administrative and Support Services</td>
<td>3,679</td>
<td>3,793</td>
<td>-3.01%</td>
</tr>
<tr>
<td>15</td>
<td>Public Administration and Safety</td>
<td>7,148</td>
<td>5,068</td>
<td>41.04%</td>
</tr>
<tr>
<td>16</td>
<td>Education and Training</td>
<td>10,907</td>
<td>10,011</td>
<td>8.95%</td>
</tr>
<tr>
<td>17</td>
<td>Health Care and Social Assistance</td>
<td>15,690</td>
<td>12,258</td>
<td>28.00%</td>
</tr>
<tr>
<td>18</td>
<td>Arts and Recreation Services</td>
<td>2,130</td>
<td>1,418</td>
<td>50.21%</td>
</tr>
<tr>
<td>19</td>
<td>Other Services</td>
<td>6,122</td>
<td>4,849</td>
<td>26.25%</td>
</tr>
<tr>
<td></td>
<td>Total industries</td>
<td>116,191</td>
<td>107,506</td>
<td>8.08%</td>
</tr>
</tbody>
</table>

**Source:** Compiled by the author using data from LMIP, 2014.
FIGURE 2.3
PORTION OF SECTORAL EMPLOYMENT WITHIN THE REGION 2014

Source: Compiled by the author using data from LMIP, 2014.
FIGURE 2.4
COMPARISON OF THE ILLAWARRA SECTORAL EMPLOYMENT IN 2009 AND 2014

Source: Compiled by the author using data from LMIP, 2014.
FIGURE 2.5
COMPARATIVE SECTORAL EMPLOYMENT OF THE ILLAWARRA AND NSW IN 2014

Source: Compiled by the author using data from LMIP, 2014.
2.5 Conclusion

This chapter has presented a detailed account of the current state of the regional economy in the Illawarra. This chapter indicates that the economy of the Illawarra is emerging as a diverse economy, prone to economic transition and inclined to collaboration, highly skilled labour orientation, and research and innovation. On one hand, certain sectors, such as health care and social assistance, education, and public administration and safety have recorded significant employment growth\textsuperscript{26}. On the other hand, employment growth in the formerly sturdy sector of manufacturing has been in decline and is likely to come under pressure following the aftermath of globalization, the competitive advantage of Asian manufacturers and job losses by BlueScope Steel and related suppliers and support sectors as well as coal mining. Such economic transformation substantiates the importance of and need for an accurate regional analysis and requires the Illawarra to reinvent its economy as a sustainable regional economy. In this respect, it is critical to develop new economic drivers to substitute the traditionally strong economic drivers that served the region in the heavy industrial era.

Over and above a continuous approach in diversifying the regional economy, there are some major areas that require attention. To name a few, development of the regional infrastructure; issues related to land use, particularly the discussion over coal seam gas exploration; and planning for the regional ageing population are the major areas that require attention. Overall, the adjustments that have occurred over the past three decades in the regional economy signify the time of transition for the Illawarra economic focus. Although the region has been facing economic structural challenges, accurate economic analysis and further research enable the region to take advantage of significant opportunities for growth.

\textsuperscript{26} It is also noteworthy to mention that the mining sector has also experienced a revival in fortune in recent years.
This makes the Illawarra an interesting case study and microcosm of the overall Australian economy, and the focus of this study. In subsequent chapters we develop a regional modelling analysis that can facilitate identifying the impact of alternative scenarios relating to the future evolution and development of this regional economy. Chapter 3 of this thesis reviews the studies found in the literature on application of input-output analysis and econometric modelling to different regions around the world. The focus in Chapter 3 is to compare and contrast different studies in the literature with a view to developing a superior methodology for impact analysis and forecasting of the Illawarra economy.
Chapter 3

Regional Input-Output Analysis - Literature Review

3.1 Introduction

Some theoretical aspects relating to traditional input-output (hereafter referred to as IO) models, econometric (henceforth referred to as EC) models, as well as integrated IO with EC (hereafter referred to as IO-EC) models were reviewed in Chapter 1. Integrated models were asserted to be in a superior position because they offer the combined benefits of standalone IO models and EC models and in producing a higher level of accuracy in results of forecasting and impact analysis. The purpose of this chapter is to provide a literature review, in particular to highlight and examine the empirical results derived from using these various modelling approaches found in the literature. This provides a deeper understanding which will be beneficial for comprehending the subsequent chapters of the study.

As discussed in Chapter 1, forecasting and impact analysis are the main components of regional planning. There are two requirements to improve forecasting capabilities in regional planning and to produce an impact analysis of the potential effects of a policy on a region. First, the availability of rich data; second, regional analysts require tools that enhance the accuracy level and reduce the degree of error in their results. The most recent milestone in this direction is the integration of IO with EC models (Isard & Anselin, 1982; Moghadam & Ballard, 1988; Anselin & Maden, 1990; Bertuglia et al., 1990; Conway, 1990; West, 1991; West & Jackson, 1998; Rey, 1998; Rey, 2000; Motii, 2005; Kim & Hewings, 2012). This has generated a significant amount of literature in the past three decades, of which the most crucial elements are explored in this chapter.

Our review of the empirical literature is categorized under four main sections. Section 3.2 provides a general overview of the main motivations behind the integration approach and
a comparison of the traditional input-output and integrated input-output econometric models. Section 3.3 sheds some light on different integrating strategies and their applications. Section 3.4 identifies the statement of the problem, upon which this thesis will focus. Finally, Section 3.5 provides a summary and states some concluding remarks.

3.2 Comparison of the Traditional IO Model with the Integrated IO-EC Model

Most integrated models aim to benefit from the detailed inter-sectoral depiction of an economy as well as the dynamics of changes over time through the combined framework. Early studies on the integration framework were mainly based on highlighting the combined advantages of traditional IO models and EC models (Gerking, 1976; Bullard, 1978; West, 1982).

Several studies suggest that there is a degree of uncertainty in traditional IO models despite their deterministic characteristics (Gerking, 1976; Bullard, 1978; West, 1982; Schumann, 1990). This uncertainty is due to two factors: a) the unpreventable occurrence of statistical errors while collecting large sets of data from various sectors; b) the time lag due to the interval between the time of data collection and the time that the collected data is applied in constructing the table, which is usually about one year (West, 1982). Nevertheless, in return for the time lag drawback, IO offers a detailed snapshot of the transactions among the various sectors of the economy.

On the other hand, regional analysts also employ EC modelling for regional economic analysis and forecasting. The regional EC model avoids the time lag drawback by offering a dynamic analysis of industry variables over time, which is its main competence for forecasting purposes. However, the EC model fails to provide an exhaustive picture of the economic structure and its inter-sectoral interactions for regional impact analysis (West, 1991). On that account, researchers have attempted to unravel the dilemma by integrating the
two models, namely IO and EC, to combine the merits of inter-sectoral disaggregation of IO with the forecasting qualities of EC. The earliest works on integrating the two models dates back to the 1970s, where a study by Klein (1978) suggested it was a useful exercise for obtaining higher accuracy in regional analysis.

West (1995) suggests that although applying the integrated model mostly has yielded favourable results, that is to say the detailed disaggregation of economic structure of IO and the dynamics of the time-series, it is crucial for the regional modeller to consider the objectives for building the model. Each model, be it traditional IO, simple EC, or the integrated IO-EC model, serves certain purposes and is thus pertinent to a certain objective. West (1995) performs a comparative analysis of the main three regional planning models, namely IO, integrated IO-EC, and Computable General Equilibrium (CGE). The basis for his study is the 1985-86 15-sector IO table for the state of Queensland. All models are calibrated to the data in the 1985-86 table and all variables are measured based on the constant values of the same period. His comparison provides results that encourage modellers to emphasize the main purpose of the modelling and consider the characteristics of the region before selecting a model. Furthermore, we consider some different integration approaches that are applied in other regions around the globe.

Chen & Wu (2008) propose a method of input-output structural decomposition analysis (IO SDA) by incorporating a Keynesian model and a two-tier capital, labour, energy and material (KLEM) production function framework. This model is based on a macro-economic theory and production function form, in which they assume that IO SDA complements IO table coefficients in addition to employing the ingrained economic theory. They decompose the changes in sectoral outputs into three factors: a) the change in autonomous final
demand, b) the change in import coefficients, and c) the change in induced demand coefficients. The problem that arises from the IO SDA is that the commonness decomposition complicates the interpretation of the IO SDA results. Chen & Wu (2008) address this problem by implementing a weighted Shapely value (WSV) to consider different decomposition forms. The results of this implementation satisfy the efficiency and aggregation quality of the weighted Shapely value.

Gim & Kim (2009) describe the building of a new open static output-output (O-O) model, which relates the gross output for the final demand to the gross output for the output. They compare the two models, namely IO and O-O, in terms of their structure and characteristics. This study shows that an O-O model can be a supplementary model for an IO model. It can be useful as it gives rise to a fundamental framework for the analysis of different regional and national economic activities. In terms of application, the O-O model can be applied in output impact analysis, O-O multipliers, pollution generation for output, and intensity analysis for resources for output. The O-O model is not completely separate from the IO model. However there are not as many publications using the O-O framework compared to the numerous studies on the integration framework in the literature.

In the line of research on regional IO modelling Kronenberg (2009) describes construction of IO tables using a new non-survey method, named the cross-hauling adjusted regionalization method (CHARM). He argues that traditional regionalization methods overlook the cross-hauling strategy which results in an underestimation of the trade and an overestimation of the regional output multipliers. This approach is implemented for the North

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27 In later stages the change in autonomous final demand is divided into level and mix effects.
28 Subsequently, induced demand coefficients are decomposed according to the framework of the KLEM production function.
29 The Shapley value was first proposed by Lloyd Shapley for evaluating cooperative games. He argued that cooperative games can be measured uniquely using symmetry, efficiency and aggregation axioms.
30 It can be both exogenous and endogenous.
Rhine-Westphalia region of Germany. This study shows a reduction in the underestimation of trade and in the overestimation of the multipliers. Nonetheless, the results of CHARM indicate that if regional data on labour income by sector are not available, the results would show a restrictive assumption of equal labour productivity in the region and the nation. Another drawback of this method is that if data on regional consumption by households are not available, then the restrictive assumption of equal consumption per employee in the region and the nation must be made. Overall, CHARM is a useful approach in more densely populated regions where cross-hauling is significant.

In summary, considering the outcomes of the few studies available in this section, it is concluded that a traditional IO model is most applicable to a demand driven analysis for a small region with fixed technology and partial equilibrium. Whilst, on the other hand, other approaches that complement IO modelling are deemed to be in a superior position; particular among them being the integrated IO-EC framework. The IO-EC models offer dynamics of time series in addition to the detailed inter-sectoral disaggregation of cross-sectional analysis and thus are suitable for a region with technological changes, data on unemployment and total income. Lastly, the CGE model, which provides features such as demand and supply, full response price effects, both full employment and unemployment, is mostly noted as an impact analysis model. Before delving into a thorough review of the literature on the integrated framework, it is important to mention that there has been nearly a decade since the last attempt at merging IO with an econometric model has taken place (Motii, 2005). Although an integrated framework has proven to yield more accuracy and better capabilities in simulation and forecasting, as discussed earlier, there have not been many attempts at building such a framework due to its complexity and data requirements. This explains why the most relevant studies in this review of the literature may not seem updated.
There are other major studies in the literature highlighting the combined advantages of the integrated IO-EC that are discussed in the following sections of this chapter. Table 3.1 summarizes the pros and cons of the integrated IO-EC model compared to the traditional IO model and EC model.

### TABLE 3.1
SUMMARY OF ADVANTAGES AND DISADVANTAGES OF THE IO, EC, AND IO-EC MODELS

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>IO</th>
<th>EC</th>
<th>IO-EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Disaggregated</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Price Responsive</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Impact Analysis</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Demand Driven</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Forecasting</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

*Source:* Configured by the author and inspired by Rey (2000).

### 3.3 A Comparison of Integration Strategies

The number and methods of integrating regional IO and EC models present in the literature have proliferated in the past 20 years because regional economists strive to combine the benefits of IO and EC models. Most of these efforts share two mutual objectives. These are to improve forecasting abilities and to provide a more accurate estimation of impact and structural analysis. There have been comparative analyses, examining different integration strategies, their applicability, pros and cons, and the ways to extend the future direction of the research on these methods (e.g. West & Jackson, 1998; Rey, 1998; Rey 2000).

West & Jackson (1998) suggest that one of the key criteria in selecting the right type of integration approach is the primary objective of the modeller, such as impact assessment, forecasting and simulation. They argue that integration strategies include two main categories. The first category is the IO-EC model, i.e. a model in which IO tables are the central part followed by EC equations that are employed to endogenise the link between the
inputs and final demand. The second category is the EC-IO model, by which the analyst employs a regional EC model but then seeks to extend the model by implementing an IO component to substitute for the output module.

An example of an IO-EC model is the Queensland Impact and Projection (QUIP) model (West & Jackson, 1998). This is an interregional model, divided into five regions and contains 15 sectors per region. Data are obtained from government publications, and the character of the model is IO-EC, which is a bottom-up\(^{31}\) model. The primary use of the model is impact assessment. This is because the model is dominated by a national IO framework thus it would not be equally suitable for forecasting. Therefore, the main setback associated with the model is an emphasis on demo-economic interactions while using a national IO framework to build the main part of the model.

Moreover, an example of an EC-IO model is the Ohio Projection and Simulation Model (OPSM) (West & Jackson, 1998). This is a single region, with 53 industries and three public sectors. Data are obtained from a special census data compilation and the structure is dominated by an econometric framework and an IO module in used to close the model. This is a top-down\(^{32}\) model. Its primary use is for projection and simulation. The main issue with it is that household consumption and other final demand activities are estimated to enhance the output, income and employment projections.

West & Jackson (1998) compared the QUIP model and the OPSM model. Although both models provide similar benefits, the modelling structure and suitability are poles apart. They are different in modelling structure in terms of type of data used (geographical for IO-EC or industrial for EC-IO), availability of data, direct endogeny or indirect exogeny; and the

\(^{31}\) A bottom-up model is a model that is dominated by an IO table and implements econometric equations to endogenize the linkages between the dynamic inputs and final demand.

\(^{32}\) A top-down model is a model that is dominated by a regional EC model and replaces the component of output with a block of an IO table.
fitness for the modeller’s objective in terms of whether the model is suitable for impact analysis (IO-EC) or for its forecasting capability (EC-IO).

Rey (1998) examined different integration strategies to model the Southern California economy. They identified three strategies; namely ‘embedding, linking, and coupling’. The three strategies are principally distinguishable on the basis of their use of integration regime and integration structure (Rey, 1998). The integration regime addresses the extent to which IO components engage with that of the EC components in the integrated model. The integration structure addresses the mathematical account of the selected approach of the integrated model. Southern California consists of five regions. Rey (1998) applies five isolated models; namely a single region IO (SRIO); a closed single region IO (SRCIO); a multiregional IO (MARIO); a closed multiregional IO (MRCIO); and a multiregional EC (MREC); as well as three integrated models, namely linked IO-EC (LINK); embedded (EMB); and coupled model (COUP) for each region (Rey, 1998). Rey (1998) suggests that his detailed classification can be applied as a foundation for future comparisons on the peculiarities of different integration methods.

Similarly, Rey (2000) examined integrated studies in the literature and asserted that integrated IO-EC models offer a more detailed sectoral disaggregation, thus providing an advantage in comparison with IO or EC models applied alone. He found that an integration approach offers more accuracy in forecasting, higher level of disaggregation in impact analysis and, as previously addressed, reduced errors in terms of measurement. Rey (2000) provides two motivations for the integrated framework; theoretical and practical. The theoretical motivations for implementing IO-EC models is because of the restrictive postulations of each component model (i.e. EC or IO) when used in isolation. Practical motivations are improved forecast performance, more comprehensive impact analysis capabilities, and reduced concerns over measurement errors.
Rey (2000) found that in the coupling approach, a complete mutual feedback between the IO and EC components takes place in both directions. The two main channels are the flow from final demand to IO and the connection of IO to the labour market. In the linking approach there is only one linkage between the IO component and the EC component and the integration linkages generate successive terms of recursion. In the embedding approach there is a simultaneous interaction between components of the EC and IO, yet the portion of integration is much less than in the coupling approach. The strength of this study is that it features a thorough examination of different integrations methods. This feature makes Rey’s (2000) study a vital foundation for regional analysts to rely on when defining their objectives; analysing their regions; selecting the most suitable integration approach; and subsequently obtaining higher level of accuracy in forecasting the economy and conducting impact analysis at the regional level. Rey’s (2000) classification is applied in this thesis as the main groundwork for classifying the three integration methods and comparing their results for the Illawarra region.

In summary, this section covers the taxonomy of different integration strategies from two perspectives. Although West & Jackson (1998) acknowledge Rey’s (1998) classification, they suggest that the integration is either IO-EC, which is an EC component dominated by an IO model; or EC-IO, which is an IO component dominated by an EC model. A shortcoming of their study, related to the objective of this research, is that both QUIP and OPSM are considered composite approaches based on Rey’s (1998) classification. Yet both models achieve the combined benefits of traditional IO and standalone EC models and thus provide higher accuracy in impact analysis and forecasting. Figure 3.1 illustrates Rey’s classification of the three integrating strategies.
3.3.1 Composite Strategy

One of the earliest studies on the composite approach is the Washington Projection and Simulation Model (WPSM), which was first constructed in 1977 for economic forecasting and analysis of the state of Washington. Conway (1990) used this model to assess its simulation and forecasting characteristics; and to further compare it with the initial model that he built for the same state nearly a decade earlier (Conway, 1979). Conway (1990) identified four key issues. First, a decisive element in generating a useful regional policy is forming long range projections. The WPSM demonstrated high precision results for this objective. Second, in order for long range projections to provide less degrees of error, projections need to be compatible with both internal and external environment. Internal compatibility is about consistency among the endogenous variables and external compatibility is when there is consistency between endogenous and exogenous variables. For this purpose WPSM takes investment and government expenditure as being endogenous in the model, in order to exhibit multipliers that are significantly higher than the usual models. Third, WPSM is primarily demand driven, although it extensively incorporates the supply side as well which is mainly observed in the labour market. Finally, the monetary cost of

Source: Author’s summarized illustration of integration approaches, inspired by Rey (2000).
building an integrated model similar to WPSM varies depending upon the desired level of accuracy and the desired degree of using survey or non-survey data to construct the model (Conway, 1990).

Considerable interest in the composite approach led to a further IO-EC model for the state of Queensland (West, 1991). The IO-EC model developed for the Queensland Integrated Model (QIM) used the 1985-86 Queensland IO table as its inter-industry foundation. In order to track the structural changes through time and to incorporate the dynamic feature, the IO table was “superimposed on” the 1978-79 output figures. The annual inflation was then applied to update the figures, thus enabling a realistic comparison of the results of the original traditional IO model and that of QIM (West, 1991). QIM is a fifteen-sector model, and applies labour and income components to estimate household expenditure per capita for major commodity groups.

The outcomes of the comparison show that the traditional IO model has a noticeable level of inconsistency with the real data, particularly for gross output and gross regional product (West, 1991). The results of the analysis show, however, that the QIM is a suitable model for forecasting and impact analysis. It also features added values in projecting other variables, e.g. labour force, population, total and disposable income, and unemployment (West, 1991). West (1991) concludes that even though his composite model possesses certain advantages compared to the traditional IO model used for Queensland, it might not suit all geographical circumstances and there is still room for improvement of the model.

Applying a composite approach, Treyz et al. (1993) developed a model to enhance the quality of decision making in the public and private sectors. They calibrated their model to sub-national areas for forecasting and policy implication analysis of Southern California. The model incorporates inter-industry interactions and endogenous final demand. They developed a Regional Economic Model Inc. (REMI); an Economic-Demographic Forecasting and
Simulation (EDFS) model; and a Computable General Equilibrium (CGE) model. The outcomes for their paper show that although their models have some commonalities, such as price responsive products as well as factor demands and supplies, they differ in that REMI and EDFS determines the time path of variable responses by conjoining a base model through econometric estimated parameters. The CGE model assumes market clearing in all factor markets in its static form and invokes perfect prior inter-temporal market clearing or temporary market clearing in case of unclear expectations in its dynamic form. Their findings show that their composite model is useful for regional forecasting and policy simulation. The advantage of their model is that it can be adjusted to suit different regions, in addition to improving the forecasting and policy impact analysis capabilities of the model.

Along the same lines, Israilevich et al., (1996) developed a model, named the Chicago Regional EC-IO Model (CREIM), using three IO tables containing data that was collected using a variety of methods such as fully survey-based, adjusted national coefficients, and random numbers (where there was no local data). A comparative analysis of the model shows that there are significantly different outcomes produced from each of the three tables when they are applied for forecasting analysis. Based on their findings, emphasis should be placed on the objectives of the modeller (as also pointed by West, 1995; Rey, 1998; Rey, 2000) in order to select the right source of data that match the types of analysis and the specifics of the region, for which the analysis is being carried out.

Within a similar line of research Schindler et al. (1997) suggest that in reality, output multipliers are undoubtedly related to the output growth rate, otherwise there have to be fixed multipliers which would then deny the dynamic features of the EC models. The same interconnection exists between income and employment. This relationship is simultaneous and nonlinear, and implies that inter-sectoral relationships are to be examined in a multi-dimensional fashion when analysing a regional economy in order to capture the dynamics of
inter-industry interdependency. In traditional IO multipliers are assumed to be static over time. In the composite approach changes in the multipliers are tracked both in magnitude and in ordinal ranking. Schindler et al. (1997) reapply CREIM for the six-county Chicago metropolitan region and concludes that there is not a linear relationship between the interactions of the variables in CREIM with structural changes over time.

In summary, the reviewed literature in this section suggests that a composite approach is the most dominant approach in terms of sectoral employment forecasting. In comparison with other approaches the composite approach is extremely data-intensive, and more suitable for large and highly developed regional economies. Lastly, it generates estimated impacts that are fully spread across industries within a regional economy, and it provides a detailed view of distributional effects across industries.

3.3.2 Embedding Strategy

In the embedding strategy, the intermediate demand components of an IO model are incorporated into a host econometric model. Most of these models disintegrate the intermediate demand information into a single composite variable and reflect them as prior information. This prior information represents the inter-sectoral interactions among industries of a regional economy.

Moghadam & Ballard (1988) developed an Integrated-Small Area Modelling of the Industrial Sector (I-SAMIS) for Northern California, aiming to gain the benefits or dynamic qualities of EC as well as the precision of inter-industry matrices from IO. The data applied in their model are time-series and matrix data. Moghadam & Ballard (1988) chose employment data only for their particular sub-state region, albeit output data is more comprehensive and preferable for larger regions. Because of their long-term forecasting they used annual data from 1962 to 1985. Although they faced two issues for their model, namely
a shortage of adequate data and significant mixture of economic facets along the chosen region and its consisting sectors, the outcome of the analysis proved the embedded approach to be quite practical for regional modelling in terms of forecasting and impact analysis.

In a similar study to Moghadam & Ballard (1988), Coomes et al. (1991a) implemented the I-SAMIS approach for evaluating the impacts of taxation policies and economic development proposals on different levels, i.e. city, county and state, for the economy of Louisville. Coomes et al. (1991a) applied a non-survey regional IO model and used information obtained from the direct requirement coefficients of an IO table to estimate the input linkages between a certain industry and all other industries at any point of time. As suggested by Moghadam & Ballard (1988), Coomes et al. (1991a) used regional employment as a substitute for output to calculate inter-industry linkages. They concluded that although I-SAMIS is not currently the main influential factor for policy makers to weigh their options, it is unquestionably an appropriate method for policy makers to use in selecting policy alternatives and it is also appropriate for urban regions with similar characteristics (Coomes et al., 1991a).

Following the embedding approach, Stover (1994) argued that coefficients of an IO model change as a result of relative changes in technology, demand, prices, flows of trade, etc. Stover (1994) implemented an I-SAMIS technique and applied Inter-industry Demand Variables (IDV) to measure the use of an industry’s output by other industries in the region, and applied an IO model to calculate the amount of the output. The model employed annual employment data for the manufacturing sector in the St. Louis metropolitan area. The findings showed that applying a single year IO account ignores structural changes over time when analysing highly aggregated regional industries, which leads to the occurrence of measurement errors. This study showed that the use of several annual IO models significantly increases the necessary computations to break down the coefficients for the regional level.
This factor suggests that unless there is evidence of significant changes in input usage between sectors over time, it is not recommended putting much effort into the enormous calculations.

Most recent studies have highlighted the combined benefits of IO and EC in an embedded approach, as a response to the growing concern over non-inter-industry modules of regional economies such as consumption, investment, government, labour demand, expenditures, and income distribution (Rey & Jackson, 1999). Rey & Jackson (1999) add to the literature focused on the methodological issues associated with the integrated framework. The embedding approach of Moghadam & Ballard (1988), IDV, has been developed by a line of studies in the integration framework (West & Jackson, 1995; Israilevich et al., 1996; Rey, 1998). The IDV method has one drawback: there is no multi-dimensional consistency among its model components (Rey & Jackson, 1999). Rey & Jackson (1999) substitute a Dynamic Inter-industry Employment Demand Variable (DIEDV) for the original IDV in order to address the productivity variations in the model through an embedded IO-EC model, performed on the San Diego metropolitan area. Their findings show that inter-industry linkages, local and export final demands are important in determining regional employment; however, a collinearity problem occurs between these drivers. The study results show that extending the static regional labour productivity in the embedded model is useful to take changes into account and thus provide more accuracy. Also, dynamic adjustments are necessary to avoid overestimation of impact effects in labour productivity (Rey & Jackson, 1999). The issue of multicollinearity between inter-industry variables and macro-variables is not fully addressed in their study. Also labour productivity is practically endogenous, which requires further research in this area.

One of the most recent works on the embedding strategy is the Dynamic Integration Approach (DIA), which is essentially an extension to the work of Moghadam & Ballard
Motii (2005) applies regionalized coefficients in his approach and implements time-series variables to examine the connectedness of the industrial sectors within the economy. Data applied in this model is quarterly adjusted employment levels in the private sector (excluding farms) for the state of Oklahoma over the time period 1972 to 1994. Motii (2005) extends the embedding model by applying a dynamic Intermediate Employment Demand Requirement (IEDR) component, a Cost Adjustment Factor (CAF), and final demand (final local and national demand, or activity variables) component. There is a noticeable decrease in multicollinearity due to the variance inflationary factor. The outcomes of the analysis suggest that the precision of the projected figures provided by the DIA model places it in a superior position compared to that of ADIA and other integrated embedded models. However, there is still room for improvement in terms of pragmatic examination for different time periods or different regions.

All the existing embedded models can be grouped into two different classes with respect to the treatment of inter-sectoral linkages that are incorporated from the IO module into the econometric host. The first class would apply an overall methodology, where intermediate input demand information is embedded into the econometric framework as one variable, which works as a proxy for all the inter-sectoral demand linkages. The second class, namely the partial methodology, would only embed the inter-sectoral linkages that are considered significant and relevant. These linkages are disaggregated before being incorporated into the econometric module. Building an overall methodology is less complex than the partial methodology. Nevertheless, models in partial methodology are argued to be more accurate (White & Hewings, 1982; Glennon et al., 1987; Glennon & Lane, 1990; Magura, 1990). There is an extensive literature on the embedded models classified on this basis. A selected number of studies that are related to the Illawarra econometric IO model (IEIOM) is presented in Chapter 5 before construction of the IEIOM.
To summarize this section, a review of the embedding approach literature suggests that it is less data intensive than the composite approach. It is more suitable for less diversified economies for employment forecasting and one of its features is that it generates estimated impacts that are concentrated in specific industries within particular regions where it is of interest.

3.3.3 Linking Strategy

Contrary to the embedding approach, where IO components are fully embedded within the EC model, in the linking strategy the IO component remains mostly independent of the EC component. One of the first papers to use a linking approach is L’Esperance et al. (1977) which attempted to estimate the final demand components for six individual sectors, applying a macro EC model. Using the estimated final demand components, an IO model was derived to estimate gross sectoral output for the state of Ohio. L’Esperance et al. (1977) aggregated a 76-sector IO model to the six sector macro EC model, and then linked modules of the two models. The obtained estimates did not provide sufficient channels of integration between the two modules. Thus the main limitation of the strategy was the loss of the IO detailed disaggregation.

In a similar line of research, Rey (1998) also employed the linking approach for the five regions of Southern California to translate final demand changes into changes in output. The output changes were then translated into employment changes through labour coefficients of a fixed diagonal matrix (Rey, 1998). Then he aggregated the increased labour demands from the IO model to the industrial sectors of the EC model. Finally, the feedback from the final demand changes was translated into the difference between two solution values for a certain variable in the EC model; the first solution value being from an isolated EC model without the shock, and the second being from simulating the linked model after the shock is introduced to the integration of IO and EC (Rey, 1998). This study shows a significant
overestimation obtained from the linking approach in terms of employment impacts. This is possibly due to the double counting involved in the linking approach of integration (Rey, 1998). The results also suggest that the linking strategy would be mostly favourable when a qualitative comparison is performed for obtaining results from different regional settings. It is also suggested that further advances are required to address the overestimation issue in this study.

In summary, the two studies provided in the literature suggest that the linking approach generates extreme overestimations of impacts compared to the composite and the embedding approaches; it is therefore more suitable for a qualitative comparison. Furthermore, the linking approach is not appropriate for estimating quantitative policy impacts because of its overestimation of potential effects.

The literature discussed in this chapter regarding the empirical studies of IO modelling and different integrated IO-EC modelling is summarized in Table 3.2.
<table>
<thead>
<tr>
<th>No.</th>
<th>Year</th>
<th>Author</th>
<th>Aim</th>
<th>Location Under Study</th>
<th>Methodology</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1977</td>
<td>L’Esperance et al.</td>
<td>To estimate the final demand components for six individual sectors</td>
<td>Ohio</td>
<td>Linking IO-EC</td>
<td>No subsequent feedback from estimates to additional final demand changes in the EC model.</td>
</tr>
<tr>
<td>2</td>
<td>1988</td>
<td>Moghadam &amp; Ballard</td>
<td>To integrate the flexibility of time-series with inter-industry details of IO</td>
<td>Northern California</td>
<td>Embedded I-SAMIS</td>
<td>Testing of the model proves successful.</td>
</tr>
<tr>
<td>3</td>
<td>1990</td>
<td>Conway</td>
<td>To analyse accuracy of long range forecasts</td>
<td>Washington</td>
<td>Composite WPSM</td>
<td>Long range forecasting is a worthwhile exercise.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Evaluate model’s simulation properties</td>
<td></td>
<td></td>
<td>WPSM multipliers are not exceedingly high.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>WPSM considers supply side as well as demand; it is noticeable in labour force.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The cost of a regional IO-EC model depends on sources of data.</td>
</tr>
<tr>
<td>4</td>
<td>1991</td>
<td>Comes et al.</td>
<td>To evaluate economic development proposals using integrated IO-EC model</td>
<td>Louisville</td>
<td>Embedded I-SAMIS</td>
<td>The model determines the time-path and long term effect of a project on private sector, city, and county and state tax collection.</td>
</tr>
<tr>
<td>5</td>
<td>1991</td>
<td>West</td>
<td>To incorporate the advantages of IO and EC</td>
<td>Queensland</td>
<td>Composite IO+EC QIM</td>
<td>IO shows a significant underestimation of gross output and gross regional product.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In IO while wages and salaries are underestimated, employment is overestimated.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>All the info obtained in simple IO is obtained from QIM in addition to unemployment, labour force, and population, total &amp; disposable income.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QIM provides dynamics impact studies.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Suitable for impact analysis and forecasting.</td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>Author(s)</td>
<td>Objective</td>
<td>Location</td>
<td>Model/Method</td>
<td>Notes</td>
</tr>
<tr>
<td>---</td>
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<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 6 | 1992 | Treyz et al.    | To perform regional forecasting and policy simulation                                                                                       | Southern California | Composite REMI EDFS | • REMI EDFS is suitable for regional forecasting and policy simulation.  
• Advantage of updatability.  
• There is room for improvement. |
| 7 | 1994 | Stover          | To compare annual IO account to a fixed benchmark IO table through I-SAMIS                                                                   | St. Louise metropolitan area | Embedded I-SAMIS | • Involving an annual IO model is not necessary unless confronted with large changes in input usage across sectors over the relevant time period. |
| 8 | 1995 | West            | To compare IO, IO-EC, and CGE                                                                                                                   | Queensland | IO-EC CGE | • There is a shift from IO to more comprehensive models as a result of trends in technology advancement.  
• There are substantial differences between the models.  
• IO is still applicable and resilient at the small-region level. |
| 9 | 1996 | Israilevich et al. | To compare IO, social accounting system, and EC-I0 for forecasting and impact analysis on the role of IO coefficient estimation            | Chicago   | Composite CREIM CIO NIO RIO | • Differences in construction of IO tables translate into differences over the forecast periods.  
• Overall level of output prediction by NIO is higher than the corresponding value predicted by CIO.  
• For forecasting, the differences of table are significant. |
| 10| 1996 | Schindler et al. | To analyse economic performance and examine the interactions between industry multipliers and output growth rates                           | Chicago   | Composite CREIM | • It is paradoxical to say output multipliers are independent of output growth.  
• The same goes with income and employment.  
• The relationship between output, multipliers, employment and income is simultaneous and nonlinear.  
• An integration method is a must to examine the true dynamic nature of economic structure. |
<p>| | | | | | |</p>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>1998</td>
<td>Rey</td>
<td>To examine the properties of different integration strategies</td>
<td>Southern California</td>
<td>COUP EMB Linked SRIO SRCIO MRCIO MRIO MREC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Integrated models as a framework offer higher forecasting accuracy and improved impact analysis capabilities compared to traditional IO.</td>
</tr>
<tr>
<td>12</td>
<td>1998</td>
<td>Rey</td>
<td>To perform a comparative analysis of integration strategies</td>
<td>Southern California</td>
<td>Linking IO-EC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Linking model showed an “inherent flaw” that results in significant large estimations in impact analysis.</td>
</tr>
<tr>
<td>13</td>
<td>1998</td>
<td>West &amp; Jackson</td>
<td>To compare IO+EC and EC+IO</td>
<td>Queensland Ohio</td>
<td>Composite IO+EC: QUIP EC+IO: OPSM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Both emphasize on export production and population growth as the principal factor behind regional economic growth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Both aim to achieve benefits of IO and EC.</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Differences in data availability, geographical specificity, QUIP is impact model, OPSM is forecasting model.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Important to study the environment and landscape of the region before deciding upon the model.</td>
</tr>
<tr>
<td>14</td>
<td>1999</td>
<td>Rey &amp; Jackson</td>
<td>To extend IEDV variable and transform it from static to dynamic</td>
<td>San Diego</td>
<td>Embedded IO-EC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>To evaluate its forecasting performance and estimation properties</td>
<td></td>
<td>• Problems of multicollinearity plague the conventional specification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Embedded models stress the importance of inter-industry linkages and local and export final demand.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Dynamic adjustments result in lower values for partial and total employment multipliers compared to the original IDV.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Ignoring labour productivity can lead to overestimation of impact effects.</td>
</tr>
<tr>
<td>Year</td>
<td>Study Year</td>
<td>Author(s)</td>
<td>Summary</td>
<td>Methodology</td>
<td>Results</td>
</tr>
<tr>
<td>------</td>
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</tr>
<tr>
<td>15</td>
<td>2000</td>
<td>Rey</td>
<td>To explain the motivations for integration and different integration methods. To address the future directions of research.</td>
<td>Studies in various locations. Integration strategies.</td>
<td>- There are theoretical and practical motivations for integration. - 3 types of integration strategies. - 3 approaches towards calibration of integrated models. - Future direction would be to add to the literature in terms of integrated framework.</td>
</tr>
<tr>
<td>16</td>
<td>2005</td>
<td>Motii</td>
<td>To introduce the dynamic properties of inter-sectoral relationships among the economic sectors of a region.</td>
<td>Oklahoma. Embedded DIA.</td>
<td>- DIA reduces multicollinearity to acceptable levels through interactive right-side variables. - In terms of predictive accuracy it outdoes other models. - Adjusting for labour productivities in the integrated models results in applicability across a wider range of sectors. - Application of DIA is needed for other time periods, different regions to verify its superiority.</td>
</tr>
<tr>
<td>17</td>
<td>2008</td>
<td>Chen &amp; Wu</td>
<td>To compare IO SDA and traditional IO.</td>
<td>Taiwan. IO SDA.</td>
<td>- The problem of complicating the interpretation of IO SDA results is addressed by using WSV. - The use of WSV also fits the hierarchical structure of IO SDA. - The model provides a set of IO SDA solutions that gratifies aggregation and efficiency axioms of WSV and avoids random transfer of ad hoc decomposition forms.</td>
</tr>
<tr>
<td>18</td>
<td>2009</td>
<td>Gim &amp; Kim</td>
<td>To compare O-O and IO.</td>
<td>Korea. O-O.</td>
<td>- O-O can be applied in many areas such as output impact analysis, O-O multipliers, pollution generation for output, and intensity analysis of output resources. - Use of both models jointly provides more flexibility in application.</td>
</tr>
</tbody>
</table>
To lessen the restrictive assumptions of common regionalization methods, Kronenberg analyzed the North Rhine-Westphalia region using the CHARM method. CHARM yields much higher estimates of regional trade and lower estimates of regional output multipliers.

As a non-survey method, CHARM can be applied as a top-down hybrid approach.

*Source:* Compiled by the author.
3.4 Statement of the Problem

A large number of studies in the literature have focused on highlighting the merits of the integrated framework compared to the standalone traditional IO model and the standalone EC model. On account of the comparative advantages of the integrated framework, over the stand-alone IO and EC models, studies on the application of the integrated approach have proliferated over the past two decades. This literature review has shown that with the exception of Rey (1998), which compares the alternative integration strategies for one region, all studies have applied a single integration approach for a certain region at a given time rather than applying all three approaches to one region and then comparing them. At the same time, considering the location specifics of different studies, the literature shows that except for a few studies for the state of Queensland (West, 1991; West, 1995; West & Jackson, 1998) most of the studies have been performed for different regions within the US.

Having said that, a significant gap exists in the literature as we do not know how each integration approach would perform in a region with the characteristics of Illawarra, which is going through a period of major transition and transformation of its economic structure. This thesis fills this gap by applying the three integration methods and comparing their outcomes with that of an existing regional IO table of the Illawarra. We apply the three integration approaches to the Illawarra region. We examine how they compare with each other with respect to forecasting and impact analysis when applied to a region with location specifics of Illawarra. Also, we analyse how well they perform subject to cost and data availability, and observe how the results of each approach substantially compares for this type of region. This research adds to the literature by highlighting the advantages and issues, the strengths and weaknesses associated with each approach. This research leads the way for future studies using an integration framework with a view to building models that fit a more diverse range of applications.
Supplementary to our theoretical objective of filling a gap in the literature, the paramount practical objective of this thesis is to address the following questions in the context of the Illawarra economy:

- Which changes are likely to happen in the future (over the next five years)?
- Which industries were the most important in prompting large economic shifts in the past 10 years, and will they continue to be prominent in future transformations?
- What impacts will different policies have on regional employment, regional output, and income?
- How might these impacts affect other regional economies?

The Illawarra econometric input-output model (IEIOM) is calibrated with the objective of addressing these questions, and thus improving forecasting and policy impact analysis for government and private stakeholders concerned with the Illawarra region.

3.5 Summary and Conclusions

This chapter has reviewed the literature on regional integration strategies. We found that, as a framework, the combined approach offers both noteworthy improvements in forecasting and a higher precision in impact analysis compared to the isolated application of IO or EC models.

A wide variation is evident in the manner in which each integrated approach has been developed and also a vast difference in the characteristics of the regions that they have been applied to. The results of previous studies imply that for economies with less diversity and smaller inter-industry structure, where exogenous factors are important in forming regional growth, embedding approaches yield favourable outcomes. The composite approach is much more promising in highly diversified economies with a more elaborate inter-industry structure. The only two studies performed for the linking approach suggests that this
approach results in overestimation in impact analyses, signifying a requirement for future studies and different applications of the linking approach.

Building upon Rey (1998; 2000); West (1991; 1995); and Motii (2005) the main purpose of our research is to add to this line of literature by investigating an issue that has received merely a limited attention: to apply three different integration methods for one location and compare the results. By doing so this thesis contributes to the development of a research agenda in the integrated literature that focuses on the comparison of traditional IO and different integration strategies, suggests methods for improvement of the models, and achieves more accuracy in results obtained. In the following chapter, the main framework for construction of the IO model is presented in the first section and the procedure for specifying the regional econometric equations is presented in the second section. The two models are then used in Chapter 5, using three different methodologies, namely composite, holistic embedded and linking, to merge and build the Illawarra econometric input-output model (IEIOM).
Chapter 4

Theoretical Framework

4.1 Introduction

The focus of this chapter is on the development of the two main frameworks applied in this thesis, namely input-output (IO) analysis and econometric modelling. The fundamental forms and building process of the standalone IO analysis and regional econometric modelling is described in this chapter. These two models will be conjoined and compiled as the component modules for building the Illawarra econometric input-output model (IEIOM) in Chapter 5. The results from the IEIOM will be applied to conduct scenario analyses in Chapter 6. Additionally, in Chapter 6, results from the three different approaches undertaken to integrate the two models are compared subject to data availability.

Regional IO modelling originated from the innovative work of Isard & Kuenne (1953), Moore & Peterson (1955) and Miller (1957), twenty years after the development of Leontief’s Nobel Prize winning model of the US economy (Leontief, 1936). Since then regional IO modelling has become an important component of the regional modellers’ toolkit and in the regional science literature. This importance is attributable to two aspects. The first aspect relates to the large number of applications of IO analysis in modelling regional socioeconomic issues. The second aspect relates to the large number of studies in the literature that focus on the methodological extensions and developments of regional IO models. Similar to regional IO models albeit less popular, a number of regional econometric

33 For industry and government modellers, cost of building the model is also an important factor.
34 Regional econometric models are less popular due to the higher calibration requirements and lack of available time series data which will be discussed further in subsequent sections and in detail in Chapter 6.
models have been implemented with the objective of addressing the inter-sectoral interactions between different blocks of industries in a regional context.

Literature on the application of IO analysis and econometric modelling at the regional level is extensive, and there are a number of excellent key references on the subject available (Richardson, 1985; Miller & Blair, 1985; Hewings et al., 1987; Anselin, 1988; Dewhurst et al., 1991; Cassing & Giarranti, 1992; Motii, 2005; Miller & Blair, 2009). Therefore, before we move on to integrating the two models at the regional level, it is essential to form a fundamental representation, describe the mathematical notation of these two models, and elaborate on the building procedure of each model separately.

The reminder of this chapter proceeds as follows. In Section 2 an exhaustive overview of IO models is presented. Section 3 provides a detailed description of the equations for the regional econometric model of the Illawarra. The final section contains a summary and some concluding remarks.

4.2 The Input-Output Framework

The Leontief IO model in its basic form is constructed using a cross sectional set of observed economic data for a particular region. The main objective in IO modelling is capturing the interaction between industries that produce outputs and either the industries that consume those outputs in order to produce their own outputs (intermediate inputs) or the final consumers of those outputs (final demand vector). From a practical perspective the number of industries in an IO model can vary from only a few to hundreds and sometimes to thousands. The type of region can also range from a local government area (LGA) to a statistical division (SD), state, and national or even to international scale. The determining factor would be the desire for complexity over simplicity or vice versa. A more detailed IO model is generally
preferable but this requires more data calibration requirements and results in a much more complex model.

The primary data utilised in an IO analysis centres around the expenditure flows related to the supply of products (output) from each industrial sector $i$, to each of the other industrial sectors, including $i$ itself, that consume those products (input) in an economy, either to produce their own output (intermediary) or as final consumers (final demand vector). This central data on which an IO analysis is constructed is collected and implemented in an inter-industry transaction table\textsuperscript{35}. The construction of the basic IO analysis is the key purpose of this section. In general, an IO model consists of three basic tables, namely, the transaction table; the technical coefficients table; and the independent coefficients matrix (direct requirements table), which are analysed in the following subsections.

\textit{4.2.1 The Transactions Table}

As described above, the primary data for construction of an IO model is contained in a transaction table, which is the focal point of an IO analysis. The transaction table depicts a snapshot of all the inter-sectoral transactions within an economy over a specific time period. The value of a particular sector’s output that is purchased by other sectors as input is the main requirement for building a transaction table (Leontief, 1986). Although in theory inter-sectoral flows can be intuitively considered as physical units, in practice most IO tables are built based on monetary values of the expenditure flows due to numerous issues related to physical measurement.

\textsuperscript{35} An example of such a table is provided in Figure 4.1 in the following subsection.
The first step in construction of a transaction table is collecting a large volume of quantitative data. There are usually three different types of data, namely, survey-based regional coefficients; national proportion-based coefficients; and randomly generated coefficients, which can be used to build a transaction table. The types of surveys required to collect the survey-based coefficients are expensive and time consuming (West, 1995; West & Jackson, 1998), resulting in coefficients that are outdated before they are presented. As pointed out earlier in Chapter 2, there is an inevitable time lag that occurs between the time of accumulation and the collation of large volumes of survey based data and the time that data is implemented in constructing the transaction table. This time lag is usually one year until all the survey based responses are converted to raw data and implemented in the table (Moghadam & Ballard, 1988). Hence by the time the table is built the containing data relates to the economic structure of the previous year. It is also important to note that regular update of IO tables can be highly challenging for regions that are undergoing major and continual structural adjustments and transformations. Therefore, a standalone IO table does not capture possible shifts that may have occurred in the structure of the economy during that one year, leading to the table being old before it is born. This means that not only is using survey-based data costly but, to inevitable time lags, it leads to measurement errors due to not capturing the most recent trends in economic structure.

For this reason, survey-based coefficients can be used only to constitute the original figures in the table, subject to correction and fine-tuning based on subsequent economic trends that occur after collecting the survey results. The rest of the data can be interpolated and extrapolated based on national coefficients, which is discussed in the following sections. The advantage of this method is that it is considerably less costly and time consuming, nonetheless; the national coefficients do not necessarily represent the regional coefficients of
inter-industry expenditure flows, hence leading to possible occurrence of heterogeneity and autocorrelation which are discussed in detail in Chapter 6 and Chapter 7.

In the transaction table the rows represent the flows of an industry’s output throughout the economy and the columns represent the consumption of inputs required by a particular industry to produce its output. These inter-industry flows of goods and services form the grey portion of the table presented in Table 4.1. For example, let \( x_{ij} \) be an inter-industry transaction, where \( i \) is the sector which produces the product and \( j \) is the sector which purchases the product\(^{36}\). The horizontal figures (the rows) in the table represent the total sales and the vertical figures (columns) represent the inputs or purchases of each sector in relation to the other sectors. Since each figure in any row is also a figure in a column, the output of each sector is also an input in another. The last four columns contain details of Final Demand, consisting of sales to households, investment, government and net exports expenditure, which is the monetary value of exports less imports.

From a practical perspective the output of sector \( i \) may be used within the same sector \( i \), sold as an input to sector \( j \), or sold to one of the final demand elements. For example, financial services are sold to the financial services sector itself; it is also sold to all other sectors as business financial facilities as well as to final demand elements as personal financial services. After all inter-sectoral purchases and sales are entered in the table; total sectoral output must equal total sectoral input.

\(^{36}\) This is fully explained in the following context.
### TABLE 4.1
**INPUT-OUTPUT TRANSACTION TABLE SAMPLE**

<table>
<thead>
<tr>
<th>Producers as Consumers</th>
<th>Final Demand</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Producers</th>
<th>Agriculture</th>
<th>Mining</th>
<th>Construction</th>
<th>Manufacturing</th>
<th>Trade</th>
<th>Transportation</th>
<th>Services</th>
<th>Other Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mining</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Trade</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Industries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value Added</th>
<th>Employee Compensation</th>
<th>Profit-Type Income and Capital Consumption Allowances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Owners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Indirect Business Taxes**

**Gross Domestic Product**

*Source*: The author, based upon the IO Transaction Table used by the US Department of Commerce, Bureau of Economic Analysis, 2010.
Accordingly, if the economy is divided into $n$ sectors, and if we denote the total output of sector $i$ by $X_i$ (production) and the total final demand for sector $i$’s product by $Y_i$, we can write:

\begin{equation}
(4.1) \quad X_i = x_{i1} + x_{i2} + \cdots + x_{ij} + \cdots + x_{in} + Y_i
\end{equation}

The $x$’s on the right side of the equal sign represent inter-industry sales by sector $i$, therefore the entire right hand side of the equation is the sum of all sector $i$’s inter-industry sales and its sales to the final demand elements, representing the distribution flow of sector $i$’s output. Therefore, for each of the $n$ sectors there will be:

\begin{align*}
X_1 &= x_{11} + x_{12} + \cdots + x_{1j} + \cdots + x_{1n} + Y_1 \\
X_2 &= x_{21} + x_{22} + \cdots + x_{2j} + \cdots + x_{2n} + Y_2 \\
& \quad \cdots \\
X_i &= x_{i1} + x_{i2} + \cdots + x_{ij} + \cdots + x_{in} + Y_i \\
& \quad \cdots \\
X_n &= x_{n1} + x_{n2} + \cdots + x_{nj} + \cdots + x_{nn} + Y_n
\end{align*}

\begin{equation}
(4.2)
\end{equation}

where the $x$’s on the right hand side of the equation denote the sales to sector $i$, in other words it represents $i$’s purchases of the products of the producing sectors in the economy. In addition to the industrial intermediate transactions, each sector records expenditure on outputs such as labour and capital as well as purchasing other inputs such as inventoried
items. All of these inputs are denoted by value added in the transaction table. Finally, imported goods can also be recorded as inputs by sector $i$.

### 4.2.2 The Technical Coefficients Table

Although the transactions table provides a detailed snapshot of the inter-sectoral structure of an economy it only considers a trend of inter-sectoral connectedness over a given time period, and is, therefore, not very accurate for economic impact analysis (Moghadam & Ballard, 1988; West, 1995; Rey, 2000). A technical coefficients table is required in order to use IO analysis to investigate how production adjustments in each sector behave in response to a change in final demand.

The technical coefficients table represents the production function for each producing sector in the economy. Such a table depicts the monetary value of inputs purchased from $n$ sectors in the economy per monetary unit of output in sector $i$. For a given sector $i$, technical coefficients show the value of purchases from each of the $n$ sectors in the economy that is purchased by the sector $i$ in order to produce one monetary unit worth of $i$’s output. As a result, technical coefficients can be computed by dividing all entries in each sector’s column by the total value of purchases of that sector. In other words, if $x_{ij}$ denotes the value of sales from sector $i$ to sector $j$, and $x_j$ denotes the total output of sector $j$, the technical coefficients, symbolized by $a_{ij}$ for each sector is computed by equation (4.3):

$$(4.3) \quad a_{ij} = \frac{x_{ij}}{x_j}$$

A technical coefficients matrix, or sometimes called a structural matrix, is a rectangular table composed of a complete set of all sectoral input coefficients in an economy. These coefficients can be adjusted by the adjustments in intermediate demand for output of industry
The technical coefficients table provides a quantitative picture of the internal structure of an economy (Leontief, 1986). The secondary demand on the output of n industries that supplies industry i’s suppliers can be computed through the sequential outputs in the technical coefficients matrix. In a practical sense, the impacts of any shock in the economy are spread through to the rest of the elements in the economic structure, sector by sector, through a series of transactions that link the whole sectoral structure.

4.2.3 Independence Coefficients Matrix

The central part of the three IO matrices for economic analysis purposes is considered to be the interdependence coefficients matrix (Miller & Blair, 1985; Leontief, 1986). The independence coefficients measure the total, namely, direct and indirect, required outputs produced by n sectors’ in order for sector i to produce, or sell, one monetary unit to any of the elements in the final demand vector. It, therefore, measures the total impact of a change that occurs in final demand for the sector i’s output on the output of n sectors in the economy after the entire effects of output increases have been recorded. Algebraically speaking the output flow structure takes the form of equation (4.4):

\[
X + M = A_X + F = A_X + f^C + f^G + f^i + f^V + f^{NE}
\]

where \(X + M\) on the left hand side, represents the total supply of commodities by a sector and the right side represents the total demand for outputs where:

\(X\) denotes an \(n\)-vector of total sectoral output;

\(M\) denotes an \(n\)-vector of sectoral imports;

\(A_X\) denotes an \(n \times n\) matrix of technical coefficients, where the \(a_{ij}\) denotes the amount by which sector i’s output is used as input by sector j per unit of output;
\( F \) denotes an \( n \)-vector of sectoral output used by final consumers;

\( f^C \) denotes private consumption which includes households and private not-for-profit institutions;

\( f^G \) denotes government expenditure;

\( f^i \) denotes gross fixed capital formation by production sector, i.e. investment;

\( f^V \) denotes changes in inventories plus statistical error;

\( f^{NE} \) denotes net exports, i.e. total exports – imports.

Equation (4.4) determines the total output produced in the entire economy given the level of total final demand for outputs, namely, private consumption, government expenditure, investment, changes in inventory, and net exports. As described before, the inter-sectoral relationships in the economy was defined by equation (4.3). Therefore this equation can be rearranged into:

\[
(4.5) \quad x_{ij} = x_j \times a_{ij}
\]

This means that \( x_{ij} \) (the level of sales from sector \( i \) to sector \( j \)) is dependent upon \( x_j \) and \( a_{ij} \) (respectively, the level of output in sector \( j \) and the technical coefficient of input requirements of sector \( j \) from sector \( i \)). Hypothetically, if the Illawarra economy contains only three producing sectors; the final demand vector is denoted by \( F \); the technical coefficients matrix is denoted by \( A \); and the sectoral output vector is denoted by \( X \); the transactions of the producing sectors can be formulated in a set of simultaneous equations as in the following:

\[
(4.6) \quad \begin{align*}
    x_{11} + x_{12} + x_{13} + F_1 &= X_1 \\
    x_{21} + x_{22} + x_{23} + F_2 &= X_2 \\
    x_{31} + x_{32} + x_{33} + F_3 &= X_3
\end{align*}
\]
where $x_{ij}$\textsuperscript{37} denotes sales from sector $i$ to sector $j$; $F_i$ denotes sales from sector $i$ to final demand; and $X_i$ is the total output of sector $i$.

Substituting equation (4.5) into equation (4.6) and rearranging them to investigate the producing sectors ($i = 1, \ldots, 3$) we obtain:

\begin{align*}
    a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + F_1 &= X_1 \\
    a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + F_2 &= X_2 \\
    a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + F_3 &= X_3
\end{align*}

(4.7)

Equation (4.7) represents sectoral interdependence as it depicts the effects of an increase (decrease) in the level of output in all sectors as a result of an increase (decrease) in the level of output in each sector. In other words it depicts the interconnectedness of the economy. Likewise it depicts the relatedness of the input requirements of each sector relevant to the level of its final demand. For example, consider $F_i$ the final demand for sector $i$, and exogenous to the producing sectors in the following expression:

\begin{align*}
    X_1 - a_{11}X_1 - a_{12}X_2 - a_{13}X_3 &= F_1 \\
    -a_{12}X_2 + X_2 - a_{22}X_2 - a_{23}X_3 &= F_2 \\
    -a_{31}X_1 + a_{32}X_2 + X_3 - a_{33}X_3 &= F_3
\end{align*}

(4.8)

Factoring the $X$’s from the equations above, we have:

\textsuperscript{37} In the entire matrix mathematical notations throughout this text, the terms $i$ and $j$ take on any value to denote different sectors. For example, in equation 4.6, $x_{11}$ denotes $i=1$ and $j=1$; $x_{12}$ denotes $i=1$ and $j=2$ and so on. Likewise, $F_1$ denotes $i=1$; $F_2$ denotes $i=2$; and so on.
\[(1 - a_{11})X_1 - a_{12}X_2 - a_{13}X_3 = F_1\]
\[-a_{21}X_1 + (1 - a_{22})X_2 - a_{23}X_3 = F_2\]
\[-a_{31}X_1 - a_{32}X_2 + (1 - a_{33})X_3 = F_3\]

We can simplify equation (4.9) into the following matrix format:

\[
\begin{bmatrix}
X_1 \\
X_2 \\
X_3
\end{bmatrix} =
\begin{bmatrix}
(1 - a_{11}) & -a_{12} & -a_{13} \\
-a_{21} & (1 - a_{22}) & -a_{23} \\
-a_{31} & -a_{32} & (1 - a_{33})
\end{bmatrix}
\times
\begin{bmatrix}
F_1 \\
F_2 \\
F_3
\end{bmatrix}
\]

and we can then denote equation (4.10) by the following expression:

\[
(I - A) \times X = F
\]

We can then multiply each side of the equation by \((I - A)^{-1}\), which then gives us \(X\) (sectoral output) as a function of \(F\) (final demand):

\[
X = (I - A)^{-1} \times F
\]

Equation (4.12) is the main IO system through which we can find the effects of changes in final demand elements on the level of sectoral output. The \((I - A)^{-1}\) is known as the matrix of interdependence coefficients (inverse Leontief matrix) which measures the direct and indirect output levels produced by each sector in the economy given the levels of final demand components. \((I - A)^{-1}\) is also known as the multiplier matrix because it indicates the direct and indirect requirements of input-output per unit of sectoral final demand. As a result, equation (4.12) can be derived from an iterative process that indicates the adjustments in the output level relevant to the input requirements and the elements of final demand, i.e. we can expand it to include an infinite number of inter-sectoral transactions:

\[
X = (I + A + A^2 + A^3 + \cdots + A^{n-1}) \times F
\]
where $I$ denotes the direct production requirements to meet the elements of the $F$ (final demand) vector; $A$ denotes the direct output requirements to meet the $AF$ (intermediate demand) vector, which is also required for the production of vector $F$ in the previous round; $A^2F$ denotes the direct output requirement for intermediate consumption, which is also required for the production of vector $AF$ in the previous round; and the same fashion continues until the sum of the series converges to the multiplier matrix $(I - A)^{-1}$.

It is important to note that equation (4.12) measures the increase (decrease) in the total level of output, $X$, required to satisfy an increase (decrease) in the final demand elements, $F$. It is used to analyse how sectoral production adjusts in response to a shift in the final demand elements. Similar to equation (4.12), equation (4.4), is also suitable to determine the value of total output through the real value of final demand as mentioned earlier.

When the objective is to compare the present inter-sectoral structure and the past inter-sectoral structure by measuring the changes in the economy over different time periods, we use equation (4.13). However, when the objective is to measure the total sectoral output in the economy as a result of changes in the final demand elements, we use equation (4.4).

If we want to purely use standalone IO for this purpose, we can incorporate dynamics by considering investment behaviour and stating the rules for a time lag in the following format. Equation (4.12) then is transformed into equation (4.14), which becomes the prominent Leontief dynamic system:

$$X(t) = A X(t) + B (X(t+1) - X(t)) + F(t)$$

where $F(t)$ denotes the final demand vector after considering new capital adjustments and matrix $B$.
\[(4.15) \quad B_{x(t+1)-x(t)} = i(t) = k_{t+1} - k_t \]

(4.15) is the matrix of the capital coefficients, representing the adjusted capital requirements for the IO sectors for a one unit change in the output vector.

Although the dynamic types of IO analysis are much closer to the actual processes of an economy compared to the static (traditional) type, it requires data on the flow of building allowances\(^{38}\); capital equipment; dwellings; goods; household stocks of durable consumer goods; and inventories of goods (work in process and in finished form). This type of data may be available at the national and state levels, but are impossible to find at the regional level. Furthermore, it requires unconventional mathematical approaches such as linear differential equations instead of ordinary linear equations to run such dynamic IO models. As a result the static method described above is integrated with a regional econometric model, which will be discussed in the subsequent sections, to track the dynamics of the Illawarra economy which is explained in detail in Chapter 5.

### 4.2.4 Regional Input-Output Model

As pointed out earlier the main applications of IO modelling were originally carried out at the national level. However, as regional science has developed, so has interest in economic analysis at the regional level\(^ {39}\). This interest\(^ {40}\) has resulted in a number of extensions of IO modelling which attempt to reflect the peculiar characteristics of regional economic issues. A review of the literature on regional IO models reveals a twofold motivation for describing the particular features of a regional IO study in this chapter.

\(^{38}\) The terms building allowances and building approvals are used interchangeable throughout this text.

\(^{39}\) Regional IO modelling ranges from a group of states, to an individual state, to a local government area.

\(^{40}\) With the rising importance of globalisation, interest in regional economic development has increased. The development of globally competitive regions has become pivotal to broader based national economic growth and development.
First, as noted in Chapter 1 and Chapter 2, regions are becoming paramount factors in shaping the dichotomy between successful and ineffective national economies. This alludes to the distinctions that exist between regional economic structure and national economic structure. It is an unavoidable truth that the data used in a national IO coefficients table represents a summation of the average data collected from different regions within that nation. Nonetheless, production in a particular region may have a distinct structure from the production structure in a nation, in which the region is located. For this reason the early strategies for regional IO applications, which implemented national input coefficients, are increasingly replaced by coefficient tables that contain data specific to a region.

A second factor relates to the increasing dependence of small regional economies on interregional transactions with external economies\(^{41}\), for imports and exports of goods and services. This external dependence forms the need for investigating the effects of changes in final demand elements of external economies on the regional economy\(^{42}\) under analysis. Investigating these external effects is essential in obtaining more accurate results from applying IO analysis to the regions where a high proportion of inputs (outputs) are imported (exported) from (to) producers (consumers) located outside of the region.

### 4.2.5 Regional Coefficients

Consider a hypothetical Australian bank in the financial sector with branches in all the states and regional areas. In the New South Wales (NSW) table, this would include the provision of a mix of commercial, business, and personal financial facilities. One input to this sector

\(^{41}\) External economies refer to adjacent regional economies and/or broader economies at the state or national level.

\(^{42}\) In this case the dependence of the Illawarra economy on interregional economic activities with regions such as Shoalhaven, Wingecarribee and Sydney.
would be the huge funds deposited by holders of letters of credit (LC) in large cities like Sydney, when conducting international imports and exports of goods. On the other hand, the financial sector in the regional table for the Illawarra might chiefly reflect the provision of small personal financial facilities, for which the LC’s are not an input at all; in a NSW table, however, LC’s are an extremely important input.

In more disaggregated national IO tables each sector is composed of a variety of products. The firms that compose each sector are located in various regions within the state, and they commonly produce a small number of those products. This causes the so-called “product-mix” issue in IO analysis (Miller & Blair, 1985); production of different product groups by firms within the same industrial sector. The direct approach to solve this issue is to conduct regional surveys and eventually develop a survey-based regional IO table. When conducting such surveys it is essential to inquire from firms in sector $j$ in a particular region about their use of inputs produced by sector $i$. The inquiry should address two areas:

a) Use of sector $i$’s products in making sector $j$’s product

b) Purchases of sector $i$’s products from firms outside the region

If such surveys are conducted and the response rate is 40%, which is referred to as a satisfactory rate (Miller & Blair, 1985; West, 1991; Rey, 1998; Miller & Blair, 2009), a truly regional technical coefficients table can be constructed which would reflect production structure in the region. Nonetheless, not only are such surveys expensive and time consuming, but they also do not address the question of how much of each required input came from within the region and how much was imported. Subject to data availability, regional production structure can be measured by measuring the coefficients based on inputs

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43 For example, how much iron ore used by steel manufacturers in the Illawarra was purchased from producers in Newcastle?
supplied by firms within the region as outputs for firms in the region. These coefficients, which are commonly known as regional\textsuperscript{44} input coefficients (Miller & Blair, 2009), are different from regional technical coefficients in the sense that input coefficients only indicate the structure of input consumption by local firms.

More sophisticated notation is required in order to examine the regional input coefficients. In the following equation, superscript $r$ stands for the region in question. Then let $z_{ij}^{rr}$ represent the monetary flow of goods from sector $i$ in region $r$ to sector $j$ in region $r$. If a complete set of data on $z_{ij}^{rr}$ for all $n$ sectors in the regional economy are available, and also data on gross outputs ($X_j^r$) of each sector in the region, a set of regional input coefficients could be derived from equation (4.16):

\begin{equation}
(4.16) \quad a_{ij}^{rr} = \frac{z_{ij}^{rr}}{X_j^r}
\end{equation}

Also if we consider $Z_{(n \times n)}^{rr} = [z_{ij}^{rr}]$ and $X_{(n \times 1)}^{r} = [x_j^r]$; then the regional input coefficients matrix is derived from the following expression:

\begin{equation}
(4.17) \quad A^{rr} = Z^{rr} (\hat{x}^{r})^{-1}
\end{equation}

And, finally, we can measure the effects of a change in final demand on regional production sectors by:

\begin{equation}
(4.18) \quad x^r = (I - A^{rr})^{-1} f^r
\end{equation}

\textsuperscript{44} Despite its cumbersomeness, intraregional input coefficients would be a more precise term given to these coefficients (Miller & Blair, 2009).
4.2.6 Closing a Regional Model with Respect to Households

The results of the fundamental form of an IO model (equation 4.12) depends on the value of the final demand sectors which have considerable impacts on the value of overall output and are exogenous to the intermediate production sectors. As pointed out earlier, these exogenous sectors are composed of sales to households, government, private investment and foreign trade transactions (exports minus imports), which are the elements of the final demand vector. Among all, households being the most crucial\(^{45}\), is composed of two elements, a) the labour row or the income earners who are paid for their inputs into production; b) final demand consumers column who spend their income on the sectoral outputs. Hence a change in the level of required labour for production in any sector will lead to a change in the consumption expenditure of the household sector in the final demand vector. This shows that an increase in income leads to an increase in consumption expenditure, postulating the theory of the marginal propensity to consume (MPC).

IO models applied to the US and Australia in the literature depict that household consumption expenditure comprises the largest portion of the final demand vector (Moghadam & Ballard, 1988; West, 1991; Miller & Blair 2009). Hence IO modellers attempt to move the household consumption column from the final demand vector and the labour input row from the value added vector\(^{46}\) and implement it inside the technical coefficients table to endogenise the household. This is known as “closing” an IO model with respect to the household sector (Leontief, 1986; ten Raa, 2005).

\(^{45}\) It is the most crucial because the restrictive IO assumption of constant returns to scale is mostly evident in this sector. This is explained in further details in the text that follows.

\(^{46}\) Refer to Table 4.1.
IO models at the state level can be closed with respect to households by adding a household consumption column and a labour input row. We can also add more than one row and one column to the direct input coefficients matrix to endogenise the household sector at the state level. A number of regional modellers have also applied this approach in the past (Miernyk, 1967; Tiebout, 1969; Blackwell, 1978; Madden & Batey, 1983; Batey & Madden, 1999). Nonetheless, in standalone IO models the inevitable impact of an increase in final demand would be an increase in sectoral output, which in turn leads to an increase in labour inputs in the value added vector. In practice, however, production can increase without corresponding increases in employment. This accentuates the restrictive assumption of constant returns to scale in traditional IO models which was explained in Chapter 1 and Chapter 2. Since the household sector has the highest impact on the overall model and exhibits the highest constant returns to scale, it has to be endogenized and treated more realistically to increase the accuracy of the impact analysis.

Highly disaggregated data is required to increase the accuracy of an IO model if one aims to close a standalone IO with respect to the household sector, and it is important to relax the constant returns to scale and linearity assumptions. Such extensive disaggregated data at the regional level is not conveniently available. Therefore, instead of disaggregating households into different categories of residents in a static model, in order to endogenise the household sector, we apply econometric equations to endogenise the household sector.

In a static IO model the household sector is considered homogeneous; the distinction between the active and the unemployed groups of the labour force is, however, obscure. However, the distinction between currently employed and currently unemployed workers is
explored in detail by the demographic block\textsuperscript{47} in our econometric model for the Illawarra. It investigates extensions to multiple blocks of household consumption and income recipients. We explore econometric model closures (three different strategies) in Chapter 5 when we investigate the compilation procedure for a specific Illawarra econometric IO model (IEIOM).

4.3 The Econometric Framework

As mentioned in the introduction section, attention here is focused on the scope and impetuses of regional econometric models in general and on a discussion of specifying the component blocks of the regional econometric model for the Illawarra. Principally at the regional level, an econometric model is composed of a series of stochastic behavioural and deterministic identifying equations that are intended to represent the important elements of a region’s\textsuperscript{48} economic and demographic characteristics. The question of the availability of data grows the gap between real life application of the theory and the specification of the individual equations of the model. Nevertheless, a classic econometric model includes equations for identifying characteristics of a region with respect to:

a) Demographics
b) Industrial employment
c) Labour market dynamics
d) Local, state, or federal government expenditure and revenue
e) Non-wage income

\textsuperscript{47} This, in addition to the other four blocks of the econometric module, is explained in detail in subsection 4.3.2.2.

\textsuperscript{48} As for the case for the regional IO models, the definition of the region in existing models ranges from Census Divisions (Milne \textit{et al.}, 1980) to states (West, 1991) down to individual metropolitan areas (Rey, 1998).
4.3.1 Regional Econometric Models

When specifying a regional econometric model, there can be several exogenous variables that may be skipped over and represented by the disturbance term, $u$, due to lack of available data. There is also the openness of a region and the interregional economic linkages that may be omitted in building econometric models. In this regard the effect of external impacts as well as the openness of a region raises the question of the accuracy of current regional policy studies that investigate business and household tax adjustments; land use and environmental issues; or public investment in infrastructure. Similarly, a serious lack of economic data at the regional level prohibits the ability of a modeller to conduct these important policy studies (Conway, 1991; West & Jackson, 1998; Rey, 1998; Ichimura & Wang, 2003). Therefore, applying econometric models to regional policy analysis involves extra issues and challenges, such as interregional linkages, lack of available time-series data, and consequent potential
errors due to data manipulation, compared to applying national econometric models for impact analysis purposes.

Regional econometric models have peculiar characteristics that make them distinctive not only from the national econometric models, but also from other types of regional economic modelling\textsuperscript{49} in several important dimensions. The first dimension is attributable to the coefficients of the equations in the model. In regional econometric models the coefficients are estimated econometrically while in the other models they are largely deterministic\textsuperscript{50} in nature.\textsuperscript{51} The advantage of this feature of econometric models is that the possibility of random error\textsuperscript{52} is taken into consideration. This allows for the uncertainty level to be estimated in the process of forecasting and the policy impact analysis, contrary to the deterministic methodologies where there is no room for error and the level of uncertainty is either unknown or ignored, hence leading to measurement error. The second dimension relates to their dynamic nature, specifying lags in the relationships between endogenous variables and exogenous policy instruments. This characteristic increases greater consistency in ex-ante forecasting and policy analysis compared to other methodologies. The equations are performed iteratively for the number of observations to measure the difference between the effects of lagged explanatory variables on the dependent variables and the effects of current explanatory variables on the dependent variables. This is performed to capture the dynamic trends in the regional economy, leading to improved forecasting capability.

\textsuperscript{49} These models are IO analysis, economic base, shift-share, and linear programming.
\textsuperscript{50} Throughout this text the term deterministic denotes a mathematical model that is free of error, while the term econometric is the opposite and denotes statistically estimated providing room for error and measurement error.
\textsuperscript{51} The coefficients in other impact analysis models are based on single-point observations.
\textsuperscript{52} Also referred to as stochastic disturbances.
The specific regional econometric models considered for this research are known as structural econometric models in the econometric literature (Israilevich et al., 1997; Emran & Shilpi, 2010; Wymer, 2012). This is because these models feature the logical advantage of detailing the economic and statistical assumptions required to estimate the variables for which data are available at the regional level\(^{55}\). In such models, the equations are built upon current substantive theory applicable to regional economic growth. Particular advantages of structural models are the flexible statistical descriptions of data in such models and their sensitivity to the stochastic nature of economic data (Rey, 1998; Reiss & Wolak, 2007; Li et al., 2011). This feature makes this type of model distinctive from the theoretical time-series models such as Box-Jenkins and vector autoregressive (VAR) models. This is because not only is an extensive volume of data on regional variables required but also estimating the parameters in such models requires a quite complicated and non-linear process, requiring high quality software programs (Magura, 1987; Mjelde & Paggi, 1989; Moghadam & Ballard, 1988). Overall, time-series approaches require data that are not available annually at the regional level. In addition, since there are a limited number of time series data that are published on a quarterly or monthly basis, the fundamental structure of such models is mostly basic and lacks substantive policy implications (Rickman & Schwer, 1995; Israilevich et al., 1997; Schindler et al., 1997).

4.3.2 Model Specification

Although there is a wide range of econometric models at the regional level to choose from (Zaccomer & Mason, 2011; Kim & Hewings, 2012; Arbia et al., 2013; Kopoin et al., 2013; Hermannsson et al., 2014), the main application in this research derives from well-known

\(^{55}\) In this case the Illawarra regional data.
models in the literature that are mostly applicable to the forecasting and analysis of small regions\textsuperscript{54}. The equations are specified relevant to spatial economic theory reflecting the way the variables and the market environment operate in a regional economy\textsuperscript{55}. Nevertheless, the absence of observation-based data on certain variables\textsuperscript{56} is a major shortcoming in applying the theoretical structure of the econometric model in an effective way. A number of regional modellers have attempted to address this shortcoming by building a mock series of the essential variables by using methods such as Kendrick-Jaycox or fixed ratios between national and local variables (Kendrick-Jaycox, 1965). A number of early econometric models built at the regional level were constructed on this methodology (L’Esperance \textit{et al.}, 1977; Smith \textit{et al.}, 1983).

The Illawarra econometric model, which is developed in this thesis, is more of an income oriented framework rather than being constructed based on measures of regional output. This feature recognizes income measures as indicators of regional economic performance and as a means to formulation and evaluation of policy implications. From an applied viewpoint the availability of consistent local area personal income data at an annual frequency has served to inspire the model specification. This approach relies on specific theoretical equations and through a series of substitutions, final equations express the endogenous variables as functions of the predetermined observable exogenous variables. To address the issue of data limitation in this thesis the second approach is adopted in the development of the econometric equations, relying on reduced forms by specifying a final equation through using endogenous variables as functions of predetermined exogenous variables.

\textsuperscript{54} The application of structural models was explained in the previous subsection.
\textsuperscript{55} This is further explained in the subsections that follow, discussing the model equations.
\textsuperscript{56} Local output, product price, capital services and prices, etc. are notoriously unavailable.
Overall the model consists of five blocks of equations, all of which are endogenous to the model. The labour market block is the core of the model and determines labour demand for 30 industries whose definitions can be found in Chapter 5. The sectors represent divisions in the standard industrial classification system. The labour market block generates the unemployment rate, unemployment level, employment rate, labour force participation rate and labour force.

Total population is obtained in the demographic block using components of growth specification in which births, deaths and net migration are considered. The income block defines regional income as being composed of labour income together with a number of non-labour sources. The overall model has 60 stochastic variables and 65 identities resulting in a total of 125 endogenous variables for the region. Because a detailed equation by equation discussion of the model would be rather unreasonable\(^{57}\), the general specifications for the equations in each block are described and a summary of the estimation results is presented in Chapter 5. The Illawarra econometric model is developed around a similar structure to the WPSM, REMI and QUIP models (Conway, 1990; Treyz \textit{et al.}, 1991; West, 1991)\(^{58}\).

\textit{4.3.2.1 Labour Market Block}

The labour market block provides a number of important links between a region’s economic and demographic structures. This block also facilitates integrating the demand for labour

\(^{57}\) There are 20 observations (1990-2000) thus 20 iterations for each round of observation; for each observation there are 125 variables and as pointed out, we use the predetermined exogenous variables as endogenous variables to specify each equation. This would require nearly 200 additional pages to discuss all the equations one by one. However, an overall representation of the procedure for specifying the econometric equations for each sectoral and regional variable is provided as follows.

\(^{58}\) This applies to the block of the model equations that follow.
inputs and supply of labour outputs. The labour market block is composed of six interlinked variables:\(^{59}\):

1) Regional unemployment rate
2) Ratio of sectoral gross regional product to sectoral employment (sectoral production function)
3) Regional employment
4) Regional labour force
5) Regional labour force participation rate
6) Regional population

To begin with, the unemployment rate in the region is modelled stochastically\(^ {60}\) as a function of the national rate and regional unemployment lagged to capture the regional adjustment process:

\[
(4.19) \quad UNEMPRIW_t = \beta_0 + \beta_1 UNEMPRAU_t + \beta_2 UNEMPRIW_{t-1} + \epsilon_t
\]

where \(UNEMPRIW_t\) is the unemployment rate in the Illawarra in time \(t\), \(UNEMPRAU_t\) is the national unemployment rate in time \(t\), and \(UNEMPRIW_{t-1}\) is a lagged regional unemployment rate of the Illawarra. Equation (4.18) estimates the sensitivity of the regional unemployment rate to the effects of the national unemployment rate and lagged regional unemployment rate, postulating the interconnectedness of the region to external economies\(^ {61}\).

\(^{59}\) There are 5 regional variables and 1 sectoral variable for 19 sectors.

\(^{60}\) The stochastic approach is the opposite to that of the deterministic approach, which was explained earlier in the text. Stochastic estimation provides us with room for error.

\(^{61}\) This is explained earlier in the chapter in section 4.2.4.
The estimation results are used for a comparative analysis of the results obtained from the IEIOM and the Illawarra IO table, explained in Chapter 6.

Employment levels in every industry, with weights based upon the contribution to the regional economy, are then estimated from a function of gross regional output and lagged industrial employment as follows:

\[
(4.19) \ EMP_{it} = \beta_0 + \beta_1 GRO_{it} + \beta_2 EMP_{it-1} + \beta_3 GRO_{it-1} + \epsilon_{it}
\]

where \( GRO_{it} \) is gross regional output of sector \( i \) in time \( t \) and \( EMP_{it-1} \) is employment in sector \( i \) at time \( t \). Sectoral employment is estimated in order to be implemented into the IO table under the corresponding sector. Average production per employee can vary with the level of value-added, which is composed of gross operating surplus; income payments; overtime; and taxes. This variation is shown in the estimated result of equation (4.19) in every iteration to capture the temporal shifts in the production function. This will then lead to measuring the dynamic behaviour of the production function over the 20 iterations (observations). The estimates of every iteration are then implemented into the IO table.\(^{62}\)

Aggregate regional employment can then be calculated from summation of all sectoral demand equations from the employment block based on the following identity:

\[
(4.20) \ EMP_{ILW}^t = \sum_{i=1}^{n} EMP_{it}
\]

\(^{62}\) The main use of the econometric model in this thesis relates to the composite approach, where there is a two way interaction between the IO block and the econometric model developed here. The econometric variables explained in this section will be estimated for the 19 sectors over the 20 observations and implemented into the IO table after each iteration. This is explained in detail in the composite section in Chapter 5.
where $EMP_{t}^{ILW}$ is total employment in the Illawarra at time $t$. The total labour force is a function of labour demand and it includes both persons working or actively looking for work in the region and can be calculated as follows:

\[(4.21) LF_{t}^{ILW} = \beta_0 + \beta_1 LF_{t-1}^{ILW} + \beta_2 EMP_{t}^{ILW} + \beta_3 EMP_{t-1}^{ILW} + \varepsilon_t\]

where $LF_{t}^{ILW}$ is the total number in the labour force at time $t$. When we think of the total labour force, we generally think about the supply side and not the demand side. The demand side determines how much of the available labour force is actually employed. As pointed out in section 4.2.6 this crucial element of the household sector is obscured in a simple deterministic IO model, leading to the assumption of linearity in the production function. This is the fundamental motive behind integrating an econometric module into the standalone IO model.

To estimate the components of the income block, which will then be implemented in specifying equations for disposable income, it is important to determine the number of people in different income classifications. Numbers of people who receive aged or invalid pension, family allowances, and unemployment benefits are all to be estimated for each observation in the econometric model to integrate the supply and the demand sides of the household sector. Since the number of the active labour force is the difference between the total labour

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63 Some of these figures are readily available from ABS (census data) on a semi-decennial basis. Nonetheless the main objective of the thesis is to gain higher accuracy and add dynamics to the simple IO model. This requires the need to estimate the annual value of these variables in order to measure the temporal shifts that occur in household related variables. These estimates are then implemented to the IO block, using a make matrix (matrix showing how industries make commodities, also known as output matrix) to endogenise the household without losing the dynamic characteristics of the demographic-economic specificities of the regional economy.
force and the current employment, it was decided to estimate the regional labour force participation\(^{64}\) rate as a function of the total labour force and employment as follows:

\[
LFPR_t^{ILW} = \beta_0 + \beta_1 LFPR_{t-1}^{ILW} + \beta_2 L_t^{ILW} + \beta_3 LF_{t-1}^{ILW} + \beta_4 EMP_t^{ILW} + \epsilon_t
\]

where \(LFPR_t^{ILW}\) is the regional labour force participation rate at time \(t\). Equation (4.22) is an extension of the general equation applied by the Australian Bureau of Statistics for estimating the labour force participation rate (ABS, 2013)\(^{65}\). Furthermore, since the labour force is the portion of the population that is either working or looking for work, the working age population can be then estimated from the following identity:

\[
PPLW_t^{ILW} = \left(\frac{L_F^{ILW}}{LFPR_t^{ILW}}\right) \times 100
\]

4.3.2.2 Demographic Block

The regional demographic system is treated in an aggregate form in the econometric model. Total population changes reflect both the natural population changes and general workforce changes as people move in and out of the region for work. Thus, in order to measure the interregional population activities, it is crucial to estimate the effects of the total number in the labour force \(L_F^{ILW}\) on the regional population. The idea behind including lagged regional population in equation (4.24) is because a small portion of people might migrate interstate or

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\(^{64}\) This is expressed as a percentage.

\(^{65}\) It is explained on [www.abs.gov.au](http://www.abs.gov.au) in Catalogue 6202.0 in the summary section.
internationally because of various unrelated work reasons. Therefore, the Illawarra total population can be estimated from:

\[(4.24) \ PPL_{t}^{ILW} = \beta_0 + \beta_1 PPL_{t-1}^{ILW} + \beta_2 LF_t^{ILW} + \epsilon_t \]

In the census survey conducted by the ABS for population, there are different categories in the income statistics. As pointed out earlier, there are three important groups of household sector, namely, children younger than 15, pensioners and unemployed persons, who are paid yet are not in the active labour force (employment demand input). This discrepancy would lead to measurement error in a simple deterministic IO when attempting to close the model with respect to the household sector as it overestimates the labour input demand proportional to the household consumption expenditure. Therefore, it is crucial to disaggregate these groups into separate categories in the demographic block. There are three population groups in this demographic block: number of children below 15; number of people on aged or invalid pensions; and number of people who receive unemployment benefits. Because children below the age of 15 are not considered as working age population, it was decided to derive the number of children less than 15 years of age from the total and working age population:

\[(4.25) \ PPLCH_{t}^{ILW} = PPL_{t}^{ILW} - PPLW_{t}^{ILW} \]

Therefore, the number of persons who are receiving aged or invalid pensions can be estimated from:

\[(4.26) \ PPLPEN_{t}^{ILW} = \beta_0 + \beta_1 PPLPEN_{t-1}^{ILW} + \beta_2 PPL_{t}^{ILW} + \beta_3 PPL_{t-1}^{ILW} + \epsilon_t \]

The number of persons who are receiving unemployment benefits can be estimated from:
\( UNEMPBEN_{t}^{ILW} = \beta_0 + \beta_1 UNEMPBEN_{t-1}^{ILW} + \beta_2 UNEMPBEN_{t}^{ILW} + \beta_3 UNEMP_{t-1}^{ILW} + \varepsilon_t \)

And overall number of persons who are receiving government benefits can be calculated from a summation of all the three groups:

\( PPLBEN_t^{ILW} = PPLCH_t^{ILW} + PPLPEN_t^{ILW} + UNEMPBEN_t^{ILW} \)

The absolute increase in population and net migration into the region, which is an optional estimation and is not necessary to be implemented in the model, can be estimated from:

\( PPLINC_t^{ILW} = \beta_0 + \beta_1 PPL_t^{ILW} + \beta_2 PPLCH_t^{ILW} + \varepsilon_t \)

And, finally, net migration into the Illawarra is calculated from the following identity:

\( NTMGRT_t^{ILW} = PPL_t^{ILW} - PPL_{t-1}^{ILW} - PPLINC_t^{ILW} \)

### 4.3.2.3 Wage Block

Wages need to be estimated based on industrial sectors to be implemented in our IO table but income block components can be estimated at the aggregate level. The average wage rate in industry \( i \) in year \( t \) is estimated from the following:

\( AWR_{it} = \beta_0 + \beta_1 GRO_{it} + \beta_2 EMP_{it} + \beta_3 LF_t^{ILW} + \varepsilon_{it} \)
where \( AWR_{it} \) is the average wage rate in industry \( i \) at time \( t \), \( GRO_{it} \) is the gross regional output of industry \( i \) at time \( t \), \( EMP_{it} \) is the sectoral employment for industry \( i \) at time \( t \) and \( LF_{ILW}^{t} \) is the regional labour force at time \( t \).

The ability of an industry to pay the wage rates is indicated by the gross regional output of the industry, which in turn indicates sectoral employment and labour supply. Total wages in sector \( i \) in year \( t \) is calculated from the following identity:

\[
4.32 \ W_{it} = AWR_{it} \times EMP_{it}
\]

And finally total wages in the Illawarra is estimated from a summation of all sectoral wages:

\[
4.33 \ W_{ILW}^{t} = \sum W_{it}
\]

4.3.2.4 Income Block

The main objective of the equations in the income block is to produce an estimate of household disposable income, which is then implemented in the household expenditure relations in the consumption block. A household total income is usually composed of income from dwelling rent, government transfers, and other unidentified income sources plus wages and salaries\(^{66} \). Wages and salaries had to be estimated at a sectoral level to provide the required disaggregation for implementation in the IO model, as explained in Chapter 5. However, the income sources on the income block can be estimated at a regional level because it is impossible to obtain this level of disaggregation of income earners at a sectoral

\(^{66}\) This figure is also available from the ABS on a semi-decennial frequency.
level. The components of the income block are estimated in a per capita structure. We use a priori data on the explanatory variables of the income block components. Therefore, income from dwelling rent is determined by the net operating surplus from properties minus the interest payments on those properties. Recalling from general accounting principles, the difference between gross operating surplus and depreciation is known as the net operating surplus. By the same token, the difference between gross rent and operating expenses is known as gross operating surplus. Therefore, income from dwelling rent deflated by the regional housing price index is estimated from:

\[
(4.34) \; IDR_t^{ILW} = \beta_0 + \beta_1 IDR_{t-1}^{ILW} + \beta_2 PPL_t^{ILW} + \beta_3 PPL_{t-1}^{ILW} + \epsilon_t
\]

As pointed out earlier, the portion of the population that receives government benefits is composed of three components: people on aged or invalid pensions, children below 15 that are in the form of schooling, and people on unemployment benefits. As a result, income from government transfers, which is composed of aged and invalid pensions, family allowances, university scholarships, unemployment benefits, etc., can be estimated from:

\[
(4.35) \; IGT_t^{ILW} = \beta_0 + \beta_1 PPLBEN_t^{ILW} + \beta_2 IGT_{t-1}^{ILW} + \beta_3 PPLBEN_{t-1}^{ILW} + \epsilon_t
\]

The recipients of the all other income, in Equation 4.36 below, is assumed to be among the working aged population (children below 15 are excluded). All other income is composed of dividend payments, interest payments, third party insurance transfers, grants, transfers from overseas, etc. The ratio of the other income receivers to the working age population is assumed to be a function of the ratio of lagged other income receivers to lagged working aged population because of the natural changes in population that was estimated earlier. Therefore it can be estimated as follows:
(4.36) \[ OI_t^{ILW} = \beta_0 + \beta_1 PPLW_t^{ILW} + \beta_2 OI_{t-1}^{ILW} + \beta_3 PPLW_{t-1}^{ILW} + \epsilon_t \]

Total income before taxes paid are estimated from a summation of (4.33), (4.34), (4.35), and (4.21):

(4.37) \[ TI_t^{ILW} = W_t^{ILW} + IDR_t^{ILW} + IGT_t^{ILW} + OI_t^{ILW} \]

Income taxes and other taxes and deductions need to be deducted from overall income. Hence, income taxes and other taxes and deductions must be estimated separately. Therefore, the ratio of population to average wage can be a determinant factor in estimating the average value of income tax paid for labour input. Therefore, to estimate household overall income after taxes are paid we use the following equation:

(4.38) \[ TIT_t^{ILW} = \beta_0 + \beta_1 W_t^{ILW} + \beta_2 TI_t^{ILW} + \beta_3 EMP_t^{ILW} + \epsilon_t \]

Total income after other taxes and deductions are paid is derived from:

(4.39) \[ TOTD_t^{ILW} = \beta_0 + \beta_1 TOTD_{t-1}^{ILW} + \beta_2 TI_t^{ILW} + \beta_3 PPLW_t^{ILW} + \beta_4 PPL_t^{ILW} + \epsilon_t \]

And, finally, overall regional disposable income is calculated from summation of all the three modules:

(4.40) \[ DISI_t^{IL} = TI_t^{ILW} + TIT_t^{ILW} + TOTD_t^{ILW} \]
The New South Wales (NSW) state accounts breakdown total household final consumption expenditure into twelve categories. On the other hand, the NSW consumer price index disaggregates commodity groups into 11 different groups. Hence a consistent set of expenditure and price data for every category are needed to estimate a set of demand relationships. Therefore, due to the complexities involved in disaggregating the price data, in this study the expenditure data is aggregated into 11 categories, which is explained in Chapter 6.

There are two alternative approaches to estimate household expenditure for each of the 11 categories. The first approach is to estimate the 11 consumption categories independently by linking the expenditure per capita on each commodity to total disposable income, which would help produce reasonable results for the short term. Nevertheless, the longer term results produced less reasonable figures in the ex-poste forecasting when compared with the actual results. The second approach is to estimate an aggregate regional household expenditure relation along with the separate commodity expenditure relations. The individual expenditure classes are now estimated as functions of total expenditure, making one of the expenditure categories redundant. The miscellaneous goods and services category was

67 These are: 1) food & non-alcoholic beverages 2) alcoholic beverages, tobacco and narcotics 3) clothing and footwear 4) housing, water, electricity, gas and other fuels 5) furnishings, household equipment and routine maintenance of the house 6) health 7) transport 8) communications 9) recreation and culture 10) education 11) hotels, cafes and restaurants 12) miscellaneous goods and services (ABS, Cal 5216.0, 2000).
68 These are: 1) Food and non-alcoholic beverages 2) alcohol and tobacco 3) clothing and footwear 4) housing 5) furnishing, household equipment and services 6) health 7) transport 8) communication 9) recreation and culture 10) education 11) insurance and financial services (ABS, Cal 6401.0, 2013).
69 This approach produces results with a maximum error bound for total expenditure of less than 4.5% over the estimation period. A complete account of the empirical results is provided in Chapter 6.
therefore estimated as the difference between total expenditure and the sum of other expenditures on the 11 items. This version produced more reasonable longer term results.

Therefore, aggregate household consumption expenditure can be a function of total expenditure per capita and disposable income, which can be estimated from the following:

\[
\ln \left( \frac{CEX_{t}^{ILW}}{PPL_{t}^{ILW}} \right) = \\
\beta_0 + \beta_1 \ln \left( \frac{DISI_{t}^{ILW}}{PPL_{t}^{ILW}} \right) + \beta_2 \ln \left( \frac{CEX_{t-1}^{ILW}}{DISI_{t-1}^{ILW}} \right) + \\
\beta_3 \ln \left( \frac{CEX_{t-1}^{ILW}}{PPL_{t-1}^{ILW}} \right)
\]

where we express the total consumption expenditure and disposable income, using the natural log form to define a positive real number which would be less or equal to the area under the \( CEX_{t}^{ILW} = \frac{1}{DISI_{t}^{ILW}} \) curve.

Then total consumer expenditure on commodity \( i \) deflated by the price index of commodity \( i \) is calculated by the following:

\[
CEX_{it}^{ILW} \Bigg/ PPL_{it}^{ILW} = \beta_0 + \beta_1 \left( \frac{CEX_{it-1}^{ILW}}{PPL_{t-1}^{ILW}} \right) + \beta_2 \left( \frac{CEX_{t}^{ILW}}{PPL_{t}^{ILW}} \right)
\]
And, lastly, since total saving is the difference between disposable income and expenditure, total household savings is estimated by subtraction of disposable income and total household consumption in the following identity:

\[(4.43) \quad SV_t^{ILW} = DISI_t^{ILW} - CEX_t^{ILW}\]

### 4.4 Summary and Conclusion

In this chapter the specification of the regional IO modelling and econometric modelling was presented. Together with the series of integration strategies for the Illawarra region developed in the following chapter these models will provide a basis for investigating structural shifts and industrial adjustments involved in the Illawarra regional economy. These issues will form the subject matter of Chapter 5, Chapter 6, and Chapter 7.

Both models, namely regional IO analysis and econometric modelling, have been proven to provide a consistent analytical framework for analysing, respectively, a regional inter-industry economy and industrial trends in the economy. When applied alone, however, especially at the regional scale, each model has its own shortcomings with respect to accuracy and performance. Although the detailed depiction of the IO analysis is unmatched by other economic analysis tools the underlying assumptions which make this precise representation are somewhat restrictive, such as infinite supply elasticity, constant returns to scale and a hefty cost of conducting surveys. Specifically, the absence of data on regional production and consumption structure requires adjustment of national technical coefficients to obtain regional figures, which, as we described, results in inaccuracy of the results. On the other hand the lack of economic structure representation in the econometric models makes them less desirable for impact analysis purposes. Given the nature of these issues the extent
to which the performance of an integrated model is improved by incorporating the two models would shed some light on these accuracy issues.

Finally, the development of regional IO or econometric models represents a challenging task, even if the modeller relies heavily on non-survey methods. Nonetheless, in the current research effort the models discussed in this chapter are viewed as components in a larger integrated analytical framework that is the subject of the subsequent chapter. Therefore, the use of non-survey data is considered a means to an end. The essential question of whether applied regional modellers should focus on further development and research of the integrated IO-EC models or they should retain the standalone models remains unanswered empirically and will be treated in Chapter 5. In Chapter 5, the procedure for integrating the two models, namely IO analysis and the regional econometric model of the Illawarra, built in this chapter is presented as component modules of the Illawarra econometric input-output model (IEIOM) and the empirical results of the integrated models are provided in Chapters 6.
Chapter 5

Compilation Procedure for the Illawarra Econometric Input-Output Model

5.1 Introduction

Having described the process of developing an individual IO model and an econometric
model in Chapter 4, the focus of this chapter is on the process of merging these two models
and applying the resulting integrated model to the Illawarra economy. As pointed out in the
literature review in Chapter 3, there are several studies in the literature that apply the
integrated framework to different regions within the US (Moghadam & Ballard, 1988;
Conway, 1990; Coomes et al., 1991; Israilevich et al., 1996; Rey, 1998; Motii, 2005) albeit
only one study was found in the Australian context (West, 1991). In addition, West’s (1991)
integrated framework is applied to the state of Queensland. The application adopted in this
study is characterised by West’s (1991) attempt at a state level model, requiring entirely
distinctive methods for data collection and model development from those models built at the
regional scale. Factors such as sectoral diversity, demographic characteristics, household
behaviour, sectoral income and production, and interregional labour migration place severe
challenges on the development of a regional model.

This chapter is the first of three chapters focusing on integrated modelling for the
Illawarra. The current chapter provides an extension to the existing integration studies in the
literature at both the national and regional levels. Additionally, the development of integrated
models for the Illawarra economy is described. As discussed in Chapter 4, three integrating
methods are used in the following two chapters to examine the empirical results from
hypothetical scenarios and provide implications for policy makers. The major theoretical
novelty of this thesis is presented in this chapter, by applying three main integration
methodologies, namely, composite, linked and embedded, to the economy of the Illawarra. A
further theoretical novelty lies with the embedded methodology where nine variations, which will be explained thoroughly in the following sections, of this methodology have been applied to a single regional economy. Moreover, the practical novelty of this thesis is presented by applying an integrated framework to the economy of the Illawarra for the first time. As mentioned in Chapter 2 the Illawarra economy is of particular interest to regional economists due to its current economic transformation, its transition from heavy industrial manufacturing towards skilled labour orientation and innovation. Although the Illawarra is not a significant contributor to the Australian economy, it is considered a small-scale version, in other words, a microcosm of the Australian economy. Hence, setting a pioneering work for modelling its economy is considered a stepping stone in conducting further research and a significant contribution to the currently available studies on the science and practice of regional economics.

The organization of this chapter is as follows. In section two a detailed overview of the integrated framework, which will be the basis for the Illawarra econometric IO model (IEIOM), is presented, including the construction specifics of integrating strategies and the three different strategies that exist in the literature. Section three presents the development process of the integrated framework for the Illawarra economy. In this section, it was decided to review integrated national accounts and integrated regional accounts in order to provide a prologue for a more detailed account of the three integration strategies that follow in the same section afterward. Finally, the chapter closes with a concluding summary of the main findings.

5.2 The Integrated Framework

As explained in Chapter 1, Chapter 3 and Chapter 4, there are several impetuses for developing an integrated IO-EC model to investigate the Illawarra economy. As suggested in
earlier chapters, these impetuses are grouped into two categories: theoretical and practical. One of the important theoretical impetuses is the claim that an integrated framework offers a fully disaggregated general equilibrium structure, which helps capture inter-sectoral interactions within an economy (Preston, 1975; West, 1991). The integrated IO-EC model is a closed model\(^{70}\) that captures the simultaneity between supply and demand (Chowdhury, 1984; Israilevich et al., 1997). Unlike the standalone application of the component models, namely, econometric and IO that only trace the effects of change from one side of the market (demand), the advantage of simultaneity between supply and demand gives the integrated framework a superior appeal to regional modellers. Nevertheless, as pointed out in Chapter 4, both econometric modelling and IO analysis are classically demand-driven at the regional scale. Thus, it is claimed that a model originating from a combination of these two components, namely, IO and EC, cannot integrate supply and demand simultaneously (Beaumont, 1990; Conway, 1990).

It is further argued that since integration of supply and demand is a critical motive for integrating the two models, the integrated framework is to be viewed as a failure and hence to be replaced with computable general equilibrium (CGE) models (Beaumont, 1990). Nonetheless, it can be contended that this argument is a case of not seeing the forest for the trees; as such a critical motive for simultaneously capturing supply and demand interactions is an excessive objective at the regional scale (especially as is the case of the Illawarra). Because not only is there a dire dearth of time series price data at the regional level (particularly in the Illawarra), but also not all proponents of the integrated approach consider that motive very critical for integration. Moreover, development of CGE models at the

\(^{70}\) In this particular context, the term “closed” refers to the treatment of the household sector as an endogenous variable. Nonetheless, the Illawarra econometric input-output model is an open model with respect to extra-regional trades.
regional level is oppressed by a number of restrictions related to data availability, incorporation of temporal dynamics and requirements for model calibration. As a final point, the distinction between the accuracy of the results from CGE and integrated models is argued to be a blurred one (Almon, 1991; Treyz et al., 1996; West & Jackson, 1998).

As explained in detail in Chapter 3 and Chapter 4, there are a number of other theoretical impetuses for developing an integrated framework for the Illawarra. In contrast to the above mentioned argument, the critical objective\(^{71}\) for incorporating an IO analysis into a time-series model is relaxing the restrictive assumptions of each of the two models. Constant coefficients, a linear production function, and constant returns to scale are the major restrictive assumptions that can be set at ease by endogenising the sectors that are otherwise exogenous in either of the traditional models. The three approaches developed in this chapter are aimed to relax these limiting assumptions, making the model responsive to price movements and considering the nonlinearities in production technologies. This objective is set to increase the accuracy of the model by representing the behavioural characteristics of the Illawarra economy more realistically\(^{72}\).

---

\(^{71}\) There is a growing consensus among regional modellers regarding the main objectives of the integrated framework which are fully discussed in Chapter 1, Chapter 3 and frequently referred to throughout the text.

\(^{72}\) The procedures are explained in the following sections.
### Table 5.1
**Accounting Framework for Integrated Econometric Input-Output Models**

<table>
<thead>
<tr>
<th>(X_{ij}) Intermediate sales from sector (i) to sector (j)</th>
<th>(\sum_i X_{ij}) Total intermediate sales by sector (j)</th>
<th>(\sum_j X_{ij}) Total intermediate sales by sector (i)</th>
<th>(\sum_j MI_{ij}) Total intermediate imports of sector (i) purchased by sector (j)</th>
<th>(\sum_j \sum_i MI_{ij} = MI_i) Total intermediate imports purchased by sector (j)</th>
<th>(V_{kj}) Payment to factor (k) by sector (j)</th>
<th>(\sum_k V_{kj} = V_j) Total value added sector (j)</th>
<th>(\sum_i X_{ij} + M_j + V_j = X_j) Total sector (i) purchases</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\sum_j X_{ij}) Total intermediate sales by sector (i)</td>
<td>(\sum_j \sum_i X_{ij} = \sum_i \sum_j X_{ij}) Total intermediate sales by sector (i)</td>
<td>(\sum_j MI_{ij} = MI_i) Total intermediate imports of sector (i) purchased by sector (j)</td>
<td>(\sum_j \sum_i MI_{ij} = \sum_i \sum_j MI_{ij}) Total intermediate imports purchased by sector (j)</td>
<td>(\sum_j V_{kj} = V_j) Total payments to factor (k)</td>
<td>(\sum_j V_j = \sum_k V_k) Total sector (i) purchases</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \sum_j X_{ij} + f_i = X_i \]

Total gross output sector \(i\)

\[ \sum_j X_{ij} + f_i = X_i \]

Total gross output sector \(i\)

**Source:** created by the author, adapted from Chowdhury (1984).
Moreover, a quick review of the pragmatic impetuses of the integrated framework from Chapter 1 reveals a number of objectives that are taken into consideration for developing the following approaches. Pragmatic impetuses such as increased disaggregation of the econometric model to improve its impact analysis capabilities and separating the income generating and employment determining characteristics of the household sector are the main objectives for forming the integrated approaches discussed in the following sections.

However before detailing the compilation procedure for the Illawarra econometric input-output model (IEIOM), it is necessary to provide a quick review of the national integrated models. This is because the main notion of regional integrated modelling has been derived from successful attempts by national integrated modellers (Walras, 1954; Morishima, 1964; Klein, 1978; Klein, 1983; Chowdhury, 1984; Almon, 1991; McCarthy, 1991). A review of the literature reveals that the first comprehensive attempt at construction of a national integrated framework was made by Klein (1978; 1983). Klein addressed the demand side of the economy using a Keynesian macro model and the supply side by a Leontief inter-industry micro model. In a national integrated model the Keynesian module determines estimates for the factors of the macro economy, while the Leontief module determines the sectoral distribution of these aggregate estimates as the final demand drivers of the IO table. While the regional and national integrated models are distinctive with respect to their analytical frameworks and data availability, they share a number of mutual interactions which are applied in building the integrated models developed in this chapter. Table 5.1 summarizes the national and regional integrated systems and the areas shaded in grey depict the domains of interaction\textsuperscript{73} between the regional and national integrated models.

\textsuperscript{73} These interactions are discussed in detail in the subsequent sections where the Illawarra integrated modelling procedure is explained.
In spite of the fact that the regional integrated framework originates from the pioneering national integrated models, it is distinctive on a number of aspects as a result of the challenges that regional modellers are faced with. The subsection that follows provides a review of these challenges by examining the existing regional integrated models. Although there are a number of studies that provide important insights on regional integrated models (Kort & Cartwright, 1981; Kort et al., 1986; Beaumont, 1990; Rey, 2000), the scale of their review is mostly at a state level. They are majorly focused on theoretical challenges and not particularly concerned with comparison of performance properties of different integrating strategies. As indicated earlier in Chapter 2 and Chapter 4, there is a growing interest in regional integrated modelling due to their comparative theoretical and practical advantages. Hence a significant contribution to the existing studies in the literature would require application of and a detailed comparison on the results of different integrated approaches to one region with evolving economic characteristics. Moreover, several methodological challenges are involved in regional integrated modelling that require attention and are not examined in the other studies. Hence, we extend the development of the integrated approaches reviewed in Chapter 3 so as to highlight the neglected methodological challenges mentioned above and how to treat them with respect to regional specificities such as that of the Illawarra.

5.2.1 Configuration and System of the Merger

The classification of the integrated models in the literature is summarized in Table 5.2. Composite, embedding and linking are the three taxonomic integrating approaches identified in Table 5.2. In general, the accounting relationship among sectors, factor payments, final demand, and IO balancing equations are employed to form channels for merging IO and econometrics. An integration approach relates to the method and the degree to which the IO analysis and econometric model are merged. The main differences between the three
integrating approaches are based on the choice of which interaction system and integration configuration are developed. The interaction system relates to the degree and the nature of the interaction between the two component modules, namely IO analysis and econometric model. The interactive nature between the component modules can be grouped into two categories: recursive or simultaneous. In the former there is a sequential ordering of the direction of causality between the econometric equations and the IO block and in the latter there is a two-way conjoint feedback and interaction between econometric equations and the IO block. The degree of interaction reflects the scale of sectoral aggregation of the IO block with the spatial aggregation of the econometric equations. It also reflects the common specifications that are determined in incorporating one module into the other.

Configuration of the integration approach relates to specification of the mathematical equations and the method chosen to solve and operate the equations in the model. The configuration can also be grouped into two categories: compound and modular. In a compound configuration method a sequence of linear and/or non-linear equations are solved through a set of iterative algorithms. The modeller can choose to retain selected aspects from both the IO block and the econometric modules to implement in the iterative algorithms. The number of iterations equals the number of time series observations. Hence for the Illawarra econometric model where there are 20 annual observations (1990-2010), there are 20 iterations for all the equations in the econometric blocks. The estimated results of each time series block are employed in the subsequent block and then the final estimates are disaggregated through a make matrix to be implemented into the IO table.

74 The composite approach uses a compound configuration.
75 As explained in Chapter 4, make matrix, also known as output matrix, shows how industries produce commodities.
On the other hand, a modular configuration\textsuperscript{76} characterizes more degrees of independence in integration. The mathematical formulation in modular configuration for a given point in time is solved in a sequential order. This means that one module is operated and run to convergence before the subsequent interaction with the other module takes place. The choice of configuration can have significant impacts on error transmission throughout the integrated framework, and therefore requires detailed scrutiny which is examined in the following chapter.

Although the two dimensions of an integrating approach, its interaction system and integration configuration, appear to be closely related, it is essential to note that it is the specific combination of the two that defines an integration approach. It is likely that an integration approach is modular in its configuration but simultaneous in its interaction system. A good example of such an approach in the literature would be the innovative framework developed by Isard & Anselin (1982) for the US economic-demographic system. However, the definition of the three types of integrating approaches contained in Table 5.2 originates from the combination of interaction system and integration configuration found in the existing integrated models in the literature\textsuperscript{77}.

\textsuperscript{76} The modular configuration is used for the embedding approach.

\textsuperscript{77} Diagrammatically, the three classes of integrating approaches are represented in Figure 3.1 in Chapter 3.
<table>
<thead>
<tr>
<th>Integrating Approach</th>
<th>Study</th>
<th>Interaction System</th>
<th>Integration Configuration</th>
<th>Location</th>
<th>Scale</th>
<th>Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>Conway (1990)</td>
<td>Simultaneous</td>
<td>Compound</td>
<td>Washington</td>
<td>State</td>
<td>26, 26</td>
</tr>
<tr>
<td>Composite</td>
<td>Israilevich &amp; Mahidhara (1991)</td>
<td>Simultaneous</td>
<td>Compound</td>
<td>Chicago</td>
<td>State</td>
<td>36, 36</td>
</tr>
<tr>
<td>Composite</td>
<td>West (1991)</td>
<td>Simultaneous</td>
<td>Compound</td>
<td>Queensland</td>
<td>State</td>
<td>15, 15</td>
</tr>
<tr>
<td>Composite</td>
<td>West &amp; Jackson (1998)</td>
<td>Simultaneous</td>
<td>Compound</td>
<td>Queensland</td>
<td>State</td>
<td>15, 15</td>
</tr>
<tr>
<td>Composite</td>
<td>Rey (2000)</td>
<td>Simultaneous</td>
<td>Compound</td>
<td>California</td>
<td>Multiregional</td>
<td>71, 26</td>
</tr>
<tr>
<td>Embedded</td>
<td>Glickman (1977)</td>
<td>None</td>
<td>Compound</td>
<td>Philadelphia</td>
<td>State</td>
<td>18, 18</td>
</tr>
<tr>
<td>Embedded</td>
<td>Duobinis (1981)</td>
<td>None</td>
<td>Compound</td>
<td>Chicago</td>
<td>State</td>
<td>21, 21</td>
</tr>
<tr>
<td>Embedded</td>
<td>White &amp; Hewings (1982)</td>
<td>None</td>
<td>Compound</td>
<td>Multicounty areas</td>
<td>Multiregional</td>
<td>32, 32</td>
</tr>
<tr>
<td>Embedded</td>
<td>Prastacos &amp; Brady (1985)</td>
<td>None</td>
<td>Compound</td>
<td>San Francisco</td>
<td>State</td>
<td>32, 32</td>
</tr>
<tr>
<td>Embedded</td>
<td>Moghadam &amp; Ballard (1988)</td>
<td>None</td>
<td>Compound</td>
<td>Northern California</td>
<td>Sub-state</td>
<td>19, 19</td>
</tr>
<tr>
<td>Embedded</td>
<td>Glennon &amp; Lane (1990)</td>
<td>None</td>
<td>Compound</td>
<td>Kentucky</td>
<td>State</td>
<td>23, 23</td>
</tr>
<tr>
<td>Embedded</td>
<td>Magura (1990)</td>
<td>None</td>
<td>Compound</td>
<td>Toledo</td>
<td>Sub-state</td>
<td>11, 11</td>
</tr>
<tr>
<td>Embedded</td>
<td>Coomes <em>et al.</em> (1991)</td>
<td>None</td>
<td>Compound</td>
<td>Louisville</td>
<td>Metropolitan City</td>
<td>28, 28</td>
</tr>
<tr>
<td>Embedded</td>
<td>Rey (1998)</td>
<td>None</td>
<td>Compound</td>
<td>Southern California</td>
<td>Sub-state</td>
<td>71, 26</td>
</tr>
<tr>
<td>Embedded</td>
<td>Motii (2005)</td>
<td>None</td>
<td>Compound</td>
<td>Oklahoma</td>
<td>State</td>
<td>9, 9</td>
</tr>
<tr>
<td>Linked</td>
<td>L’Esperance (1981)</td>
<td>Recursive</td>
<td>Modular</td>
<td>Ohio</td>
<td>State</td>
<td>7, 7</td>
</tr>
<tr>
<td>Linked</td>
<td>Stevens <em>et al.</em> (1981)</td>
<td>Recursive</td>
<td>Modular</td>
<td>Massachusetts</td>
<td>State</td>
<td>29, 484</td>
</tr>
<tr>
<td>Linked</td>
<td>Sullivan &amp; Gilless (1990)</td>
<td>Recursive</td>
<td>Modular</td>
<td>Northern California</td>
<td>Sub-state</td>
<td>2, 538</td>
</tr>
<tr>
<td>Linked</td>
<td>Rey (1998)</td>
<td>Recursive</td>
<td>Modular</td>
<td>Southern California</td>
<td>Sub-state</td>
<td>3, 71</td>
</tr>
</tbody>
</table>

*Source:* collected and created by the authors from the literature.
The objective of the econometric model is to analyse the correlation between the total expenditure and the total income of the macro factors. While, the objective of the IO model is to analyse the impact of changes in the final demand block on the inter-sectoral transaction block as well as representing the interdependence of intermediate demand and supply. Upon merging the two models, the relationship between the IO analysis and the econometric model varies as we range from the composite approach to the linked and then to the embedded approach. The composite approach represents a union of the econometric model and IO analysis. In this approach the integration involves several parts of overlay, which is in a way similar to the embedding approach, albeit each module retains a degree of autonomy which is also found in a linking approach. In the linked approach there is a slight connection between the two modules, each module remains somewhat independent with the outputs of one model becoming inputs into the other in a recursive manner. Finally, in the embedded models, the IO module is completely incorporated within an econometric framework and hence the integrated structure is mainly dominated by econometric relationships.

It is important to highlight some key issues that will be continuously referred to in the subsequent sections and chapters before we begin to describe the compilation of the three integrating approaches in detail. The first relates to the composite models that are most similar in nature to an ideal national model presented in Table 5.1, whereas the embedded and linked models characterize distinctions from the ideal national model from a number of aspects. The second relates to the greater number of applications of the embedded approach in the literature compared to the other two approaches (Moghadam & Ballard, 1988; Rey, 1998; Motii, 2005). This popularity is because of factors such as less intensive data requirements, simpler fundamental theoretical perspectives, and the incorporation of modeller’s objectives. Furthermore, apart from a number of linked applications a close correspondence is evident between the sectoral aggregations of the IO analysis and
econometric models, as can be seen in the third column of Table 5.2. Lastly, most of the integrated models existing in the literature are developed for a single region analysis (see column 6), and as a result there has been limited attention on the comparison of different integrated approaches.

5.3 The Illawarra Econometric Input-Output Model (IEIOM)

The philosophy adopted for developing different integrated models for the Illawarra is analogous with the “encompassing principle” (Hendry & Richard, 1982). The encompassing principle reflects a method of model building where the building begins with a general structure and through a series of refinements reaches the ultimate simpler model (Mizon, 1984; Moghadam & Ballard, 1988). After a careful examination of studies in the literature and scrutiny of data available for the Illawarra economy, it was decided to apply a two-step process for the integration framework. The first step is to build up a consistent time series of accounting frameworks employing readily available primary data\footnote{This set of primary data is from various sources such as ABS, IRIS, profile.id.com.au, LMIP, etc. A full list of data sources are provided later in the text.} as well as data extrapolated and based on national and state proportion coefficients. This is done because each of the three integrating methodologies for the Illawarra relies on the same accounting framework albeit to varying degrees. The second step is to select out the specific variables required for each integration approach. The specific procedure for the construction of the different integrated models is now detailed, while in the following chapter these models will be used to provide empirical results and analyse different economic scenarios for provision of policy implications for Chapter 7.

5.3.1 The Illawarra Composite Approach

The first class of the Illawarra econometric IO model (IEIOM) is the composite approach. The models in this class come closest in structure to the ideal time-series framework built in
Chapter 4, as the channels between the labour market and demographic block; demographic block and wage block; wage block and income block; and income block and consumption block are explicitly represented. Each of the six operational existing models listed in Table 5.2 has a distinctive approach in the specification of these channels and the role that each of the IO and econometric modules plays in the integrated framework. To highlight the important methodological comparisons associated with integration in composite models, each of these versions is modified and extended in building the integrated models for the Illawarra in this chapter. Since the models are very complex and because details of each of the models have been presented in the review of the literature in Chapter 3, the focus will be limited to the specification of the linkages between the IO and econometric models for the Illawarra only, which is explained in the following paragraphs. It is important to note that in addition to the specific compilation of the merging procedure presented in this chapter, the econometric model specifications outlined in Chapter 4 is a theoretical contribution of this thesis to the literature. Moreover, all the techniques and methodologies applied to combine IO and econometric models presented in this chapter represent innovative contributions of the thesis to the literature and extensions to the current models. All equations presented in the chapter are original work of the author, unless references are made to the relevant articles from which certain techniques or theories are obtained.

The first part of the composite model is sectoral output, which is extracted from the regionalized IO table based on the following general IO identity:

\[ X_i = \sum_{j=1}^{30} r_{ij}X_j + R_i (C_i + I_i + G_i) + (EX - IM)_i \]

where \( X_i \) is the regional output in industry \( i \), \( r_{ij} \) is the regional technical coefficient, \( R_i \) is the regional input coefficient, \( C_i \) is the regional personal consumption element of final demand, \( I_i \) is investment, \( G_i \) is government expenditure, and \( (EX - IM)_i \) is net regional exports.
Sectoral output is then incorporated into the stochastic time-series equation (4.19) in Chapter 4 to begin the econometric model from the first block as pointed out in Chapter 4. The re-iteration process continues for all the five blocks that were outlined in the regional econometric model in Chapter 4. Then the final step would be to transform consumption expenditure on each of the 11 commodity groups in the consumer price index, which was defined in the consumption block in Chapter 4, into household demands for each of the 30 sectors in the Illawarra IO table. This transformation is done by using a ‘make’ matrix, which is a matrix showing how sectors make commodities and is usually denoted by $V$ (Miller & Blair, 2009). In using a ‘make’ matrix, $v_{ij}$ denotes an element of $V$, indicating the value of the output of commodity $j$ that is produced by commodity $i$ in such a way that the structure of the $V$ would be a matrix where columns represent industries and rows represent commodities. Hence, it is also referred to as commodity by industry matrix (Miller & Blair, 2009).

To prepare the make matrix the first step is to download a table of product and industry concordance from ABS (2012)$^{79}$. Based on the concordance table the 11 commodity expenditure groups were disaggregated into 114 industry demands to match with the 2009-2010 national IO table (ABS, 2012)$^{80}$. Because interest payments on some state account expenditure groups are not available, a proportion of total household income$^{81}$ is added to the finance and public administration sector to adjust for this lack of data. Having the added element to the household final demand, we exclude the import element from each of the sectoral expenditure cells before we convert them into basic values by using conversion ratios from the 2009-2010 national IO table to determine commodity taxes and commodity transaction, and insurance margins. Finally, the 114 elements of sectoral household

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$^{79}$ They are catalogues 5215.0, 55.001.02 and 5209.0, 55.001.40.

$^{80}$ This would be catalogues under 5209.0, 55.001.

$^{81}$ This is calculated from the household expenditure survey for 2009-2010, catalogue number 6530.0 (ABS, 2012).
expenditure are aggregated to the 30 industries to match the sectoral breakdown of the Illawarra IO table (Table 5.3) and then the make matrix is multiplied by commodity expenditures to incorporate the results from the time-series equations into the IO module.

5.3.2 The Illawarra Embedded Approach

The second class of the integrated framework for the Illawarra is the embedded approach, which can be viewed as an extension of the econometric equations specified in Chapter 4. Among the integrated models presented in Table 5.2, the embedded approach uses the least amount of time-series regional data and thus is most suited towards modelling a region with the characteristics of the Illawarra. Hence it is necessary to re-review some of the important characteristics of the current operational embedded models before we begin discussing the procedure for the Illawarra embedded models. A characteristic common among all the embedded models is their objective of representing the inter-sectoral linkages that represent the foundation of a regional economy. Embedded models attempt to model these linkages within a dynamic framework.

Inter-industrial linkages indicate the network through which each sector services the other. Firms purchase goods and services (inputs) from firms within the same region in addition to the firms outside the region (White & Hewings, 1982). The original notion of such linkages is formed by regional IO models, albeit regional IO models are limited to a single temporal observation and thus fail to capture the dynamic structure of changes in technology as the regional economy evolves through time (Czamanski, 1971; O hUallachain, 1984; Howe, 1991). On the other hand, regional econometric models are dynamically oriented in that they provide a mechanism for incorporating technical change; nonetheless, they are criticised for not explicitly reflecting inter-industry transactions that take place

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82 This point is discussed in detail in the following sections.
83 This means that they are based on time-series data and track structural changes through time.
within the economy (Moghadam & Ballard, 1988). It is argued that regional econometric models’ representation of the economy is an overly simplistic view of economic interactions and does not address or incorporate many critical variables (Wilson, 1984). Hence the objective of developing an embedded approach is to capitalize on the merits of the two mainstream models, namely the detailed inter-industry analysis and the dynamic representation of market variables, so as to relax the restrictive assumptions of each.

The reason why this integration methodology is called embedding is because the \textit{a priori} inter-industry linkage from an IO module is “embedded” into an econometric framework to improve its forecasting accuracy (Moghadam & Ballard, 1988). Hence, another characteristic common among such models is their domination by an econometric module. The only input from the IO analysis, the \textit{a priori} information, is solely employed to identify important inter-industry linkages. After incorporating the linkages in the econometric equations we can estimate sectoral employment \( EMP_i \) and sectoral output \( X_i \). Since the main channel of integration in the embedded methodology is based on an employment/output estimate the extent of integration is much less significant compared to the composite methodology discussed earlier. Here, the channels of integration are restricted to demand-production and production-income yet, unlike the composite methodology, there is no income-demand channel in the embedded methodology. This is because of a dearth of data on consumption and non-residential investment for the Illawarra region. The main objective for building an embedded framework for this thesis is to investigate the impacts of hypothetical policies on employment and income with superior accuracy derived from the \textit{a priori} information.

As pointed out earlier there are three reasons why the embedded approach has gained increased popularity compared to the other two integrating methodologies. Firstly, the embedding methodology is the least data intensive compared to the other two integrating methodologies. Also, the focal point of the embedding approach in the existing models has
been on employment (Moghadam & Ballard, 1988; Coomes et al., 1991b; Stover, 1994; Rey, 1998; Motii, 2005). This explains the second reason for its popularity, as employment is by and large the main policy variable and a key element of the income variable. Finally, due to the dearth of sectoral output data at the regional level, models applying employment data are more widely feasible. Hence, there are a number of extensions and modifications of this methodology in the regional science literature (Duobinis, 1981; Moghadam & Ballard, 1988; Coomes et al., 1991; Stover, 1994; Rey, 1998; Motii, 2005). In this study, the embedded model’s algebraic notation, which aside from the regional econometric model is an extension of Moghadam & Ballard’s (1988) work and another methodological contribution of this study, is based on the following specification:

\[
(5.2) \quad EMP_t = \beta_0 + \beta_1 V_t + \beta_2 Z_t + \beta_3 ID_t + \epsilon_t
\]

where \(EMP_t\) is employment\(^8\) at time \(t\), estimated by a function of local \(V_t\), external \(Z_t\) and inter-industry \(ID_t\) variables. \(V_t\) represents local macro economy variables, both endogenous and exogenous, such as total personal income, population, wage rates, etc. \(Z_t\) represents national and other external variables that can impact the region. These variables can be either sectoral estimated coefficients that establish the elasticity between the region and the nation as well as certain policy variables that are important in industries where the Illawarra significantly differs from the rest of the Australia, such as steel or the education industry. Finally, \(ID_t\) represents inter-sectoral values and IO linkages, which measures the demand for the output of one industry from the other industries within the region.

In the embedded approach the number of sectors (denoted by \(n\)) can be equal to or greater than the number of time series observations\(^9\) (denoted by \(t\)) available for estimation. Therefore, there can be an unlimited number of estimations for all the inter-sectoral

\(^8\) \(EMP_t\) can also be replaced with \(X_t\) which denotes output.

\(^9\) In the case of the Illawarra this number is 20.
coefficients in equation (5.2) albeit this would be impractical. Thus restrictions are to be placed on the inter-sectoral coefficients in an attempt to limit the number of unknown parameters that are estimated. As a result the models in the embedded category can be separated based on two main methodologies. The criterion for forming these methodologies relates to the role that the a priori information plays in specification of these restrictions.

The methodologies are formed based on the degree of inter-sectoral linkages that are incorporated in the specification of the equations. The methodologies can be either partial or overall\(^\text{86}\) with respect to the treatment of the inter-sectoral relationships. There can be a further categorization of these two methodologies based on the relative extent of the restrictions that are imposed on the coefficients that represent the inter-sectoral linkages in each methodology. There are two forms of restrictions on coefficients: light and fixed. The overall decision is made based on two criteria. The first criterion relates to the number of inter-sectoral relations that the restrictions determine should appear in equation (5.2). The second criterion relates to the form of each of the inter-sectoral relations that is included in equation (5.2). As discussed in Chapter 3, the partial methodology requires a highly complex procedure due to the unlimited number of inter-sectoral linkages that can be involved and suffers from a lack of regional data. Therefore, it was decided to apply an overall methodology for incorporating inter-sectoral linkages from the Illawarra IO table into the econometric host module for this thesis.

There are four different forms of the embedded models developed for the Illawarra region (all applying an overall methodology for the treatment of inter-sectoral linkages). The distinction is in the approach is based on the inter-industry linkages which are defined. The four different forms are:

\(^{86}\) Partial and overall are called partitive and holistic by Rey (1997) and Motii (2005), respectively.
1) Dynamic intermediate demand variable (DIDV)

2) Dynamic intermediate employment demand variable (DIEDV)

3) Illawarra dynamic intermediate demand variable (IDIDV)

4) Intermediate employment demand requirement (IEDR)

The first 2 forms employ the national IO coefficients in determining the relevant demand variables. The third form substitutes the national coefficients with regional IO coefficients that are developed by the location quotients (LQ) approach explained in the following text. The last form employs a cost adjustment factor to account for the relative wage and productivity differences between a specific year’s regional and the benchmark year’s national economy. In both DIEDV and IEDR models an element is added to account for labour productivity adjustments denoted by $E$. In DIDV and IDIDV models the inverse productivity term is eliminated. All the embedded models for the Illawarra are dynamic. Each model is thoroughly discussed in the following text.

In DIDV we employ national IO coefficients and, since it is a dynamic model, these coefficients are adjusted through time. Meaning that DIDV will be defined as:

\[
(5.3) \quad DIDV_{it}^{ILW} = \sum_{j \neq i} a_{ij} e_{jt}^{ILW}
\]

where $DIDV_{it}^{ILW}$ is a regionalized dynamic inter-industry demand variable at time $t$, $a_{ij}$ is the national IO coefficient at time $t$, and $e_{jt}^{ILW}$ is $j$’s sectoral employment at time $t$. Hence, equation (5.2) can then be re-written as:

\[
(5.4) \quad EMP_{it}^{ILW} = \beta_0 + \beta_1 V_t + \beta_2 Z_t + \beta_3 \sum_{j \neq i} a_{ij} e_{jt}^{ILW} + \varepsilon_{it}
\]

In specifying DIEDV we employ a dynamic labour productivity adjustment term, which indicates labour productivity adjustment through time. In doing so, the values for regional labour productivity coefficients are considered to be equal to the values for national labour
productivity coefficients in any given sector. This assumption was made based on the Illawarra being microcosm of and resembling the national economy. Therefore DIEDV takes the following form:

\[
(5.5) \text{DIEDV}_{it}^{ILW} = \sum_{j \neq i} \omega_{ij}^{ILW} a_{ijt} e_{jt}^{ILW}
\]

where \( \text{DIEDV}_{it}^{ILW} \) represents the regionalized dynamic inter-industry employment demand variable, \( \omega_{ij}^{ILW} \) represents labour productivity ratios in sectors \( i \) and \( j \) as follows:

\[
(5.6) \omega_{ij}^{ILW} = \frac{l_{ij}^{ILW}}{l_{i}^{ILW}}
\]

Hence, DIEDV can be incorporated into equation (5.2), which then takes the following format:

\[
(5.7) \text{EMP}_{it}^{ILW} = \beta_0 + \beta_1 V_t + \beta_2 Z_t + \beta_3 \sum_{j \neq i} \omega_{ij}^{ILW} a_{ijt} e_{jt}^{ILW} + \epsilon_{it}
\]

In specifying IDIDV, we add an element of an income based location quotient (LQ) for industry \( i \) in the Illawarra. This is because it is assumed that economic activities in the Illawarra can be divided into two forms, namely, basic and non-basic. Basic sectors are those that export from the region and bring income from outside, while non-basic sectors support basic industries. Because of lack of data, it is unfeasible to model interregional sectoral output and trade flows. Hence, we employed LQ which is defined as:

\[
(5.8) \text{LQ}_i = \frac{e_i^{ILW}}{E_i^{ILW}}
\]

where \( e_i \) represents sectoral employment in the Illawarra, \( e^{ILW} \) represents total regional employment, \( E_i \) represents sectoral employment in the reference sector, and \( E^{ILW} \) represents total employment for the reference region.

Thus, IDIDV is embedded into equation (5.2) and results in the following form:
\[(5.9) \ EMP_{it}^{ILW} = \beta_0 + \beta_1 V_t + \beta_2 Z_t + \beta_3 \sum_{j \neq i} LQ_{ij}^{ILW} \omega_{ij}^{ILW} \alpha_{ij} e_{jt}^{ILW} + \varepsilon_{it}\]

Finally, in specifying IEDR, we replace the IDV with a nonlinear inter-industry employment demand requirement and apply regional labour coefficients to determine the structural changes in the regional economy. IEDR can be defined as

\[(5.10) \ IEDR_{it} = \sum_j r_{ijt} X_{jt}\]

Moreover, changes in regional IO coefficients are explained by structural adjustments that occur in the Illawarra economy at time \(t\). We can set a benchmark year in order to compare the adjustments in time \(t\) with the values in our benchmark year. In doing so, values of IO coefficients are estimated form national IO tables. Since structural adjustments can be associated with factor productivity and cost, a cost adjustment factor is specified to determine the relative wage and productivity variations between time \(t\) and our benchmark year. By doing so, our regional IO coefficients are proportionally adjusted to account for structural adjustments in the regional economy compared to that of the national economy. The cost adjustment factor can be defined as:

\[(5.11) \ CAF_{it} = \left( \frac{VAPE_{it}^{ILW}}{AW_{it}^{ILW}} \right) \div \left( \frac{VAPE_{i10}^{AU}}{AW_{i10}^{AU}} \right) \]

where \(CAF_{it}\) is sectoral cost adjustment factor at time \(t\), \(VAPE_{it}^{ILW}\) measures regional sectoral value added per employee at time \(t\), while \(VAPE_{i10}^{ILW}\) measures the same element but at benchmark year 2010. \(AW_{it}^{ILW}\) represents the regional sectoral average wage at time \(t\), while the subscript 10 denotes the same element but for benchmark 2010. The same elements are employed on the right hand side of the division sign where superscript AU denotes the
national figures for the same elements. Incorporating CAF into the regional IO coefficients we get:

\[(5.12) \ r_{ijt} = r_{ij10}e^{\alpha_i(DCAF_{it})}\]

where \(r_{ij10}\) represents the regional IO coefficient for the benchmark year of 2010. \(e^{\alpha_i(DCAF_{it})}\) represents the extent to which changes in the endogenous \(DCAF_{it}\)\(^{87}\) bring about changes in \(r_{ijt}\). Incorporating (5.12) into (5.10) we get:

\[(5.13) \ IEDR_{it} = \sum_j r_{ij10}e^{\alpha_i(DCAF_{it})}X_{jt}\]

Moreover, based on theory that a marginal monetary input is required from sector \(i\) to create a unit of output in sector \(j\) (Coomes et al., 1991a), we measure the marginal unit of employment required in the input sector to create a marginal unit of employment in the output sector by substituting sectoral output \((X_{jt})\) with sectoral employment requirement \((A_{jt10}E_{jt})\). Hence, the IEDR can be defined as:

\[(5.14) \ IEDR_{it} = \sum_j r_{ij10}e^{\alpha_i(DCAF_{it})}A_{jt10}E_{jt}\]

where \(E_{jt}\) represents sectoral employment in the Illawarra at time \(t\) and \(A_{jt10}\) can be defined as:

\[(5.15) \ A_{jt10} = \left(\frac{E_{i10}}{X_{i10}}\right) + \left(\frac{E_{j10}}{X_{j10}}\right)\]

Then we can re-write the general form of a dynamic IO model in a natural log form, incorporating (5.14) into it as follows:

\[(5.16) \ ln EMP_{it} = \beta_0 + \ln(\sum_j r_{ij10}e^{\alpha_i(DCAF_{it})}A_{jt10}E_{jt}) + \beta_1 ln FD_{it} + \beta_2 ln Z_{it} + \epsilon_{it}\]

We wrote (5.16) in natural log form in order to obtain linear results.

\(^{87}DCAF_{it} = CAF_{it} - 1.\)
5.3.3 Linking Methodology

The last class of the regional integrated framework is the linked approach. Compared to the previous approach where the IO relations are fully embedded in the econometric equations, the IO relations remain fairly independent in a linking approach. An analytical study of the literature reveals that the first linked model applied at a regional level dates back to four decades ago (L’Esperance et al., 1977), which was then categorized as an embedded model (Kort & Cartwright, 1981). Nonetheless, having described the embedded approach, it can be argued that L’Esperance (1977) should be considered a linked model as there is a recursive interaction system and a modular configuration in running the model.

Moreover, L’Esperance explains in an updated application of his first model that “conjoining” the IO analysis to the regional macro-econometric model was aimed at treating the final demand estimation more consistently (L’Esperance, 1981). Hence a macro-econometric model of Ohio was run to estimate the final demand elements at the sectoral level. These estimates were then applied to the IO analysis to generate estimates for gross sectoral outputs. The process of running the model can be summarized in two steps. First L’Esperance (1981) balances the state IO analysis with the macro model by aggregating the 76-sector IO table of Ohio down into six sectors. The second step was assuming a proportional relationship between output and employment, hence translating the outputs from the aggregated IO into employment demands. However, no feedback was introduced from these estimates back to the econometric model, as each component module was solved individually (L’Esperance, 1981). Both component modules generate estimates of sectoral employment; albeit the main reliance was on the estimates generated by the IO component as there was greater disaggregation in the 76-sector IO table (L’Esperance, 1981).

The loss of comprehensive disaggregation in the IO model was one key pitfall of the linked approach in the above mentioned application (L’Esperance, 1981). This model was
modified later with an attempt to preserve the detailed disaggregation of the IO analysis (Stevens et al., 1981). The objective was to retain the accuracy of a fully disaggregated IO analysis in capturing inter-industry linkages and flow-on impacts as the main strength of linking while featuring the flexibility of the macro-econometric model in reflecting the effects of factor substitution, locational decisions and relative cost fluctuations (Stevens et al., 1981). Hence they combined the two modules to incorporate the distinct strengths of both components into an impact analysis.

In an economic impact analysis for a port expansion in the state of Massachusetts, a 484-sector IO table was linked to a 29 sector econometric model. Nevertheless, contrary to the direction of the linkages in the Ohio model, in this study the IO table was applied to generate detailed estimates of the direct effects of port activity. The estimates were then aggregated from 484 sectors to 29 sectors to be commensurate with the econometric model. A system was developed based on an “add” factor\(^{88}\) to trace out the dynamics of the impacts of the project. This application resulted in a twofold improvement over the Ohio model. The first relates to the A matrix\(^{89}\). Since the IO analysis here is only applied to measure the direct impacts, the stability of the A matrix is not a critical issue unlike the embedded approach where an A matrix for each year during a simulation period is a critical factor. The second improvement relates to applying a fully disaggregated IO analysis to generate the estimates of the direct impacts prior to aggregation. In this scenario linking is dynamic as a more aggregated model will only result in an unbiased set of estimates of the impacts in such restrictive conditions. This is because aggregation bias would only be zero if final demands in a future year are proportional to the demands in a base year upon which the IO model is based (Hewings, 1972). In other words, the likelihood of biasness increases if a pre-

\(^{88}\) This is to ensure the macro-econometric model reproduces the aggregated estimates of wages and employment generated by the IO analysis.

\(^{89}\) A matrix is the other term for the table of technical coefficients.
aggregated IO table is applied in an integrated framework because in such applications the final demand elements will not be proportional by design to the base year.

Another application of the linking approach was carried out as part of a regional economic program in the Bureau of Economic Analysis (BEA) in the US (Kort & Cartwright, 1981; Kort et al., 1986). In this application a multiregional macro-econometric model used by BEA\(^{90}\) is linked with the regional IO modelling system (RIMS) that was developed to analyse regional economies based on county level aggregation. This application employs a linking approach similar to that used by Lahr & Stevens (2002), where the model is operated by channelling a one-way feedback from the IO analysis to the macro model. However, unlike the Massachusetts application, in the BEA application there is an obvious issue with the spatial distribution of estimating the indirect effects.

As explained in all the previous chapters the objective of the integrated framework is a higher level of accuracy for economic impact analysis, rather than forecasting and/or historical simulations. The RIMS IO analysis is used to determine detailed industrial output impacts\(^{91}\), assuming the specification of final demand changes were associated with a particular policy that occurs in that region. These output impacts are then transformed into add factors and implemented to the output equations of the NRIES multiregional econometric model. There are no restrictions on the add factors to the original region. Yet the add factors are allocated to the states outside the region where the policy is implemented. These “rest of the US initial impacts” are then aggregated and the sum of their aggregates serves as the difference between the outputs of the national IO model less the estimates based on the

\(^{90}\) This macro-econometric model was specified and developed by the National Research Institute for Education Sciences (NRIES) for the 51 states in the US.

\(^{91}\) These are first translated to a value added basis and then aggregated to the level of NRIES for a specific region.
regional IO model\textsuperscript{92}. These net effects are then spread to the other states in the US by a gravity model with respect to two elements: a) the linear distance of a state from the policy region; b) the share of the rest of the US reference point output in a year accounted for by the state. The spatial and temporal diffusion of the indirect and induced impacts are then generated by NRIES. The estimated impacts of the policy are then set equal to the difference between the policy-on simulation (built using the linked approach) and a reference point run of NRIES independent of the IO analysis and without considering the policy impacts.

The application of the linking approach by BEA features an attractive characteristic as the methodology for developing the RIMS is conveniently adoptable and ever, since the original application, there have been several attempts at refining and improving the NRIES. Nonetheless, exact application of the RIMS-NRIES linked approach can entail some limitations on the impact analysis capabilities of the integrated framework as the NRIES has been specified for analysing a state economy only. Therefore this framework may fail to provide clear estimates of the temporal indirect impacts at the regional level. Furthermore a review over the applications of the linked approach in the literature shows that after a shock is introduced to the RIMS model, the spatial and dynamic paths\textsuperscript{93} of the subsequent secondary and induced effects are traced by applying the NRISES model. Here the sustained impacts\textsuperscript{94} can be more complex to introduce. This is because the temporal dimension of the estimated impacts are largely unknown in an IO analysis and hence specifying the add factors as a one-time shock may result in misrepresenting the estimates of the time series impacts. Instead, the time series estimates can be reflected in add factors for several periods if we can specify a time series diffusion process for the IO impacts. This way a more realistic depiction of the induced and flow-on impacts can be provided. There are a number of studies on

\textsuperscript{92} This is the region where the policy occurs.
\textsuperscript{93} The spatial and dynamic paths are at the state level.
\textsuperscript{94} This type of impact represents a constant increase in exogenous variables over a number of periods.
sectoral and temporal multiplier decomposition and temporal dynamics of inter-sectoral linkages that can shed some light on the process of modelling the time series impacts (Charney & Taylor, 1987; Kraybill & Dorfman, 1992; Lesage, 1993).

Finally, the last study on the linking approach that has inspired the Illawarra linked model is a hybrid model where a regional econometric model is combined with a non-survey regional IO table to investigate the impacts of policy changes in the forestry sector on regional economies of Northern California (Sullivan & Gilless, 1990). This study applies the philosophy of the GRIT system where there is an emphasis on the necessity of accurate data on industries that play a major role in the regional economy, while the rest of the industries are treated using traditional non-survey data (Jensen et al., 1986). Using a Cobb-Douglas production function, conditional factor demand linkages are estimated for two key sectors to generate estimates of the substitution elasticities between labour and non-labour inputs for the sectors other than the two key sectors. Inputs of the two key sectors are dealt with as a fixed proportion of output in the sectors, and output in the sectors is assumed an exogenous function of sales from the National Forest Service (NFS). The Cobb-Douglas substitution elasticity is then applied to adjust the labour and input coefficients of the remaining sectors by considering the same direction for the flow of all the coefficients in the remaining vector. A restriction is then imposed that considers the sum of the column coefficients is constrained to equal one (Sullivan & Gilless, 1990). Lastly, the estimated coefficients are applied to the output that was determined exogenous to the key sectors, to obtain a vector of input-demands for the rest of the sectors that are introduced as add factors.

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95 It is worthwhile to mention that this model can be considered a condensed and scaled down version of Klein (1983) which was described earlier in the chapter.
96 GRIT is the generation of regional input-output tables developed by Guy West for the state of Queensland.
97 These are wood products and paper and publishing products.
98 This relates to the elasticity of the ratio of two inputs to a production function with respect to the ratio of their marginal products.
to final demand deliveries. Therefore the impact of price on factor substitution is taken into consideration in the key industries\(^99\).

### 5.3.4 The Illawarra Linked Approach

The final integrated model built for the Illawarra implements a linked approach. A linked model applies the comprehensive IO table of the Illawarra\(^{100}\) linked with an extension and modification of the econometric model that was explained in Chapter 4. The IO block is applied to disaggregate the primary impacts of final demand changes into direct, indirect, and induced impacts in terms of sectoral output and income. These estimates are then aggregated to the sectoral breakdown of the time series equations. They are then treated as add factors in the time series equations for the employment and income block. The sectoral outline for the two models is displayed in Table 5.3 and Table 5.4.

The employment demand equations are the main block of the econometric model built in Chapter 4 that are modified for the linked model. Sectoral income and employment demand are determined as linear functions of output in the disaggregated IO block. The income estimates are aggregated to be compatible with the econometric model sectors. The employment estimates are also aggregated and treated as variations in the employment demand intercepts in the econometric model.

Nevertheless, as explained in Chapter 4, total sectoral wages are determined as an identity that includes an employment variable and a wage rate variable. In the Illawarra linked model the wage identity is introduced\(^{101}\) to the econometric equations as add factors. Hence the employment and income coefficients of the disaggregated IO table are adjusted so

\(^{99}\) This would, to a limited degree, introduce changes in the input coefficients that lead to relaxing the fixed proportion assumption of the Leontief framework.

\(^{100}\) The preliminary version of the Illawarra IO table was developed in conjunction with the School of Economics at the University of Wollongong and has been extended and refined based on the methodology in Chapter 4 and this chapter.

\(^{101}\) The aggregated income from the IO model enters the wage identity into the econometric model.
that the employment and income values aggregate to the 2007 values in the econometric equations in order to exclude any double counting.

An application of the linked model is not used in a comparative analysis of the simulation and forecasting abilities of the models in the integrated framework since the linked model is more suited for impact analysis. Alternatively, it is applied to examine the sensitivity of estimated multipliers to the choice of integration approach for an impact analysis.

5.4 Conclusion

As explained in previous chapters, operational models in the integrated framework are becoming increasingly popular in the field of regional science due to their higher accuracy and more realistic treatment of critical economic factors than that offered by integrated models for policy analysis. Nonetheless, most of the attention in the regional science literature has been focused on the novel application of a single integrated model to one region, highlighting the potential policy implications of that single integrated model. The underlying emphasis in the literature has been on the benefits offered by combining the two mainstream analytical models, namely IO analysis and econometric model. However, some rather important methodological and data related areas for comparing the different approaches of integration have been ignored. Hence it can be argued that the growing gap in the literature appears to be between the results and performance properties of the integrated approaches that require further analytical examination.

Therefore, a closer analytical review of the existing national and regional integrated models was presented in this chapter in order to explicitly illuminate the foundation methodologies applied for development of the integrated models for the Illawarra. Although data availability has been a major issue in the Illawarra and a great challenge in building both
the national and regional models, the integrated framework offers greater accuracy and thus proves to be worth the extra effort. Integrated modellers in the US can conveniently apply the NIPA in building macro-econometric models yet a serious dearth of time series data and periodical IO tables for regional Australia, in particular for the Illawarra, represents a major challenge and led to resorting to different approaches for estimating the required coefficient changes.

Although the lack of time series data is a serious data related issue at the regional scale, it is only one of the challenges that regional modellers in Australia have to deal with. At this time in Australia there is no regional analogue of the NIPA, which is required for building a comprehensive integrated model. While the absence of regional data is well recognized as a serious setback in regional analysis (Hewings, 1990; West, 1991), it does not totally obstruct the development of regional IO models nor does it prevent building regional econometric models. Data limitation has been an inevitable challenge for regional modellers as explained in the review of the literature on the non-survey regionalization methods in Chapter 3. Nevertheless, uniting the two traditional models into a single incorporated model exaggerates the issue of data limitations and necessitates further attention. Moreover, as the issue of lack of data becomes more critical at the regional level, it also affects the choice of the approach used to integrate the econometric model with the IO analysis for an explicit unbiased comparison at the regional level.

As explained earlier the choice of interaction systems and integration configurations is the key criteria in distinguishing between the three different integrating approaches applied to the Illawarra. The three models in this classification range from embedded models at one end with the least data requirements to the composite models at the other end with the highest data and calibration requirements, representing the greatest comprehensive form of
integration among the three. The linked models are placed in the middle with a lesser degree of integration albeit higher data requirements than the embedded models.

The cost of developing an integrated model plays a significant role in the choice of the integration approach as it signifies the trade-off between the required effort and the comprehensive properties of the integrating approach. No study has been found in the literature to empirically compare the cost and effort associated with a certain model to the performance and accuracy of that model. A scrutiny of different strategies for integrating IO and econometric models reveals three major gaps that require attention before an empirical comparison can be done. These gaps are:

1) A comparative examination of the standalone models and the integrated models with respect to their performance properties and results

2) The effect of the integrating approach on model simulation performance

3) The nature of constraints in embedded models

Lastly, this chapter intended to apply the three integrated models to the Illawarra economy. The objective for applying three different models is to offer an empirical analysis for the methodological gaps discussed above. This empirical analysis-compelled development of a consistent integrated regional account. The procedures for compilation of all the three approaches were detailed and the estimates obtained from a number of important data series were examined\(^\text{102}\). Moreover, extensions and modifications made to the econometric model built in Chapter 4 were discussed. The operational integrated models developed in this chapter are applied in Chapter 6 to examine the comparative properties of the integrated approaches raised above. In Chapter 6 the three models are also used to examine the results of the impact analysis and forecasting experiment for the Illawarra economy. Policy

\(^{102}\text{Table 3.2 in Chapter 3 and Table 5.2 in this chapter provide a summary of the characteristics of different integrating strategies. The variance of the results from each approach is also provided in Chapter 6.}\)
implications are then represented in Chapter 7 and the sensitivity of the estimation results to the choice of integration approach is analysed to investigate the impact of government expenditure on key sectors in the Illawarra economy.
### TABLE 5.3
THE SECTORAL BREAKDOWN OF THE ILLAWARRA IO TABLE

<table>
<thead>
<tr>
<th>Number</th>
<th>Intermediate Sector</th>
<th>Final Demand Sector</th>
<th>T1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agriculture, forestry &amp; fishing</td>
<td>PCE</td>
<td>Compensation of Employees</td>
</tr>
<tr>
<td>2</td>
<td>Mining</td>
<td>I</td>
<td>GOS</td>
</tr>
<tr>
<td>3</td>
<td>Food manufacturing</td>
<td>BI</td>
<td>OVA</td>
</tr>
<tr>
<td>4</td>
<td>Textiles &amp; clothing</td>
<td>GME</td>
<td>Imports</td>
</tr>
<tr>
<td>5</td>
<td>Wood, paper &amp; printing</td>
<td>GNME</td>
<td>Total</td>
</tr>
<tr>
<td>6</td>
<td>Petroleum &amp; coal products</td>
<td>IM</td>
<td>Employment</td>
</tr>
<tr>
<td>7</td>
<td>Chemical products</td>
<td>EX</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Rubber &amp; plastic products</td>
<td>SLGE</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Non-metallic mineral</td>
<td>SLGM</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Basic metals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Transport &amp; other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Other manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Electricity, gas &amp; water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Wholesale trade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Retail trade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Repairs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Accommodation, cafes &amp; restaurant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Transport &amp; storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Communication services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Finance &amp; insurance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Ownership of dwellings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Rental, hiring &amp; real estate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Prof &amp; scientific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Administrative services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Government &amp; defence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Education &amp; training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Health &amp; social services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Cultural &amp; recreational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Personal &amp; other services</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source:* constructed by the author.
### TABLE 5.4
THE SECTORAL BREAKDOWN OF THE ILLAWARRA ECONOMETRIC MODEL

<table>
<thead>
<tr>
<th>Number</th>
<th>Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Health care and social assistance</td>
</tr>
<tr>
<td>2</td>
<td>Manufacturing</td>
</tr>
<tr>
<td>3</td>
<td>Education and training</td>
</tr>
<tr>
<td>4</td>
<td>Retail trade</td>
</tr>
<tr>
<td>5</td>
<td>Accommodation and food services</td>
</tr>
<tr>
<td>6</td>
<td>Public administration and safety</td>
</tr>
<tr>
<td>7</td>
<td>Construction</td>
</tr>
<tr>
<td>8</td>
<td>Professional, scientific and technical services</td>
</tr>
<tr>
<td>9</td>
<td>Transport, postal and warehousing</td>
</tr>
<tr>
<td>10</td>
<td>Financial and insurance services</td>
</tr>
<tr>
<td>11</td>
<td>Other services</td>
</tr>
<tr>
<td>12</td>
<td>Administrative and support services</td>
</tr>
<tr>
<td>13</td>
<td>Wholesale trade</td>
</tr>
<tr>
<td>14</td>
<td>Mining</td>
</tr>
<tr>
<td>15</td>
<td>Rental, hiring and real estate services</td>
</tr>
<tr>
<td>16</td>
<td>Arts and recreation services</td>
</tr>
<tr>
<td>17</td>
<td>Information media and telecommunications</td>
</tr>
<tr>
<td>18</td>
<td>Electricity, gas, water and waste services</td>
</tr>
<tr>
<td>19</td>
<td>Agriculture, forestry and fishing</td>
</tr>
</tbody>
</table>

*Source:* specified by the author.
Chapter 6

Empirical Results and Scenario Analysis

6.1 Introduction

This chapter presents the empirical results for both the forecasting experiment and impact analysis of the models outlined in Chapter 4 and Chapter 5, namely, input-output (IO); econometric; composite; embedded; and linked models. In Chapter 5 the compilation procedure for building three different integrated models for the Illawarra economy was discussed. As pointed out, there is an evident variation in the different integrated models available in the literature. Nonetheless, no studies have been found on investigating the comparative performance of different integrated models at the regional level in the Australian context.

The models used in this investigation have been developed to examine the Illawarra economy with respect to employment, output and income. Lack of data availability for the Illawarra region prevented a more detailed specification of the model equations and the choice of variables. The models applied have been examined for the combination of Wollongong local government area (LGA), Shellharbour LGA, and Kiama LGA. This regionalization scheme emphasizes the economy of the Illawarra Statistical Area (SA), also known as sub statistical division (SSD), according to the Australian Bureau of Statistics (ABS, 2013). In order to provide a detailed focus on the integration process the development of the component models, input-output and econometric, for the Illawarra were extended and modified based on the standard models in the literature, as discussed in Chapter 4 and Chapter 5.

As pointed out in Chapter 1, the primary objective of this research is to conduct a comparison of the results derived from the standalone IO analysis and econometric model
with the results obtained from three different integrated models in terms of forecasting and impact analysis properties. Hence we have designed two sets of experiments to achieve this objective. The first experiment constitutes a comparative test of the performance and forecasting properties of different models in an ex-post scenario for an out-of-sample period (2011-2012). The second experiment constitutes an examination and comparison of the impact analysis results of different integrated models together with the standalone IO and econometric models. In both experiments the objective is on the model performance to the choice of integrating approach. Therefore, it was decided not to focus much effort on fine-tuning the different models applied in these experiments in order to keep the emphasis on the choice of integrating approach. This is because the precision obtained by fine-tuning causes an ambiguity as to whether the accuracy is a result of fine-tuning or of the choice of integrating approach.

The results of both experiments are classified into the following main groups:

1) The first group presents the results of the ex-post forecasting experiment during the out-of-sample period of 2011-2012, representing three different forecasting models.

2) The second group presents the results of the impact analysis for the 2011-2012 period, representing four different models.

As discussed in Chapter 5, the standalone IO and the linked models have been eliminated from the forecasting experiment due to their superior competence in impact analysis application. Similarly, the econometric model has been eliminated from the second experiment, impact analysis, due to its superior forecasting suitability.

This chapter is structured as follows. Section 2 discusses the empirical results of the forecasting experiment. In this section the econometric model, composite model and different versions of the embedded model are utilised to forecast employment in the out-of-sample
period of 2011-2012. In section 3, the results of the impact analysis are presented. The models built in Chapter 4 and Chapter 5 are utilised to provide empirical results on the significance of the education and training sector on the Illawarra economy. The education and training sector was chosen due to the transformation of the regional economy from heavy industry manufacturing to knowledge and skill orientation. Section 4 concludes with a summary of the major findings of this chapter.

6.2 Empirical Results from the Forecasting Experiment

As previously pointed out, for the first experiment, three different models are applied to an ex-post forecasting scenario for the out-of-sample period 2011-2012 for the Illawarra economy. Each of the models described below is estimated based on the parameters obtained over the 1990-2010 sample period. The three different models that are compared in this experiment are as follows:

1) The regional econometric model, built in Chapter 4, which is compared with the integrated models that follow.

2) The composite model, which was built and discussed in Chapter 5.

3) The embedded model, similarly built in Chapter 5, which employs four different versions.

Furthermore, all the three models are compared using the mean absolute percentage error (MAPE) of their results for the estimated values for each variable over the two-year period\(^{103}\). The forecasts are dynamic. In other words the values for the endogenous variables of the previous year (lagged) on the right hand side of each equation are derived from the predicted

\(^{103}\) The values are derived from the average of the sum of percentage errors calculated over the two years.
values from the solution of the model for the previous period\textsuperscript{104}. The results of the comparison for all the three models are provided at the end of this section.

Lastly, as previously pointed out, since the linked model is more applicable for impact analysis it is not included in the first set of experiments for forecasting the out-of-sample period (2011-2012), but it is included in the second experiment for the impact analysis that follows.

\textbf{6.2.1 Econometric Model}

Having discussed the development process of the econometric model in Chapter 4 and Chapter 5, the process involved in estimating the coefficients of the model is described in this section. The methods of ordinary least squares (OLS), feasible generalized least squares (FGLS) and two stage least square (2SLS) are applied to specify the estimators for the individual time series in the region. Table 6.10 at the end of the chapter provides the values for $R^2$ and Durbin-Watson on all the econometric methodologies used. We also take into account temporal autocorrelation and we apply the feasible generalized least squares\textsuperscript{105} (FGLS) approach where necessary\textsuperscript{106}. With respect to the specification of the equations for the right hand side variables, we apply extra-regional demands as the level of activity in Australia\textsuperscript{107} to define employment in each sector. As pointed out in Chapter 4, the employment block is the central part of the model and determines labour demand for 19 industries whose definition can be found in Table 6.1. The sectors represent divisions in the Australian and New Zealand Industry Classification (ANZIC) system (ABS, 2013).

\footnotesize
\begin{itemize}
\item \textsuperscript{104} This is contrary to how a static forecasting experiment operates where the actual values for every subsequent period are applied to the values for the lagged endogenous variables.
\item \textsuperscript{105} This is similar to generalized least squares but it applies an estimated variance-covariance matrix because the factual matrix is not directly known.
\item \textsuperscript{106} In FGLS the first observation is treated with a Prais & Winsten (1954) approach, where the serial correlation of type AR (1) is treated in a linear model. In other words, using this approach helps in not losing the first observation and as a result leads to more efficiency.
\item \textsuperscript{107} Here the level of activity refers to both employment and/or output.
\end{itemize}
The results from the total employment forecasting in Table 6.2 show that the econometric model, with a MAPE of 5.094, ranks second after the Illawarra dynamic intermediate demand variable (IDIDV) version of the embedded model. The rankings are exactly the same for the two models with respect to forecasting sectoral employment, with the econometric model having a MAPE of 6.94111, and having only four sectors with the lowest MAPE over the two years. The high MAPES for the econometric model evidently point to the importance of spatial effects in applying the econometric model at the regional level. This also indicates that with respect to impact analysis capabilities, neglecting industrial linkages and sectoral interdependence can lead to poor performance and inevitably makes room for error. Considering the increased importance of regional econometric models in providing policy implications, it is essential to take inter-sectoral connections into account. This leads to modelling the economy with other microstructures (e.g. IO) in order to allow for industrial linkages prior to applying the macro-models in deciding upon different policies.
TABLE 6.1
INDUSTRY PROFILE FOR THE ECONOMETRIC MODEL

<table>
<thead>
<tr>
<th>Sector</th>
<th>Title</th>
<th>ANZIC Division</th>
<th>ANZIC Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Health care and social assistance</td>
<td>Q</td>
<td>84-87</td>
</tr>
<tr>
<td>2</td>
<td>Manufacturing</td>
<td>C</td>
<td>11-25</td>
</tr>
<tr>
<td>3</td>
<td>Education and training</td>
<td>P</td>
<td>80-82</td>
</tr>
<tr>
<td>4</td>
<td>Retail trade</td>
<td>G</td>
<td>39-43</td>
</tr>
<tr>
<td>5</td>
<td>Accommodation and food services</td>
<td>H</td>
<td>44-45</td>
</tr>
<tr>
<td>6</td>
<td>Public administration and safety</td>
<td>O</td>
<td>75-77</td>
</tr>
<tr>
<td>7</td>
<td>Construction</td>
<td>E</td>
<td>30-32</td>
</tr>
<tr>
<td>8</td>
<td>Professional, scientific and technical services</td>
<td>M</td>
<td>69-70</td>
</tr>
<tr>
<td>9</td>
<td>Transport, postal and warehousing</td>
<td>I</td>
<td>46-53</td>
</tr>
<tr>
<td>10</td>
<td>Financial and insurance services</td>
<td>K</td>
<td>62-64</td>
</tr>
<tr>
<td>11</td>
<td>Other services</td>
<td>S</td>
<td>94-96</td>
</tr>
<tr>
<td>12</td>
<td>Administrative and support services</td>
<td>N</td>
<td>72-73</td>
</tr>
<tr>
<td>13</td>
<td>Wholesale trade</td>
<td>F</td>
<td>33-38</td>
</tr>
<tr>
<td>14</td>
<td>Mining</td>
<td>B</td>
<td>06-10</td>
</tr>
<tr>
<td>15</td>
<td>Rental, hiring and real estate services</td>
<td>L</td>
<td>66-67</td>
</tr>
<tr>
<td>16</td>
<td>Arts and recreation services</td>
<td>R</td>
<td>89-92</td>
</tr>
<tr>
<td>17</td>
<td>Information media and telecommunications</td>
<td>J</td>
<td>54-60</td>
</tr>
<tr>
<td>18</td>
<td>Electricity, gas, water and waste services</td>
<td>D</td>
<td>26-29</td>
</tr>
<tr>
<td>19</td>
<td>Agriculture, forestry and fishing</td>
<td>A</td>
<td>01-05</td>
</tr>
</tbody>
</table>

Source: created by the author.

6.2.2 Composite Model

In forecasting total employment the performance of the composite model was eclipsed by the embedded models (as can be seen in Table 6.2 and Table 6.3) yet in total both integrated models outperformed the standalone econometric model, as pointed out in the previous subsection. Nonetheless, the composite model and the inter-industry employment demand requirement (IEDR) of the embedded strategy generated the lowest median MAPEs in forecasting sectoral employment. Such low MAPEs for forecasting sectoral employment indicate that the composite model provides increased accuracy at disaggregated levels over
not only the standalone econometric model but also other integrated models (except for the IEDR).

One possible reason why composite and IEDR models show a superior performance with respect to forecasting sectoral MAPEs is that when it comes to modelling sectoral employment in an economy with a highly sectoral interdependent structure, it is necessary to specify the employment demand variables individually for each sector. This helps retain the inter-industry linkages in estimating the employment demands for every sector. In contrast, when the focus is on a less interdependent industrial structure with a lower level of industrial diversification, these linkages may not be as critical and thus may be less developed. Therefore, for a highly diverse economy with an extensively connected inter-sectoral structure, a modelling framework that focuses on unique specifications for an individual sector is more efficient and provides higher accuracy.

Nonetheless, a dearth of time-series data, the complexity of computing all inter-industry linkages, and the opportunity cost of running the model using a dynamic method may result in the introduction of implicit transmission errors across sectors. This is due to the inclusion of the inter-industry relations in each employment demand equation for each period as well as a full set of explicit final demand relations, through the expected output term, hence the possibility of a relative performance loss in small regions where access to required primary data is limited.

In forecasting sectoral employment the estimates obtained from the composite model also dominate the comparison with respect to the number of sectors with the lowest MAPE.

---

108 As pointed out in previous footnotes, specifying and running a dynamic model with simultaneous equations is unlike specifying and running a simple static model. In a simple static model we use actual data for the equations for each period to run the model. In a dynamic model with simultaneous equations we run the whole model for each observation. In other words, there are more than 100 equations for each of the 20 observations in the case of the Illawarra.

109 As pointed out in Chapter 4 and Chapter 5, expected output is derived from the sum of the output coefficients plus the final demand vector for each sector.
Table 6.3 shows that the most accurate results for 9 out of 19 sectors belong to the composite model. On the other hand the composite model shows a relatively poor performance in terms of the MAPE for total employment as reported in Table 6.2.

As the overall MAPE results for the total employment estimates in Table 6.2 are smaller than the MAPE results for sectoral employment, shown in Table 6.3, it can be inferred that there is some error-cancellation format when we aggregate the sectoral values. However, due to the fact that only the relative average value of the MAPEs increases from total employment to sectoral employment, it is concluded that the error-cancellation format may not work in the same manner for each integrated model\textsuperscript{110}.

\textit{6.2.3 Embedded Model}

There are four different versions of the embedded model applied to forecast employment for the Illawarra economy. As thoroughly discussed in Chapter 5 the distinction between the four models lay in the treatment of the inter-industry demand variable (IDV). As a reminder, the nine different models are again listed as follows:

1) Dynamic inter-industry demand variable (DIDV)

2) Dynamic inter-industry employment demand variable (DIEDV)

3) Illawarra dynamic inter-industry demand variable (IDIDV)

4) Inter-industry employment demand requirement (IEDR)

As a brief reminder the four different versions of the embedded model represent different embedding approaches appearing in the literature, providing insight on four key characteristics with respect to the specification of the IDV and cost adjustment factor in the model. These characteristics relate to the model’s performance in terms of:

\textsuperscript{110} As already pointed out, the composite model performed better in the sectoral forecast but relatively poorly in the total forecast.
1) The choice of coefficients being from national or a regional IO table in developing the IDV.

2) The choice of including labour productivity adjustments for differentials across sectors in developing the IDV\textsuperscript{111}.

3) The choice of including a cost adjustment factor in developing the IDV.

The estimates in Table 6.2 show the forecast MAPEs for total employment obtained from the 4 different IDV approaches compared to the composite and econometric models. A review of the estimated MAPEs indicates that there is a noticeable improvement in the forecasting performance when we shift from a standalone econometric model to the integrated framework.

In embedding \textit{a priori} information from inter-industry linkages into an econometric host one has to choose between national proportion based coefficients or regional proportion based coefficients. The relative performance of the two versions differs very subtly if both versions are based on static forecasting. Nevertheless, this property does not fare as well when the coefficients are specified dynamically as is the case for the Illawarra embedded models; where the national proportion based version (DIDV) shows superior performance compared to the Illawarra proportion based coefficients (IDIDV) in forecasting total employment. To top the superior performance of the DIDV we include labour productivity adjustments to obtain the dynamic national model (DIEDV), which clearly dominates the comparison in forecasting total employment.

The superior performance obtained from using dynamic coefficients indicates the importance of capturing variations in IO coefficients over time. The dynamic IO coefficients in these versions of the embedded model are based on extrapolation of past annual national

\textsuperscript{111} This refers to the labour productivity adjustments specified in the embedded model equations discussed in Chapter 5.
tables from the Australian Bureau of Statistics. Nonetheless, the results in other studies indicate that not all the models applying dynamic coefficients show superior performance compared with models applying static coefficients. Studies show that in forecasting total employment regionalized versions of the IDV in static versions show a lower MAPE than the dynamic version, such as IDIDV. Due to the ability of dynamic models to track adjustments through time, dynamic models top comparison studies in forecasting. This indicates that the DIEDV version shows a lower MAPE than the static models of the IDV. These findings are in general agreement with those reported by Stover (1994), Rey (2000) and Motii (2005) which show that capturing the dynamic characteristics of IO coefficients will not necessarily always result in enhanced accuracy of the model.

Attention now turns to the comparative performance of the embedded versions with respect to the inclusion of labour productivity adjustments and cost adjustment factors. Among the four embedded models chosen for this study, namely DIDV, DIEDV, IDIDV and IEDR, the models applying labour adjustment perform more accurately in total employment forecasts. These results are in line with those from Coomes et al. (1991a), Rey (2000) and Motii (2005) showing that forecasting performance is not sensitive to labour productivity adjustment yet sensitive to cost adjustment factors. This section is concluded by Table 6.2, which provides the MAPE results for the total employment forecast and Table 6.3, which provides the MAPE results for the sectoral employment forecast.
### TABLE 6.2

**MEAN ABSOLUTE PERCENTAGE ERRORS FOR 2011-2012 FORECASTS OF TOTAL EMPLOYMENT**

Mean Absolute Percentage Errors for 2011-2012 Forecasts of Total Employment

<table>
<thead>
<tr>
<th>Econometric</th>
<th>Composite</th>
<th>IDIDV</th>
<th>DIDV</th>
<th>DIEDV</th>
<th>IEDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.094</td>
<td>3.9131</td>
<td>6.3215</td>
<td>1.71828</td>
<td>1.667*</td>
<td>1.531**</td>
</tr>
</tbody>
</table>

*Source:* estimated and created by the author.

*Note:* ** The model with the lowest MAPE.

* The model with the second lowest MAPE.

---

### TABLE 6.3

**MEAN ABSOLUTE PERCENTAGE ERRORS FOR 2011-2012 FORECASTS OF SECTORAL EMPLOYMENT**

Mean Absolute Percentage Errors for 2009-2011 Forecasts of Sectoral Employment

<table>
<thead>
<tr>
<th></th>
<th>Econometric</th>
<th>Composite</th>
<th>IDIDV</th>
<th>DIDV</th>
<th>DIEDV</th>
<th>IEDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Sectoral Employment MAPE</td>
<td>6.94111</td>
<td>3.5191**</td>
<td>5.172</td>
<td>6.525</td>
<td>5.754</td>
<td>4.4251*</td>
</tr>
<tr>
<td>Number of Sectors with the Lowest MAPE</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

*Source:* estimated and created by the author.

*Note:* ** The model with the lowest MAPE.

* The model with the second lowest MAPE.
6.3 Empirical Results from an Impact Analysis

As pointed out in the introduction section the second part of the experimental design consists of examining the impact analysis capabilities of the IO model together with the embedded, composite and linked models. In this set of analyses we first examine the interconnectedness of the industries within the Illawarra economy using results from the simple IO analysis. In this analysis we rank and discuss the first three industries with respect to their impacts on output, income and employment based on the numerical value of relevant multipliers (the results are presented in Table 6.5, Table 6.6 and Table 6.7).

This is followed by a comparative examination of results from five different models, namely, the Illawarra standalone IO, linked, and composite models to estimate the employment impacts arising from a hypothetical scenario of a temporary AU$200 million increase in government expenditure on the education and training sector in the region implemented in 2011-2012. The choice for this particular scenario is explained by the regional economic transition and the increasing emphasis of the regional economy on research and innovation. Table 6.8 summarizes results for this case for the five models. Focusing first on the IO models, several findings emerge as follows.

6.3.1 Input-Output Model

One concern related to the level of disaggregation in the IO model is the practicability of the computational process, since the technical coefficients matrices are of dimensions that cannot be easily processed in personal computing devices. Although a possible solution could be to only implement a unique number of sectors that represent the greatest possible industrial detail, the added intricacy in the disaggregation and re-aggregation process would mask the analysis of the main issues, namely, the comparative properties of the different models used in this study. Therefore, it was decided to use a 30-industry sectoral profile. This profile
consists of 30 industries which are listed in Table 6.4. The 30 sectors correspond closely with the ANZIC aggregation of the benchmark national table (ABS, 2013).

<table>
<thead>
<tr>
<th>Sector</th>
<th>Title</th>
<th>ANZIC Division</th>
<th>ANZIC Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agriculture, forestry &amp; fishing</td>
<td>A</td>
<td>01-05</td>
</tr>
<tr>
<td>2</td>
<td>Mining</td>
<td>B</td>
<td>06-10</td>
</tr>
<tr>
<td>3</td>
<td>Food manufacturing</td>
<td>C</td>
<td>11-12</td>
</tr>
<tr>
<td>4</td>
<td>Textiles &amp; clothing</td>
<td>C</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>Wood, paper &amp; printing</td>
<td>C</td>
<td>14-16</td>
</tr>
<tr>
<td>6</td>
<td>Petroleum &amp; coal products</td>
<td>C</td>
<td>17</td>
</tr>
<tr>
<td>7</td>
<td>Chemical products</td>
<td>C</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>Rubber &amp; plastic products</td>
<td>C</td>
<td>19</td>
</tr>
<tr>
<td>9</td>
<td>Non-metallic mineral</td>
<td>C</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>Basic metals</td>
<td>C</td>
<td>21-22</td>
</tr>
<tr>
<td>11</td>
<td>Transport &amp; other</td>
<td>C</td>
<td>23</td>
</tr>
<tr>
<td>12</td>
<td>Other manufacturing</td>
<td>C</td>
<td>24-25</td>
</tr>
<tr>
<td>13</td>
<td>Electricity, gas &amp; water</td>
<td>D</td>
<td>26-29</td>
</tr>
<tr>
<td>14</td>
<td>Construction</td>
<td>E</td>
<td>30-32</td>
</tr>
<tr>
<td>15</td>
<td>Wholesale trade</td>
<td>F</td>
<td>33-38</td>
</tr>
<tr>
<td>16</td>
<td>Retail trade</td>
<td>G</td>
<td>39-43</td>
</tr>
<tr>
<td>17</td>
<td>Repairs</td>
<td>S</td>
<td>94</td>
</tr>
<tr>
<td>18</td>
<td>Accommodation, cafes &amp; restaurant</td>
<td>H</td>
<td>44-45</td>
</tr>
<tr>
<td>19</td>
<td>Transport &amp; storage</td>
<td>I</td>
<td>46-53</td>
</tr>
<tr>
<td>20</td>
<td>Communication services</td>
<td>J</td>
<td>54-60</td>
</tr>
<tr>
<td>21</td>
<td>Finance &amp; insurance</td>
<td>K</td>
<td>62-64</td>
</tr>
<tr>
<td>22</td>
<td>Ownership of dwellings</td>
<td>M</td>
<td>6931</td>
</tr>
<tr>
<td>23</td>
<td>Rental, hiring &amp; real estate</td>
<td>L</td>
<td>66-67</td>
</tr>
<tr>
<td>24</td>
<td>Prof &amp; scientific</td>
<td>M</td>
<td>69-70</td>
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<tr>
<td>25</td>
<td>Administrative services</td>
<td>N</td>
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</tr>
<tr>
<td>26</td>
<td>Government &amp; defence</td>
<td>O</td>
<td>75-77</td>
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<tr>
<td>27</td>
<td>Education &amp; training</td>
<td>P</td>
<td>80-82</td>
</tr>
<tr>
<td>28</td>
<td>Health &amp; social services</td>
<td>Q</td>
<td>84-87</td>
</tr>
<tr>
<td>29</td>
<td>Cultural &amp; recreational</td>
<td>R</td>
<td>89-92</td>
</tr>
<tr>
<td>30</td>
<td>Personal &amp; other services</td>
<td>S</td>
<td>94-96</td>
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</tbody>
</table>

It is important to provide a general review of the multipliers from the IO analysis before we turn our attention to interpretation of the standalone IO analysis of the Illawarra economy. Conventionally, an increase in the final demand for a particular product increases the overall output of that product, as the producing sectors respond to meet the increased demand. This is called the **direct effect**. The increase in the output of the producing sectors will also result in an increase in demand on their suppliers’ products and so on down the supply chain. This is called the **indirect effect**. Furthermore, the direct and indirect effects result in an increase in overall production, which in turn will increase the level of employment and consequently the level of household income throughout the economy. Finally, a portion of this increased income is spent on final goods and services, which is called the **induced effect**. In conducting an impact analysis of the Illawarra economy, it is crucial to quantify the multiplier effects as they measure the significance of industries/sectors on the regional economy. Hence attention now turns to interpreting the standalone IO multipliers.

### 6.3.1.1 Multipliers

Multipliers are applied to capture the secondary effects of expenditure in an economy. As pointed out earlier, there are two types of secondary effects as follows.

The first type is the indirect effects, which are the adjustments in output, employment and income within the intermediate industries in the region. In other words, businesses that supply goods and services to firms that sell those goods to the final demand sector. For instance, restaurants and bars in the Wollongong CBD purchase a variety of goods (food and beverages) and services (barrister, waitresses, and waiters) from the local suppliers (and households) in order to provide an amiable experience for customers visiting from Sydney. Each of the local businesses, providing goods or services to these restaurants and bars, benefits indirectly from the visitors’ expenditures in the restaurants. These indirect effects are
captured by Type I multipliers. In other words, a Type I output multiplier equals the ratio of the sum of direct sales (DS) and indirect sales (IS) to direct sales. Type I = (DS+IS) ÷ DS.

The second type is the Induced effects, which are the increases (decreases) in output, employment and income in the region as a result of an increase (decrease) in household consumption expenditure of the income that was earned directly or indirectly. An example in this case would be a local hotel manager’s consumption expenditure on the local products and services (e.g. if he dines at a local restaurant), which results in subsequent output and economic activities within Wollongong. These impacts are immediately noticeable in situations arising from a significant slump (or rise) in tourism in a region. In such situations a decrease in income entails a decrease in expenditure that would also affect businesses in the retail sector (the most), followed by businesses in other sectors that depend on household expenditure. Type II multipliers capture both indirect and induced effects. In other words a Type II output multiplier equals the ratio of the sum of direct sales (DS), indirect sales (IS), and induced sales (IDS) to direct sales (DS). Type II = (DS+IS+IDS) ÷ DS.

6.3.1.2 Illawarra Output Multipliers

The output multiplier for every sector is specified as the ratio of changes in direct plus changes in indirect (and induced if Type II multipliers are used) output to the changes in direct output as a result of a change in final demand. Table 6.5 shows that the professional, scientific and research sector comes first in the ranking with a total output multiplier of 2.2126, followed by administrative services with a total output multiplier of 2.2067. The education and training sector comes fourth in the ranking, with a total output multiplier of 2.1024. In Table 6.5, figures in the First Round column indicate the direct effects of change. Figures in the Industrial Supply column indicate the indirect effects of change and finally, figures in the Consumption column indicate the induced effects of change. Elasticity indicates the percentage change of output divided by the percentage change of an input.
Since the professional, scientific and research sector is directly associated, and to a certain degree is dependent on education and training, it can be inferred that the education sector plays a significant role in the regional output of the Illawarra economy.
<table>
<thead>
<tr>
<th>Sector</th>
<th>Initial</th>
<th>First Round</th>
<th>Indust Sup</th>
<th>Consumption</th>
<th>Total</th>
<th>Elasticity</th>
<th>Type I</th>
<th>Type II</th>
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<tbody>
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<td>Agriculture, Forestry, Fishing</td>
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<td>0.1148</td>
<td>0.3084</td>
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<td>1.6866</td>
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<td>0.9707</td>
<td>1.2655</td>
<td>1.512</td>
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<td>0.2042</td>
<td>1.5791</td>
<td>1.9394</td>
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<td>1.9105</td>
<td>0.6131</td>
<td>1.4477</td>
<td>1.9105</td>
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<td>1.8758</td>
<td>0.1445</td>
<td>1.4242</td>
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<td>0.0556</td>
<td>0.0916</td>
<td>1.3139†</td>
<td>0.2073</td>
<td>1.2224</td>
<td>1.3139†</td>
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<td>1.6957</td>
<td>0.6904</td>
<td>1.3963</td>
<td>1.6957</td>
</tr>
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<td>0.3658</td>
<td>1.3424</td>
<td>1.713</td>
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<td>1.5559</td>
<td>1.9652</td>
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<td>0.1507</td>
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<td>1.4163</td>
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<td>1.7176</td>
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<td>1.7582</td>
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<td>2.1525*</td>
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<td>1.3568</td>
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<td>0.4714</td>
<td>1.9688</td>
<td>0.6213</td>
<td>1.4974</td>
<td>1.9688</td>
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<td>0.2096</td>
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<td>0.7487</td>
<td>1.6066</td>
<td>2.2126***</td>
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<td>2.1024§</td>
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<td>1.157</td>
<td>2.0122</td>
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<td>1.4963</td>
<td>1.9831</td>
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<td>2.0406</td>
<td>0.3116</td>
<td>1.333</td>
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6.3.1.3 Illawarra Income Multipliers

Similar to the output multipliers, income multipliers measure the change in income (e.g. compensation of employees) which corresponds to a change in final demand (direct impact). The income multipliers indicate the ratio of direct plus indirect (plus induced if Type II multipliers are applicable) changes in income to the direct changes in income. Furthermore, we can use income effects to measure the direct plus indirect (plus induced if Type II multipliers are used) changes in income to the direct changes in output as a result of a change in final demand. The results in Table 6.6 show that the highest income effect is attributable to the education and training sector, with an income multiplier of 0.9511, followed by health and social services, which is directly affiliated with the education sector under the banner of a knowledge industry, with an income multiplier of 0.9036. The lowest income multipliers belong to petroleum and coal products, ownership of dwellings, basic metals and mining. These results place an emphasis on the economic transition, which was pointed out in Chapter 2, from heavy industrial manufacturing to highly skilled labour, higher value adding innovation orientation in knowledge industries.
### TABLE 6.6: INCOME MULTIPLIERS (Source: estimated and created by the author.)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Initial</th>
<th>First Round</th>
<th>Indust Sup</th>
<th>Consumption</th>
<th>Total</th>
<th>Elasticity</th>
<th>Type I</th>
<th>Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry, Fishing</td>
<td>0.1533</td>
<td>0.0597</td>
<td>0.0298</td>
<td>0.083</td>
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<td>0.019</td>
<td>0.0664</td>
<td>0.2604</td>
<td>1.2323</td>
<td>1.4303</td>
<td>1.9195</td>
</tr>
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<td>0.0443</td>
<td>0.097</td>
<td>0.3807</td>
<td>0.2609</td>
<td>1.846</td>
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<td>0.1246</td>
<td>0.4889</td>
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<td>0.1216</td>
<td>0.4771</td>
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<td>0.0998</td>
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<td>0.0466</td>
<td>0.1269</td>
<td>0.498</td>
<td>0.6958</td>
<td>1.6428</td>
<td>2.2047</td>
</tr>
<tr>
<td>Professional &amp; Scientific</td>
<td>0.3011</td>
<td>0.1168</td>
<td>0.0592</td>
<td>0.1632</td>
<td>0.6402</td>
<td>0.7195</td>
<td>1.5844</td>
<td>2.1264</td>
</tr>
<tr>
<td>Administrative Services*</td>
<td>0.4448</td>
<td>0.0912</td>
<td>0.0434</td>
<td>0.1982</td>
<td>0.7776</td>
<td>0.7079</td>
<td>1.3026</td>
<td>1.7481</td>
</tr>
<tr>
<td>Government and Defence</td>
<td>0.4693</td>
<td>0.074</td>
<td>0.0358</td>
<td>0.1981</td>
<td>0.7771</td>
<td>1.5559</td>
<td>1.2339</td>
<td>1.656</td>
</tr>
<tr>
<td>Education and Training***</td>
<td>0.6526</td>
<td>0.039</td>
<td>0.0171</td>
<td>0.2424</td>
<td>0.9511***</td>
<td>0.8911</td>
<td>1.0859</td>
<td>1.4573</td>
</tr>
<tr>
<td>Health and Social Services**</td>
<td>0.6286</td>
<td>0.0312</td>
<td>0.0135</td>
<td>0.2303</td>
<td>0.9036**</td>
<td>0.863</td>
<td>1.0711</td>
<td>1.4374</td>
</tr>
<tr>
<td>Cultural and Recreation</td>
<td>0.2478</td>
<td>0.091</td>
<td>0.0445</td>
<td>0.1311</td>
<td>0.5143</td>
<td>0.6578</td>
<td>1.5468</td>
<td>2.0758</td>
</tr>
<tr>
<td>Personal and Other Services</td>
<td>0.4639</td>
<td>0.0635</td>
<td>0.0296</td>
<td>0.1905</td>
<td>0.7476</td>
<td>0.2461</td>
<td>1.2009</td>
<td>1.6116</td>
</tr>
</tbody>
</table>
6.3.1.4 Illawarra Employment Multipliers

The employment multipliers measure the ratio of the sum of direct and indirect (plus induced if Type II multipliers are used) changes in employment in correspondence to the direct changes in employment. As for the case of income effects, we can use employment effects to measure the sum of direct and indirect (plus induced if Type II multipliers are used) changes in employment to the direct changes in output following changes in final demand levels. The results from Table 6.7 indicate that personal and other services come first in ranking, with total employment multipliers of 16.2266, followed by health care and social services, with employment multipliers of 15.7042, and third place belongs to education and training, with 14.3112 employment multipliers. These results suggest the interdependence of the sectors in the region on skilled labour and emphasize the spatial linkages among the industries.
TABLE 6.7: EMPLOYMENT MULTIPLIERS (Source: estimated and created by the author.)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Initial</th>
<th>First Round</th>
<th>Indust Sup</th>
<th>Consumption</th>
<th>Total</th>
<th>Elasticity</th>
<th>Type I</th>
<th>Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry, Fishing</td>
<td>9.6742</td>
<td>1.3721</td>
<td>0.4308</td>
<td>1.3373</td>
<td>12.8145</td>
<td>0.4058</td>
<td>1.1864</td>
<td>1.3246</td>
</tr>
<tr>
<td>Mining</td>
<td>1.5739</td>
<td>0.5007</td>
<td>0.2371</td>
<td>1.069</td>
<td>3.3808</td>
<td>1.379</td>
<td>1.4688</td>
<td>2.1481</td>
</tr>
<tr>
<td>Food Manufacturing</td>
<td>2.1145</td>
<td>2.3745</td>
<td>0.7137</td>
<td>1.5627</td>
<td>6.7654</td>
<td>0.3369</td>
<td>2.4605</td>
<td>3.1996</td>
</tr>
<tr>
<td>Textiles and Clothing</td>
<td>4.3976</td>
<td>1.4545</td>
<td>0.5411</td>
<td>2.0068</td>
<td>8.3999</td>
<td>0.613</td>
<td>1.4538</td>
<td>1.9101</td>
</tr>
<tr>
<td>Wood, Paper and Printing</td>
<td>3.6445</td>
<td>1.1757</td>
<td>0.4678</td>
<td>1.9583</td>
<td>7.2464</td>
<td>0.1532</td>
<td>1.451</td>
<td>1.9883</td>
</tr>
<tr>
<td>Petroleum and Coal Products†</td>
<td>0.4606</td>
<td>0.3787</td>
<td>0.1686</td>
<td>0.3972</td>
<td>1.4051²</td>
<td>0.4812</td>
<td>2.1882</td>
<td>3.0505†</td>
</tr>
<tr>
<td>Chemical Products</td>
<td>1.1916</td>
<td>0.8764</td>
<td>0.4061</td>
<td>1.2986</td>
<td>3.7726</td>
<td>1.2891</td>
<td>2.0763</td>
<td>3.1661</td>
</tr>
<tr>
<td>Rubber and Plastic Products</td>
<td>2.4064</td>
<td>0.7241</td>
<td>0.3522</td>
<td>1.6071</td>
<td>5.0899</td>
<td>0.4517</td>
<td>1.4473</td>
<td>2.1151</td>
</tr>
<tr>
<td>Non-Metallic Mineral</td>
<td>1.9205</td>
<td>0.9947</td>
<td>0.5302</td>
<td>1.7749</td>
<td>5.2202</td>
<td>0.2599</td>
<td>1.794</td>
<td>2.7182</td>
</tr>
<tr>
<td>Basic Metals and Metal</td>
<td>0.6432</td>
<td>0.3779</td>
<td>0.2301</td>
<td>0.6537</td>
<td>1.9048</td>
<td>2.3119</td>
<td>1.9453</td>
<td>2.9616</td>
</tr>
<tr>
<td>Transport and Other</td>
<td>2.9011</td>
<td>0.5237</td>
<td>0.279</td>
<td>1.5524</td>
<td>5.2562</td>
<td>0.8057</td>
<td>1.2767</td>
<td>1.8118</td>
</tr>
<tr>
<td>Other Manufacturing</td>
<td>6.3864</td>
<td>0.5332</td>
<td>0.267</td>
<td>1.6479</td>
<td>8.8345</td>
<td>0.9176</td>
<td>1.1253</td>
<td>1.3833</td>
</tr>
<tr>
<td>Electricity, Gas, Water</td>
<td>2.6122</td>
<td>0.7618</td>
<td>0.3605</td>
<td>1.55</td>
<td>5.2846</td>
<td>0.4201</td>
<td>1.4297</td>
<td>2.023</td>
</tr>
<tr>
<td>Construction</td>
<td>3.4061</td>
<td>1.4059</td>
<td>0.81</td>
<td>1.8938</td>
<td>7.5158</td>
<td>1.6092</td>
<td>1.6506</td>
<td>2.2066</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>2.9997</td>
<td>1.1688</td>
<td>0.5568</td>
<td>2.2383</td>
<td>6.9636</td>
<td>0.5854</td>
<td>1.5752</td>
<td>2.3214</td>
</tr>
<tr>
<td>Retail Trade³</td>
<td>9.6509</td>
<td>0.9977</td>
<td>0.4879</td>
<td>2.7701</td>
<td>13.9066⁴</td>
<td>0.0907</td>
<td>1.1539</td>
<td>1.441</td>
</tr>
<tr>
<td>Repairs</td>
<td>6.5239</td>
<td>0.8949</td>
<td>0.4417</td>
<td>1.9993</td>
<td>9.8599</td>
<td>0.4316</td>
<td>1.2049</td>
<td>1.5113</td>
</tr>
<tr>
<td>Accommodation, Cafes and Restaurants</td>
<td>7.3278</td>
<td>1.0057</td>
<td>0.5073</td>
<td>2.1093</td>
<td>10.9502</td>
<td>0.0214</td>
<td>1.2065</td>
<td>1.4943</td>
</tr>
<tr>
<td>Transport and Storage</td>
<td>4.0713</td>
<td>1.1956</td>
<td>0.4849</td>
<td>2.0872</td>
<td>7.8029</td>
<td>0.6714</td>
<td>1.4039</td>
<td>1.9166</td>
</tr>
<tr>
<td>Communication Services</td>
<td>2.0874</td>
<td>1.1542</td>
<td>0.5429</td>
<td>1.4387</td>
<td>5.2232</td>
<td>0.4742</td>
<td>1.813</td>
<td>2.5022</td>
</tr>
<tr>
<td>Finance and Insurance</td>
<td>1.8253</td>
<td>0.5512</td>
<td>0.2495</td>
<td>2.5001</td>
<td>5.1261</td>
<td>0.1024</td>
<td>1.4387</td>
<td>2.8084</td>
</tr>
<tr>
<td>Ownership of Dwelling‡</td>
<td>0</td>
<td>0.4211</td>
<td>0.2058</td>
<td>0.4296</td>
<td>1.0565¹</td>
<td>0.6269</td>
<td>0</td>
<td>0‡</td>
</tr>
<tr>
<td>Rental, Hiring and Real Estate</td>
<td>2.3494</td>
<td>1.1196</td>
<td>0.5551</td>
<td>2.0441</td>
<td>6.0681</td>
<td>0.8151</td>
<td>1.7128</td>
<td>2.5828</td>
</tr>
<tr>
<td>Professional &amp; Scientific</td>
<td>3.6418</td>
<td>1.4701</td>
<td>0.7373</td>
<td>2.6276</td>
<td>8.4767</td>
<td>0.7877</td>
<td>1.6061</td>
<td>2.3276</td>
</tr>
<tr>
<td>Administrative Services</td>
<td>4.924</td>
<td>1.1682</td>
<td>0.5394</td>
<td>3.1917</td>
<td>9.8233</td>
<td>0.8078</td>
<td>1.3468</td>
<td>1.995</td>
</tr>
<tr>
<td>Government and Defence</td>
<td>6.2997</td>
<td>0.9367</td>
<td>0.4427</td>
<td>3.1898</td>
<td>10.8688</td>
<td>1.621</td>
<td>1.219</td>
<td>1.7253</td>
</tr>
<tr>
<td>Education and Training*</td>
<td>9.6676</td>
<td>0.5237</td>
<td>0.2162</td>
<td>3.9038</td>
<td>14.3112*</td>
<td>0.9052</td>
<td>1.0765</td>
<td>1.4803</td>
</tr>
<tr>
<td>Health and Social Services**</td>
<td>11.429</td>
<td>0.3985</td>
<td>0.1679</td>
<td>3.7088</td>
<td>15.7042**</td>
<td>0.8249</td>
<td>1.0496</td>
<td>1.3741</td>
</tr>
<tr>
<td>Cultural and Recreation</td>
<td>4.812</td>
<td>1.2454</td>
<td>0.5716</td>
<td>2.1111</td>
<td>8.7401</td>
<td>0.5755</td>
<td>1.3776</td>
<td>1.8163</td>
</tr>
<tr>
<td>Personal and Other Services***</td>
<td>11.9724</td>
<td>0.8154</td>
<td>0.3702</td>
<td>3.0686</td>
<td>16.2266***</td>
<td>0.207</td>
<td>1.099</td>
<td>1.3553</td>
</tr>
</tbody>
</table>
For the second part of the impact analysis, several conclusions can be drawn by comparing the models in the integrated framework with the standalone models. The first relates to the estimated impacts from the composite model; which are generally larger than the impacts derived from the IO models. This is explained because of the greater degree of endogeneity in the composite model compared to the closed IO model. In other words, in addition to personal consumption expenditures, investment, changes in business inventories, imports, and government expenditures, are endogenized in the composite model too. In closed IO models, only personal consumption expenditures are treated endogenously while the remaining elements are exogenous. Therefore, the unlimited supply elasticities of the IO analysis do not generate estimates that can be considered as the upper bound of the actual estimates of the impacts as argued by Hughes et al. (1991). Instead, in the case of the Illawarra economy the induced effects associated with endogenous investment and government expenditures are the effects that result in larger estimated impacts in the composite model than those based purely on household consumption expenditures.

The second conclusion relates to the temporal element of the impact analysis. As pointed out earlier, there is an inherent time lag in building the IO tables and thus the temporal element for the total estimated impacts from the IO models is unknown. On the other hand the integrated models provide the modeller with the ability to estimate the temporal element for the indirect and induced effects. This also explains why such models generate larger impacts than the IO model, suggesting that the temporal response of the Illawarra economy is important in measuring the final impact of a policy. It can also be concluded that failure to specify a model to analyse temporal responses can result in erroneous policy implications.

6.3.2 Composite Model

In the government expenditure increase scenario of the impact analysis experiment the composite model generates estimated impacts that are more accurate with respect to sectoral
linkages. This is mostly because of the differences in the mechanism of the employment demand specifications across the five blocks in the composite model (as explained in Chapter 4 and Chapter 5). As pointed out in Chapter 5, employment in each sector is specified dynamically as a function of sectoral output and labour productivity in the composite model, while in different versions of the embedded model the employment specification is similar to the regular econometric model. Considering these specifications the variables for policy analysis, which is discussed in Chapter 7, impose more influence on a larger number of sectors in the composite model compared with the linked and embedded models. In the composite model the fluctuation in the estimated impacts across the sectors in the region show more consistency with the configuration displayed by the IO analysis. This consistency in the regional estimated impacts also reflects the more extensive nature of the inter-industry relations in the composite model, as explained in Chapter 5.

Moreover, an additional benefit that the composite (and DIA) model has in comparison with the linked and IO models is the option for analysing estimated results based on the choice of sustained or permanent impacts over a period of time. This is because of the sectoral time-series equations that we apply in the composite model, as explained in Chapter 4 and Chapter 5. This is the competitive advantage of the dynamic models, which relates to their capability of examining temporal impacts.

The estimated impacts on employment as a result of an increase in government expenditure in education and training sector are not relatively large for the composite model. The estimated impact per AU$200 million increase in the region is 35,423 jobs added according to the SIEDV model versus 21,481 for the composite model. However, the difference between the estimated regional impact between the DIA and composite models is much lower than is the case between composite and SIEDIV. In addition, the relative
variation in the estimated impacts across the sectors in the region is again larger for SIEDV compared to the composite model.

6.3.3 Embedded Model

In the two versions of the embedded model for this analysis the estimated industrial linkages are less extensive because the employment demand equations depend on econometric specifications rather than on the deterministic inter-industry identities of the IO. This resembles the structure of the variation in the performances of the composite and embedded models across different sectors reported in the previous section. Nonetheless, with respect to policy implications, which will be discussed in the next chapter, it is wise for modellers to substitute the less disaggregated total employment forecasts of the embedded models with a more disaggregated mechanism of the composite model, subject to data availability. This is because of a twofold advantage that the composite model offers. Firstly, the higher level of inter-sectoral details and re-iterative process of estimating the sectoral information for 20 annual observations; secondly the socio-economic block of the econometric model applied in the composite, both of which lead to higher accuracy for a more realistic policy impact analysis.

Table 6.8 depicts the difference between the total employment estimates from the baseline and impact simulations for each model. For example, according to the impact analysis based on the DIA model there would be a total of 11,928 more jobs in the Illawarra economy over the two-year period. This amounts to an average annual difference of 5,964 more jobs due to the increase in expenditure.

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112 In policy analysis, a detailed picture of the distribution of impacts across industries is important. This is because designing a mechanism for structural adjustment needs to consider the realistic impacts of potential policies (e.g. education and training conversion mechanism). This will be further discussed in Chapter 7.
Another set of conclusions drawn from the estimated impacts is to consider the total employment increase associated with each AU$200 million increase in government expenditure on the education and training sector. Since the total increase in the region over the two years amounts to AU$200 million, dividing the cumulative employment increase by this figure provides this measure. Continuing with the embedded model in the Illawarra, each AU$100 million increase is associated with an increase of 5,964 jobs. It is essential to note that these estimates are not regarded as multipliers in the conventional sense, because the expenditure increase is introduced in the region in a way that the models exclude domestic inter-regional linkages (employment migration from Sydney and neighbouring regions). Hence, the estimated impacts do not represent the exact intra-regional or inter-regional effects. Yet, the suggested conclusion can still be beneficial for comparative purposes among the five different models.

6.3.4 Linked Model

The linked model generates estimated impacts that are larger than the rest of the integrated models, with differences in the estimates being quite substantial. For example, the employment increase due to a AU$200 million increase in the region is estimated to be 57,468 based on the linked model. This compares to estimated impacts of 11,928 and 21,481 based on the DIA and composite models, respectively. This estimated regional impact from the linked model is over four times the size of the embedded model’s estimated impact and significantly larger than the estimated impact from the composite model. In fact, the estimated impact form the linked model is the largest of the remaining four models.

A possible explanation for the comparatively large estimated impacts from the linked model is due to the double counting involved in the integration process of the linked model, as described in Chapter 5. This occurs when we first apply the IO model to estimate the disaggregated total impacts from the policy shock. These estimated impacts are then re-
aggregated and implemented back into the econometric model to capture the dynamic adjustments of the impact.

In other words the multiplier from the IO model is ultimately overfed by the multiplier from the econometric model before estimating the final multiplier for the linked model. Moreover, as can be seen in Table 6.8, the multipliers from the IO model are larger than any of the other models. Therefore, the large multipliers obtained from the linked model represent the relations between the multipliers from the aggregate sector of the econometric model in addition to the multipliers from the disaggregated sectors in the IO models in the integration process.

On top of the interface between the multipliers from econometric and IO models, there is also estimation of the initial shock, using the Leontief inverse, which causes the impacts of the final demand shock to spread throughout the other disaggregated sectors embodied in the IO model. Hence, the interaction between the integrated multipliers is not exclusive to the specific sectors, on which the initial final demand shock was introduced.
### TABLE 6.8
COMPARISON OF MODEL IMPACT ANALYSIS: TOTAL EMPLOYMENT INCREASE DUE TO A TEMPORARY AU$200 MILLION EXPENDITURE IN EDUCATION AND TRAINING

Comparison of Model Impact Analysis: Total Employment Increase Due to a Temporary AU$200 Million Expenditure in Education and Training

<table>
<thead>
<tr>
<th>Composite</th>
<th>IEDR</th>
<th>LINK</th>
<th>IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>21,481</td>
<td>11,928</td>
<td>57,468</td>
<td>16,815</td>
</tr>
</tbody>
</table>

*Source:* estimated and created by the author.

### TABLE 6.9
COMPARISON OF THE RESULTS OF THE INTEGRATED MODEL WITH THE ACTUAL RESULTS

<table>
<thead>
<tr>
<th>Illawarra</th>
<th>Summary Data From Integrated Framework</th>
<th>Actual</th>
<th>Overall Percentage Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
<td>2011</td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>125,343</td>
<td>128,018</td>
<td>2.13%</td>
</tr>
<tr>
<td>Personal Income</td>
<td>$ 5,978,345,000.00</td>
<td>$ 6,306,265,000.00</td>
<td>5.49%</td>
</tr>
<tr>
<td>Output</td>
<td>$ 26,983,742,983.00</td>
<td>$ 27,533,932,000.00</td>
<td>2.04%</td>
</tr>
<tr>
<td>Population</td>
<td>279,392.00</td>
<td>290,648.00</td>
<td>4.03%</td>
</tr>
<tr>
<td>Gross Regional Product</td>
<td>$ 13,569,535,444.00</td>
<td>$ 14,214,545,000.00</td>
<td>4.75%</td>
</tr>
<tr>
<td>Personal Consumption Expenditure</td>
<td>$ 10,183,920.00</td>
<td>$ 10,914,610.00</td>
<td>7.17%</td>
</tr>
<tr>
<td>Exports</td>
<td>$ 8,028,382,938.00</td>
<td>$ 8,908,195,000.00</td>
<td>10.96%</td>
</tr>
<tr>
<td>Imports</td>
<td>$ 5,948,389,254.00</td>
<td>$ 6,533,657,000.00</td>
<td>9.84%</td>
</tr>
</tbody>
</table>

*Source:* the integrated results are estimated by the author; the actual results are obtained from Australian Bureau of Statistics (ABS 2013).
6.4 Conclusion

In this chapter the estimation properties of the standalone IO and econometric models were compared with the results from alternative integrated models. The results suggest that, as a class, the integrated framework offers higher accuracy in impact analysis and superior performance in forecasting compared with the standalone IO or econometric models. These results are derived from particular modelling of the Illawarra economy albeit they suggest that the integrated framework provides promising results and hence are applicable to other regions and economies.

Nevertheless, the results show a wide variation in development properties and accuracy of the integrated models. It can be concluded that the choice of a particular integrated model reflects a set of important factors that are different from the factors that are required to be considered when the decision is to choose between integrated or non-integrated models. For instance, the results suggest that the composite model produces higher accuracy than the other integrated models with respect to forecasting sectoral employment, albeit this does not apply when the objective is on forecasting aggregate employment. This suggests that the choice of integrating approach is imperative and should be consistent with the modeller’s objective. As was touched on in Chapter 5 the composite model is highly data intensive, hence running the model requires extra diligence as one subtle error in the early stages propagates and spreads the error throughout the entire model\textsuperscript{113}. Also, as the time-series data requirement is much higher in a composite model than all the different versions of the embedded model, there may not be a logical relationship between the complexity in the modelling process and its slightly superior performance. Hence initially it was considered that the trade-off between the two is more complicated, but this trade-off is directly

\textsuperscript{113} This is due to its dynamic nature, as discussed earlier in this chapter as well as Chapter 5.
dependent upon the modeller’s objective and the characteristics of the economy under analysis.

As a whole the aforementioned implications can be drawn for practice. While this chapter has presented added insights as to the sensitivity of model simulation, accuracy in impact analysis and forecasting performance to the choice of integrating approach, it is important to recognize that, except for the Australian context, the models in the integrated framework are applied in policy impact analyses quite often. Therefore, as a complement to this chapter, the issue of the role of the integrating approach in policy impact analyses is examined in the following chapter. The results of the scenarios analysed in this chapter are applied to provide policy implications in Chapter 7.
### TABLE 6.10
COMPARISON OF THE $R^2$ AND DURBIN WATSON STATISTICS FOR DIFFERENT METHODOLOGIES

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Econometrics</th>
<th>Composite</th>
<th>IDIDV</th>
<th>DIDV</th>
<th>DIEDV</th>
<th>IEDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector</td>
<td>FGLS</td>
<td>2SLS</td>
<td>OLS</td>
<td>OLS</td>
<td>OLS</td>
<td>2SLS</td>
</tr>
<tr>
<td>Health care and social assistance</td>
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<td>2.05</td>
<td>0.902</td>
<td>2.07</td>
<td>0.938</td>
<td>2.12</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.905</td>
<td>2.21</td>
<td>0.956</td>
<td>1.85</td>
<td>0.981</td>
<td>2.16</td>
</tr>
<tr>
<td>Education and training</td>
<td>0.900</td>
<td>2.30</td>
<td>0.941</td>
<td>2.31</td>
<td>0.931</td>
<td>1.88</td>
</tr>
<tr>
<td>Retail trade</td>
<td>0.951</td>
<td>2.01</td>
<td>0.925</td>
<td>1.97</td>
<td>0.918</td>
<td>2.24</td>
</tr>
<tr>
<td>Accommodation and food services</td>
<td>0.905</td>
<td>2.05</td>
<td>0.932</td>
<td>1.95</td>
<td>0.911</td>
<td>2.10</td>
</tr>
<tr>
<td>Public administration and safety</td>
<td>0.949</td>
<td>1.95</td>
<td>0.938</td>
<td>1.63</td>
<td>0.909</td>
<td>1.77</td>
</tr>
<tr>
<td>Construction</td>
<td>0.903</td>
<td>1.70</td>
<td>0.912</td>
<td>1.90</td>
<td>0.963</td>
<td>1.75</td>
</tr>
<tr>
<td>Professional, scientific and technical services</td>
<td>0.934</td>
<td>2.06</td>
<td>0.899</td>
<td>2.11</td>
<td>0.948</td>
<td>1.77</td>
</tr>
<tr>
<td>Transport, postal and warehousing</td>
<td>0.966</td>
<td>1.84</td>
<td>0.974</td>
<td>1.60</td>
<td>0.939</td>
<td>2.07</td>
</tr>
<tr>
<td>Financial and insurance services</td>
<td>0.912</td>
<td>2.30</td>
<td>0.922</td>
<td>2.02</td>
<td>0.928</td>
<td>2.10</td>
</tr>
<tr>
<td>Other services</td>
<td>0.956</td>
<td>1.96</td>
<td>0.948</td>
<td>2.10</td>
<td>0.998</td>
<td>2.20</td>
</tr>
<tr>
<td>Administrative and support services</td>
<td>0.905</td>
<td>1.94</td>
<td>0.896</td>
<td>1.97</td>
<td>0.931</td>
<td>2.33</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>0.892</td>
<td>1.62</td>
<td>0.932</td>
<td>1.92</td>
<td>0.926</td>
<td>2.31</td>
</tr>
<tr>
<td>Mining</td>
<td>0.885</td>
<td>1.89</td>
<td>0.966</td>
<td>1.97</td>
<td>0.976</td>
<td>1.79</td>
</tr>
<tr>
<td>Rental, hiring and real estate services</td>
<td>0.882</td>
<td>2.10</td>
<td>0.918</td>
<td>1.68</td>
<td>0.931</td>
<td>1.77</td>
</tr>
<tr>
<td>Arts and recreation services</td>
<td>0.937</td>
<td>1.59</td>
<td>0.930</td>
<td>2.05</td>
<td>0.974</td>
<td>1.88</td>
</tr>
<tr>
<td>Information media and telecommunications</td>
<td>0.922</td>
<td>2.01</td>
<td>0.941</td>
<td>2.30</td>
<td>0.929</td>
<td>1.84</td>
</tr>
<tr>
<td>Electricity, gas, water and waste services</td>
<td>0.913</td>
<td>2.09</td>
<td>0.923</td>
<td>1.52</td>
<td>0.960</td>
<td>2.04</td>
</tr>
<tr>
<td>Agriculture, forestry and fishing</td>
<td>0.902</td>
<td>1.96</td>
<td>0.950</td>
<td>1.95</td>
<td>0.991</td>
<td>2.06</td>
</tr>
</tbody>
</table>

**Source:** computed and compiled by the author.
Chapter 7

Policy Implications

7.1 Introduction

The empirical results obtained from five general models, namely standalone input-output, regional econometric, composite, embedded and linked, were provided in Chapter 6. These models were applied to two comparative analyses. First, a dynamic ex-post forecasting experiment where the econometric, composite and four different versions of the embedded model were applied to forecast total and sectoral employment for the out-of-sample period (2011-2012). Second, econometric, standalone input-output, linked, embedded and composite models were applied to an impact analysis scenario of estimating the total employment increase due to a temporary AU$200 million expenditure increase in education and training.

In terms of forecasting total employment the dynamic intermediate approach, followed by the dynamic Illawarra employment demand variable of the embedded model dominated the comparison. In terms of forecasting sectoral employment the composite model dominated the comparison, followed by the dynamic intermediate approach.

Results from the impact analysis, indicated that the professional, scientific and research sector topped the ranking, followed by the administrative services sector and finally construction with respect to their impacts on total output. In terms of the total impacts on income, education and training, health and social services and lastly administrative services sectors dominated the impact analysis, respectively. Finally, the significance analysis of the sectors with respect to total employment multipliers indicated that personal and other services, health and social services and education and training sectors are the top employment producers in the region.
As pointed out in Chapter 6, these results suggest the significance of the spatial linkages among highly skilled labour oriented sectors and provide inference on the economic transition, the shift from heavy industrial manufacturing to highly skilled labour orientation, that is taking place in the Illawarra. The Illawarra economy has witnessed considerable adjustments over the last three decades.

As the results showed the steel manufacturing, mining and engineering sector still plays a significant role. Nonetheless, their role is leveraged by sectors such as finance and insurance services, health and social services, education and training, tourism and retail. The education and training sector plays an imperative role with respect to total employment multipliers. As explained earlier, this is attributed to the University of Wollongong and the Wollongong TAFE. In addition, the Illawarra based primary and high schools are other major institutions in the education and training sector. Among the working age population, 34.6% have completed 12 years of education, 16.9% have received a bachelor degree, and 6.9% have completed either graduate or post graduate qualifications (ABS, 2012). Overall there are 106,220 alumni graduates from the University of Wollongong as of December 2012, of which 39% reside in the region contributing an estimated $447 million in earnings premium to regional annual income (Braithwaite et al., 2013).

Some key issues in the region are as follows. In terms of health care the region faces some issues with respect to rapidly rising demand and lengthy waits for non-urgent and elective surgery. This rise in demand is attributed to two factors that were discussed in Chapter 2. Firstly, it is the growing population as a result of international or interregional migration. There are 288,036 persons as of that last census (ABS, 2011) currently in the Illawarra, up from 279,519 in 2007. This indicates a more than 3% increase in four years. Second, factors relating to the growing ageing population. In addition to that, regional unemployment, in particular youth unemployment, has been higher than the New South
Wales state and the Australian national averages. Regional unemployment presently is at 6.7% (LMIP, 2014), while the national average is 5.6% (Census, 2011; ABS, 2012). There has been an increase in the already high unemployment rate following a recent slump in the steel industry due to the shutdown of one of the two blast furnaces in Port Kembla\(^\text{114}\) as a result of a lack of export demand and a high exchange rate for the Australian dollar resulting in a higher level of imports compared with exports.

The discussion of the major strategies and policies in this chapter is mainly associated with the current relevant economic state of the region. The main goal of the discussion presented in this chapter is to increase opportunities and access to services, training and employment for groups facing employment disadvantage and people adapting to the changing economic base of the region. Nevertheless, applying the models built in this thesis, one can employ several policy variables to investigate additional reverberations in the regional economy as a result of analysing policy handles. Table 7.1 presents an outline of the suitability of each model built in this research for analysis of different policy variables.

<table>
<thead>
<tr>
<th>Module</th>
<th>Category</th>
<th>Equations</th>
<th>Elements Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Econometric</td>
<td>Labour Market Block</td>
<td>4.19 to 4.24</td>
<td>Regional Employment</td>
</tr>
<tr>
<td>Econometric</td>
<td>Demographic Block</td>
<td>4.25 to 4.31</td>
<td>Labour Force, Economic Migration</td>
</tr>
<tr>
<td>Econometric</td>
<td>Wage Block</td>
<td>4.32 to 4.34</td>
<td>Production Costs, Wage Rates, Consumer Price Deflator</td>
</tr>
<tr>
<td>Econometric</td>
<td>Income Block</td>
<td>4.35 to 4.41</td>
<td>Disposable Income</td>
</tr>
<tr>
<td>Econometric</td>
<td>Consumption Block</td>
<td>4.42 to 4.44</td>
<td>Regional Output</td>
</tr>
<tr>
<td>Integrated</td>
<td>Embedded</td>
<td>5.1 to 5.15</td>
<td>Regional and Sectoral Employment</td>
</tr>
<tr>
<td>Integrated</td>
<td>Composite</td>
<td>4.18 to 4.43</td>
<td>Sectoral Output and Employment</td>
</tr>
<tr>
<td>Integrated</td>
<td>Linked</td>
<td>4.18</td>
<td>Total Employment</td>
</tr>
<tr>
<td>IO</td>
<td>IO</td>
<td>4.18</td>
<td>Sectoral Output, Income and Employment</td>
</tr>
</tbody>
</table>

*Source:* compiled by the author based on the models presented in the thesis.

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\(^{114}\) This is explained in detail in Chapter 2.
Moreover, the results from the two experiments in Chapter 6 together with the aforementioned account of economic adjustments taking place in the region give rise to a number of important policy implications. Considering the important role of regions in shaping the national economy, all three tiers, namely, federal, state and local governments need to consider the policy implications to allow for a sound regional economic transition while improving the future economy of the region.

7.2 Implications of the Results

In response to the aforementioned regional economic shifts and results from the economic analyses provided in Chapter 6, the need to foster local business growth, create job opportunities and increase liveability and equitability of the region emerges. This can be done through focusing on four major criteria. The four criteria are taken into consideration in order to provide appropriate policy implications. The first criterion is the resulting value added to the regional economy. As pointed out in Chapter 1 and Chapter 3 the sum of wages and salaries paid to labour, gross operating surplus, and indirect taxes on products and production minus subsidies constitute value added. The sum of value added of all sectors in the region equals gross regional product (GRP). The second criterion relates to the regional output in a given industry, which is the value of goods and services produced by a sector. This was measured by the output multipliers explained in Chapter 6. Income effects of a sector, which are measured by income multipliers, come third. Finally, the fourth criterion is the employment impacts, which relates to the number of full-time equivalent jobs generated by an industry (directly, indirectly and induced). Given the higher than national average unemployment that currently prevails in the region, the last criterion is the most important of the four criteria and requires urgent improvement.

Developing strategies to strengthen the regional economy, and, therefore, increase employment, could entail a number of different policies and emphases. As indicated by the
results from the experiments in Chapter 6 the impact of knowledge generation and the
importance of knowledge incentive centres are key principles in promoting such policies.
Based on the results of analyses in this research, four main policies considered for the
Illawarra economy are as follows:

1) Promote transport and infrastructure
2) Increase expenditure on education and training sector
3) Promote a green jobs action plan
4) Promote the Illawarra as a preferred tourism destination

7.2.1 Promote Transport and Infrastructure

The development of projects and activities that promote transport and infrastructure is a key
priority for the Illawarra with respect to job creation. Promoting transport and infrastructure
will help create indirect impacts on tourism and on facilitating imports to and exports from
the region, which will lead to induced impacts. The importance of transport and infrastructure
promotion has been acknowledged by the Department of Regional Australia (DRA). The
DRA established the Regional Development Australia Fund (RDAF) aimed at providing
funds for regional infrastructure development projects, which will facilitate economic and
community growth (DRA, 2012).

Using the aforementioned fund, three projects, namely, the Port Kembla outer harbour
expansion, Picton Road upgrade (as explained in Chapter 2), and CBD revitalization, have
been approved and are now in the design, completion and construction phases, respectively
(Road & Maritime Services, 2014). Results derived from an impact analysis of harbour
expansion suggest major improvements in shipping and freight services upon its completion
(Telford, 2013). Similarly, road and maritime reports indicate higher safety and reduced
accidents as a result of the 15 individual projects relating to the Picton Road upgrade (Road
Most importantly, Wollongong CBD revitalization is expected to help relocate Sydney jobs to Wollongong and drive economic growth to the region, which will help reduce the unemployment rate. Nonetheless, there are two other critical infrastructure projects that require major attention.

One of the critical infrastructures in need of development is the Maldon-Dombarton Rail Link, which could play a significant role in facilitating freight and coal transport to Port Kembla. Completion of this project could increase employment in construction and could enhance feasibility and thus productivity of import and export freight within the region and the rest of the NSW. In 2011 the Federal Government contributed $25.5 million to prepare detailed designs required for the future construction of the Maldon to Dombarton Rail Link to be recommenced in 2014 (NSW-Transport, 2013). Upon its completion, the freight rail line was supposed to connect Port Kembla to the Main South Line at Picton, which would lead to improvements in industrial transport, expedited logistics of shipments, port activity, and, subsequently, overall development in the shipping and freight sectors in Port Kembla. Nonetheless, a change of federal government in 2013 and the severe budget cuts in various areas, make it unlikely for the project to be recommenced.

Another critical infrastructure is the high speed rail link (HSRL) which is a strategic infrastructure for the Illawarra. Although a national infrastructure project, construction of such a significant project could noticeably increase regional output, regional income and employment according to the multipliers presented in Chapter 6. A survey conducted by the Department of Regional Development Australia (DRDA) indicated that there is increased support from key Illawarra organisations and the community for a high speed rail link to

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115 The significance of the project is because the Botany Port has a capacity of 3.2 million twenty-foot equivalent units (TEU), which is a measurement unit for port services. Nevertheless, the regional import and export productivity has not reached the full capacity of the port and it is forecasted to reach 3.2-million-TEU capacity within the next eight years (NSW-Ports, 2013).

116 This included civil, structural, geotechnical and track works.
connect the region to Sydney and to other major centres along the Australian east coast (NSW-Department of Planning & Environment, 2013). This is because employment in the construction sector is currently 7.9% of the total regional labour force (ABS, 2012). Construction of HSRL would contribute to a significant increase in regional employment as it has a total employment multiplier of 7.5158. The regional support for this project can also be explained by the current rate of regional youth unemployment stagnating at more than 25% for the past 5 years (IRIS, 2013). This is in part due to the economic transition that is taking place in the region as explained in the earlier chapters. This has led to a diversifying labour market faced with a volatile economic base, shifting from traditional sectors of employment. The challenge of high youth unemployment and an ageing workforce is indicative of the need for strategies and policies that would enhance the local employment to develop, support and implement projects to build skills, training pathways and employment outcomes for job seekers and retrenched workers in the Illawarra. In addition to the HSRL, there is also a critical need for an integrated regional transport strategy (IRTS). This strategy helps utilise strategic modelling and the latest technology to ensure public transport services at high levels of standard, for not only businesses but also the senior citizens.

Development of construction projects on either of Maldon-Dombarton Rail Link or high speed rail link would have direct impacts on the following five sectors: non-metallic mineral, basic metals, transport and other, construction, and, finally, administrative. According to the results obtained from the methodologies discussed in Chapter 6, a hypothetical AU$1 million expenditure equally distributed in the aforementioned five sectors would result in the following impacts on total regional output, total regional income, and total regional employment (direct, indirect and induced effects) exhibited in Table 7.2.
### TABLE 7.2
THE TOTAL IMPACTS OF AU$1 MILLION EXPENDITURE ON TRANSPORT AND INFRASTRUCTURE RELATED SECTORS

<table>
<thead>
<tr>
<th>Sector</th>
<th>Total Increase in Regional Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Metallic Mineral</td>
<td>$393,040.00</td>
</tr>
<tr>
<td>Basic Metals</td>
<td>$313,400.00</td>
</tr>
<tr>
<td>Transport and Other</td>
<td>$341,740.00</td>
</tr>
<tr>
<td>Construction</td>
<td>$430,500.00</td>
</tr>
<tr>
<td>Administrative Services</td>
<td>$441,340.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sector</th>
<th>Total Increase in Regional Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Metallic Mineral</td>
<td>$435,860.00</td>
</tr>
<tr>
<td>Basic Metals</td>
<td>$477,040.00</td>
</tr>
<tr>
<td>Transport and Other</td>
<td>$350,200.00</td>
</tr>
<tr>
<td>Construction</td>
<td>$511,880.00</td>
</tr>
<tr>
<td>Administrative Services</td>
<td>$349,620.00</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sector</th>
<th>Total Increase in Regional Employment Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Metallic Mineral</td>
<td>$543,640.00</td>
</tr>
<tr>
<td>Basic Metals</td>
<td>$592,320.00</td>
</tr>
<tr>
<td>Transport and Other</td>
<td>$362,360.00</td>
</tr>
<tr>
<td>Construction</td>
<td>$441,320.00</td>
</tr>
<tr>
<td>Administrative Services</td>
<td>$399,000.00</td>
</tr>
</tbody>
</table>

**Source:** computed and compiled by the author.

#### 7.2.2 Increase Expenditure on the Education and Training Sector

As the results in Chapter 6 indicated, focus on the education and training sector is essential to help the region overcome its traditionally higher-than-average unemployment rate. In order to articulate and deliver a new vision for the future of the Illawarra it is important to foster and support the knowledge sectors in the region. According to the high employment multipliers exhibited in Chapter 6, employment and economic growth can be improved by placing an emphasis on knowledge leadership and to recognize the need for regional leaders with a specialized tertiary knowledge about the key strengths, weaknesses, opportunities and challenges that affect the regional economy.
In order to develop knowledge leadership and research succession in the Illawarra, innovative solutions must be encouraged. Since a large number of business leaders are from the baby boomer generation, they are approaching retirement. Therefore, the need to produce a new generation of business leaders by fostering education and knowledge leadership through innovative ways is becoming more significant. This can be done by developing organizations that support start-ups, alumni services and programs for university students to grow their ideas into practice. This will lead to formation of a new style of business, municipal and community business leadership. In such organizations, it is critical to identify potential high performing leaders in order to enhance regional capacity through regionally focused learning experiences. This will lead to clarifying the role of knowledge leadership in the Illawarra and develop a dynamic network of leaders from the community and business sectors.

The University of Wollongong (UOW) plays a central role in the information and communication technology (ICT) sector within the region. Half of all NSW state graduates are from UOW (Illawarra Digital, 2013) and 14.23% of national ICT graduates come from UOW. In addition, one of the largest university based ICT research institutes in Australia is within the UOW, boasting the reputation of a centre of excellence in telecommunications by the NSW state government. An emphasis on the education and training sector would help develop a digital economy strategy for the region, support entrepreneurship and innovation in the regional ICT sector, providing flexible employment opportunities such as in teleworking and teleconferencing. Shifting the economic focus to education and training will result in improved ICT sector development, which will lead to improved access to important government services; formation of new business and entrepreneurship opportunities in the ICT sector; improvements in health care services accessibility, in-home aged care services and specialist medical care; increase in enrolments in technology courses; improvements in
community cohesion and connectedness, therefore reduced social isolation (Braithwaite et al., 2013).

A strong growth in the tertiary sector has taken place over the last two decades as a result of major workforce restructuring from heavy industry manufacturing and economic transition towards knowledge based sectors. The regional employment in manufacturing sector has declined from 16,000 in 2009 to 12,200 in 2013 and a further 10,600 in 2014 (LMIP, 2014). This indicates a nearly 14% decline in only 5 years. On the other hand, regional employment in the education and training sector has increased from 12,800 in 2009 to 13,500 in 2014, indicating a 6% increase in five years (LMIP, 2014). As the results in Chapter 6 indicate, tourism, education, professional, scientific and financial services industries are predicted to witness high levels of growth. Since the economic base of the region has transformed, effort must be focused to match education and training with the needs of employers and new businesses. In such an economic transformation, organizations that promote small entrepreneurial start-up companies are highly valuable. This is because sponsoring start-ups leads to new opportunities to make training and education available to unemployed and disadvantaged residents in order to prepare them for future employment opportunities. This will result in a growing pool of professional and specialist expertise throughout the region.

The results obtained from the methodologies described in Chapter 6 show that a hypothetical AU$1 million expenditure in education sector would have the following total impacts (direct, indirect, and induced) on regional output, income and employment compensation, as shown in Table 7.3.
### TABLE 7.3
THE TOTAL IMPACTS OF AU$1 MILLION EXPENDITURE ON EDUCATION AND TRAINING SECTOR

<table>
<thead>
<tr>
<th>Factor</th>
<th>Total Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Increase in Regional Output</td>
<td>$2,102,440.00</td>
</tr>
<tr>
<td>Total Increase in Regional Income</td>
<td>$1,457,300.00</td>
</tr>
<tr>
<td>Total Increase in Regional Employment</td>
<td>$1,480,300.00</td>
</tr>
</tbody>
</table>

*Source:* computed and compiled by the author.

#### 7.2.3 Promote Green Jobs Action Plan

As the results in Chapter 6 suggest, and as pointed out earlier in Chapter 2, the Illawarra region is facing unparalleled economic, environmental and social transformations. Regional stakeholders are concerned for the future of the regional economy following the decline in mining and steel manufacturing industries. These declines should prompt a different outlook for employment growth schemes, sectoral development and environmental sustainability.

In order to address concerns about the future direction of the regional economy, it is important to capitalize on potential new markets, green enterprises and a renewable energy sector. A concerted approach for the three LGAs is to promote the formation of green enterprises and to innovate new job opportunities for the university alumni within the renewable energy sector. The focus is to be on binding the technical capabilities of regional ‘green’ enterprises, fostering environmental sustainability in their operations and supporting businesses that are moving toward innovative sustainable technologies.

There is a need for a holistic approach to develop new and emerging industries while adding green value to the existing industries in the region. The aim should be on combining the research and development (R&D) capacity of regional institutions and industries, with the green technologies applied by both existing and new industries. The R&D combined with applicable green technology should cover a range of sectors including construction, engineering, manufacturing, and renewable energy generation. A government fund will be
required to employ projects to take this approach into action and to identify new initiatives to promote an environmentally sustainable future for the region. This will result in environmentally sustainable living initiatives, sustainable construction, environmentally sustainable manufacturing and engineering approach, and, most importantly, new employment opportunities.

Promotion of green jobs action plan would have direct impacts on the following six sectors: basic metals; other manufacturing, electricity, gas & water; construction; professional & scientific services; and education & training. A hypothetical AU$1 million expenditure, distributed equally on the aforementioned sectors, would increase the total regional output, income and employment based on the results shown in Table 7.4, which are obtained from the methodologies described in Chapter 6.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Increase in Regional Output</th>
<th>Increase in Regional Income</th>
<th>Increase in Regional Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Metals</td>
<td>$ 261,166.67</td>
<td>$ 397,533.33</td>
<td>$ 493,600.00</td>
</tr>
<tr>
<td>Other Manufacturing</td>
<td>$ 286,266.67</td>
<td>$ 280,650.00</td>
<td>$ 230,550.00</td>
</tr>
<tr>
<td>Electricity, Gas, Water</td>
<td>$ 293,033.33</td>
<td>$ 327,833.33</td>
<td>$ 337,166.67</td>
</tr>
<tr>
<td>Construction</td>
<td>$ 358,750.00</td>
<td>$ 426,566.67</td>
<td>$ 367,766.67</td>
</tr>
<tr>
<td>Prof &amp; Scientific</td>
<td>$ 368,766.67</td>
<td>$ 354,400.00</td>
<td>$ 387,933.33</td>
</tr>
<tr>
<td>Education and Training</td>
<td>$ 350,406.67</td>
<td>$ 242,883.33</td>
<td>$ 246,716.67</td>
</tr>
</tbody>
</table>

**Source:** computed and compiled by the author.

7.2.4 Promote the Illawarra as a Preferred Tourism Destination

The Illawarra possesses many regional features that make it an ideal tourism destination. Its geographical location, scenic landscapes and physical proximity to Sydney are among the assets that make the region a tourism destination. The Illawarra features a number of beaches, unspoiled bushland and scenic rural villages. There are road, rail, and a number of harbours
as options for access to the region. There a number of options for accommodation ranging from inexpensive backpackers’ hostels, family friendly caravan and camping options, to a few quality hotels and motels.

The region currently features an artistic community, contributing to arts and cultural events, composed of a blend of heritages from around the globe and its own Indigenous communities. The Illawarra has a potential for economic diversification through arts and culture which can be expanded by supporting music and dance schools, performance venues, galleries and arts practitioners. There are currently venues with the capacity to host events seating up to 10,000 spectators, which upon expansion will attract major tours to the region. It is critical to recognise the value of tourism, arts and culture as a key industry in the region. A continuous pursuit of initiatives that promote the region as a tourism destination for holiday, business, and cultural awareness is a key role that the local policy makers can play in revitalizing the regional economy and diversifying the economic focus within the region.

Within this spectrum, activities and projects that promote the region as a preferred conference and events destination, develop necessary infrastructure to foster tourism, and develop strategic arts-based programs would be essential. This will result in increasing the national and international reputation of the region as a preferred place to live, visit or work; new employment opportunities in tourism industries; economic diversification and divergence of emphasis from traditional heavy industry manufacturing to other areas.

Promotion of the Illawarra as a tourism destination would have direct impacts on the following nine sectors: food manufacturing; transport & other services; electricity, gas & water; wholesale trade; retail trade; accommodation, cafes & restaurant; communication services; rental, hiring & real estate; cultural & recreational. A hypothetical AU$1 million expenditure, distributed equally among the aforementioned sectors would increase total
regional output, income and employment compensation according to the results shown in Table 7.5, which are based on the methodologies described in Chapter 6.

### TABLE 7.5
THE TOTAL IMPACTS OF AU$1 MILLION EXPENDITURE ON TOURISM RELATED SECTORS

<table>
<thead>
<tr>
<th>Sector</th>
<th>Increase in Regional Output</th>
<th>Increase in Regional Income</th>
<th>Increase in Regional Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food manufacturing</td>
<td>$215,488.89</td>
<td>$275,266.67</td>
<td>$355,511.11</td>
</tr>
<tr>
<td>Transport &amp; other</td>
<td>$189,855.56</td>
<td>$194,555.56</td>
<td>$201,311.11</td>
</tr>
<tr>
<td>Electricity, gas &amp; water</td>
<td>$195,355.56</td>
<td>$218,555.56</td>
<td>$224,777.78</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>$224,188.89</td>
<td>$221,322.22</td>
<td>$257,933.33</td>
</tr>
<tr>
<td>Retail trade</td>
<td>$227,755.56</td>
<td>$192,333.33</td>
<td>$160,111.11</td>
</tr>
<tr>
<td>Accommodation, cafes &amp; restaurant</td>
<td>$211,222.22</td>
<td>$205,144.44</td>
<td>$166,033.33</td>
</tr>
<tr>
<td>Communication services</td>
<td>$201,966.67</td>
<td>$291,455.56</td>
<td>$278,022.22</td>
</tr>
<tr>
<td>Rental, hiring &amp; real estate</td>
<td>$218,755.56</td>
<td>$244,966.67</td>
<td>$286,977.78</td>
</tr>
<tr>
<td>Cultural &amp; recreational</td>
<td>$220,344.44</td>
<td>$230,644.44</td>
<td>$201,811.11</td>
</tr>
</tbody>
</table>

*Source:* computed and compiled by the author.

7.3 Issues, Opportunities & Challenges

This section presents an overview on the issues and opportunities associated with infrastructure, training, land policy and some regulatory constraints that have been identified in the region. It is a critical task for local, state and federal government agencies to address these areas for regional planning. This section also suggests some proposed innovations that aim to increase business development in the Illawarra.

As noted in the previous sections, certain sectors such as health and social assistance, tourism, financial and insurance services, and education have recorded steady employment growth in the past 2 decades. Nonetheless, employment in traditionally strong sectors of
manufacturing and heavy industry based sectors has been in a sharp decline, in particular after BlueScope’s redundancy of 800 full-time employees. This is in addition to the indirect employment effects from these structural changes. Skilled jobs are being lost while part time and less skilled jobs are being created. The population in the Illawarra SA (Illawarra economy) is nearly 300,000 (290,616); a region large enough to cushion the impacts of manufacturing sector employment decline; not only because of the growing population but also due to the current diversified and dynamic nature of the regional economy. The regional population growth and the ongoing transformations in the regional economy can mitigate the impacts of declining sectors by formation and improvement of new sectors. The recently booming sectors such as construction, education, health care, retail and tourism are currently noted as the largest employers in the region. These sectors are central to shaping the future economic structure of the region by placing an emphasis on innovation and technological advancement and a focus on creating skilled jobs.

7.3.1 Infrastructure

There has been considerable debate by Wollongong City Council over the need to upgrade, replace and develop new infrastructure in the area. How to finance this is a big challenge for local government in the region. The most critical elements of infrastructure in the Illawarra are as follows.

I. Port Kembla

One of the most integral components in the region to attract shipping related businesses is the port located at the southern district of the region, Port Kembla. There have been a number of reports and analyses identifying this port as a major asset for the region117 (NSW-DII, 2010; SGSEP, 2010). More than 15 years ago, Cooper & Lybrand (1997) suggested that programs

117 However this has now been privatised.
be implemented to develop the port and advance its infrastructure. Along the same lines, Buchan (2003) asserted that programs to improve the port would help increase the efficiency of the port with the objective to utilize the port to its full potential. Port Kembla has the potential to draw on high scores of port related businesses provided that a systematic plan of action is taken in terms of its development and expansion (NSW-Department of Planning, 2007).

II. Maldon-Dombarton Rail Line

The LGA embarked on construction of the Maldon Dombarton rail line in 1983 upon approval of a recommendation that was received in 1979. The project was annulled in 1988 following a cost-benefit analysis (ACIL, 2011). Yet the potential benefits of funding the project have been in discussion by the region’s economists for nearly thirty years (WCC, 2013). This project plays an integral role in linking Illawarra to south-west Sydney, which could result in a significant contribution to the regional economy (Cooper & Lybrand, 1997; Connell Hatch, 2009). The latest report by the Federal Government estimates the cost of the Maldon Dombarton construction in the range of AU$100 to AU$150 million according to the Illawarra Business Chamber (NSW-Business Chamber, 2012).

III. Road Upgrade

The Picton Road is an important element in the regional infrastructure and transport structure. The Picton Road is a highway in New South Wales, linking Picton and Wollongong. It provides an important link between the Hume and Southern freeways. The highway runs from Picton, crossing the Hume Highway and passing through Sydney Water Catchment areas, to Mount Ousley Road (Southern freeway) which leads to Wollongong or Helensburgh. The upgrading project is intended to link Mt Ousley Rd to the Sydney Orbital network via the Hume Highway. This would help boost regional economic development by
facilitating transportation and commuting network for interregional freight and employment, respectively. The additional traffic generated as a result of current and planned expansion of Port Kembla, makes this project a high priority. The Illawarra economy is directly dependent on the Western Sydney economy because of the complementary nature of their industry. Picton Road is heavily used as the quickest road link between these two locations, but the heavy traffic on Picton Road compels motorists to use the Appin Rd instead. The upgrading project solves the traffic issue by opening the Appin road for passenger vehicles while preserving the Picton road for heavy duty trucks (NSW-Business Chamber, 2012).

7.3.2 Commuting Services

I. Public Transportation

It is estimated that an upgrade to the rail line between Wollongong to Sydney would reduce travel time by 15 minutes. Around 20,000 people use this rail line on a daily basis to commute between Wollongong and Sydney yet there is a noticeable cost associated with this rail line due to its capacity constraints and low reliability (NSW government, 2012). The inadequate qualities of the rail line causes people to use personal vehicles to travel to Sydney which results in an increase in greenhouse gas emissions and traffic congestion, and a decrease in road safety. Improvements to the rail link would also bring about benefits to both the tourism and housing industries. Reducing the travel time would facilitate more visitors coming for sightseeing and tourism attractions (Fuller, 2012; Herron Todd White Residential, 2014). It would also be a magnet for potential residents who work in Sydney to seek lower housing costs and a quieter lifestyle.

II. Illawarra Regional Airport

Located at Albion Park Rail, the Illawarra Regional Airport (IRA) was first established as a Royal Australian Air Force (RAAF) training base during WWII (IRA, 2012). The Australian
aviation industry has endured considerable changes as a result of major airlines shifting to low cost business models to compete with new international market entrants that offer lower cost air travel (IRA, 2012). Moreover, as a result of recent changes, the focus is now on servicing regional airports which provides an opportunity for IRA to operate routine passenger flights. It is argued that frequent interregional passenger flights would promote the regional economy (IRA, 2012). Nevertheless, this has been tried quite frequently in the past and proven not to be successful.

As a passenger terminal, the last passenger flights from IRA were conducted between Illawarra and Melbourne by Qantas link in July 2008. Cox (2008) suggests that the latest cancellation was due to lower patronage levels than expected and high fuel prices leading to a lack of profitability. Nonetheless, SCC (2012) argues that overall the service had experienced good levels of patronage on its flights. There was a proposal for IRA expansion during the period in which the Qantas link Melbourne route was in service. As part of the proposal for greater flight services the Illawarra Business Chamber (NSW-Business Chamber, 2012) argues that IRA should be moved to a location further south, to prevent affecting nearby residential areas if the expansion plan is to be implemented.

7.3.3 Improvement of Industrial Land

The Illawarra is land scarce due to its narrow coastal plain location between the sea and the Great Dividing Range (the Illawarra Escarpment). The NSW-Department of Planning & Environment (2013) estimates Illawarra’s population to increase by 47,600 by 2031. Regional analysts have suggested an urgent need to develop a regional industrial land strategy to ensure the timely availability of serviced industrial land to support the expansion of business and attract new enterprises to the region (Buchan, 2003; NSW-DII, 2010; WCC, 2013). A greater area of land is required to accommodate the expected growth in both the manufacturing sector and services sector and also to fulfil housing needs over the next 25
years. Nevertheless, this type of land use would be at odds with the development of boutique agriculture products mentioned earlier.

7.3.4 General Challenges

There are four noticeable challenges that the region must grapple with; population; industrial and community; resources; and the environment. The challenge of population relates to accommodating a large proportion of the greater metropolitan area population growth in the next 20 years. Infrastructure planning must deal with both the existing infrastructure logjam as well as the needs of a growing population and workforce.

The institutional and community challenge relates to the improvement of cooperation, coordination and collaboration between government agencies, local governments and the private sector organizations in charge of planning, maintenance and development of economic infrastructure. New partnerships and deep levels of interaction between stakeholders are necessary; particularly to ensure that community expectations are continuously recognised.

The challenge of resources is about improving the efficiency and effective returns of major infrastructure investments. Once more, better coordination, cooperation and integration between agencies and innovative public-private partnerships are required. Finally, the environment challenge is about management of natural resources and assets for current and future generations whilst concomitantly increasing economic outcomes. In this fashion, sustainable ecological principles are inseparably linked with the economic development of regions.

7.3.5 Service Sector Development

The Illawarra is perceived to be a good place to live, work and visit, owing to the effectively conducted ‘Image Campaign’. Buchan (2003) advocated that there is a potential to extend
this campaign to cover commercial areas in order to prompt business attraction. A campaign to promote regional industry attraction has also been suggested by other reports prior to that of Buchan’s (2003) (NSW-DII, 2010; WCC, 2013). The design of a website and development of a centre for identifying commercial land availability in the region would also benefit and promote Wollongong as a major regional centre for services, business, and quality health and education facilities (Buchan, 2003).

7.4 Summary and Conclusions

This chapter has provided implications of policy based on the empirical results and performance of the five different methodologies applied to model the Illawarra economy in the previous chapter. The basis for the policy implications provided in this chapter is the fact that Wollongong, the major city of the Illawarra and the traditionally known ‘Steel City’, has become a city of innovation, shifting its economic focus from coal and steel to global export of knowledge, and Information and Communication Technology (ICT) (NSW- Department of Planning & Infrastructure, 2013). In this regard, there are four major areas that require attention: transport and infrastructure; education and training sector; promotion of a ‘green’ economy; and promotion of the regional tourism industry. A summary of the results of the total impacts of each policy implication on the regional output, income and employment compensation is provided in Table 7.6, followed by a summary of policy implications and their related activities discussed in this chapter in Table 7.7.

In Chapter 8, a summary the major findings of the thesis are provided along with concluding remarks. We also shed some lights on future directions and areas of improvement for this research in Chapter 8.
## TABLE 7.6
SUMMARY RESULTS OF THE TOTAL IMPACTS OF EACH POLICY IMPLICATION ON THE REGIONAL ECONOMY

<table>
<thead>
<tr>
<th>Economic Activity</th>
<th>Total Impacts on Output</th>
<th>Total Impacts on Income</th>
<th>Total Impacts on Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promote transport and infrastructure</td>
<td>$ 1,920,020.00</td>
<td>$ 2,124,600.00</td>
<td>$ 2,338,640.00</td>
</tr>
<tr>
<td>Increase expenditure on education and training sector</td>
<td>$ 2,102,440.00</td>
<td>$ 1,457,300.00</td>
<td>$ 1,480,300.00</td>
</tr>
<tr>
<td>Promote green jobs action plan</td>
<td>$ 1,918,390.00</td>
<td>$ 2,029,866.67</td>
<td>$ 2,063,733.33</td>
</tr>
<tr>
<td>Promote the Illawarra as a preferred tourism destination</td>
<td>$ 1,904,933.33</td>
<td>$ 2,074,244.44</td>
<td>$ 2,132,488.89</td>
</tr>
</tbody>
</table>

*Source*: computed and compiled by the author.
<table>
<thead>
<tr>
<th>Actions</th>
<th>Outcome</th>
</tr>
</thead>
</table>
| Promote transport and infrastructure             | • Regional infrastructure projects will be funded through the Regional Development Australia Fund (RDAF).  
• Strategic infrastructure will be highly developed in the region.  
• Regional infrastructure needs will be met.  
• Economic and community development objectives will be achieved.  
• More jobs will be created for the construction projects. |
| Increase expenditure on education and training sector | • There will be robust, educated and well-connected regional leaders.  
• Research & development succession plan with a pool of leaders in training.  
• Close collaboration between the business and community sectors and all levels of government.  
• The region will have a new generation of more knowledgeable business leaders.  
• Economic diversification with resilience to survive external market fluctuations such as GFC.  
• A new job-ready workforce with a range of skills and abilities.  
• A region with adequate communal enterprises to provide employment opportunities for the disadvantaged. |
| Promote green jobs action plan                    | • The region will be engaged and active in environmentally sustainable initiatives.  
• There will be environmentally sustainable “Green Street” which showcases sustainable living initiatives.  
• There will be new education and skills training opportunities.  
• There will be new sectors and thus more employment opportunities.  
• There will be sustainable iconic buildings retrofitted within the Illawarra.  
• There will be sustainable environmental changes in manufacturing and engineering sectors. |
| Promote the Illawarra as a preferred tourism destination | • Improved national and international profile of the Illawarra as a tourism destination.  
• New tourism businesses will emerge.  
• Economic diversification with less reliance on heavy manufacturing sectors.  
• Increased employment opportunities. |

*Source:* compiled by the author.
Chapter 8

Conclusions

8.1. Introduction

This thesis has presented a research on theory and practice of integrated IO-EC modelling at the regional level of analysis. The focus was directed towards an analytical investigation of the properties of different integration strategies as well as the empirical application of these different models to the Illawarra economy and a comparison of their simulation and forecasting capabilities. In this final chapter a summary of the main findings is canvassed, followed by a discussion of the implications of these results for the practice of regional integrated modelling and some promising directions for future studies. As explained in Chapter 1 and Chapter 2, regional economies play an important role in shaping and prospering national economies. On that note there are several regions around the world that, similar to the Illawarra, are in an economic transition as a result of globalization. Such regions go through structural adjustments as an aftermath of shutdown of major businesses and consequently decline of certain industries that once played a key role. In such economic transformation, an accurate regional analysis can lead to effective regional planning and therefore, issuing policies and creating economic activities that turn the direction of transformation on a sustainable, smart and competitive path.

The investigation in this study indicated that regional economists face two major challenges in developing a regional economy in the post-globalization era. First, is the need for sustainability and equitability while retaining the essence of economic competitiveness. The second important challenge is to develop and apply models to direct regions on a rapid track to support knowledge sectors, adapt to change, be flexible to change, and create industry clusters for competitive advantage. Future direction of regional economic
development will require advancement of additional analytical tools to support regional analysis, management of structural change and flexibility in the creation of competitive advantage.

As discussed in Chapter 1 and Chapter 3 the traditional tools applied alone deficient in accurately analysing complex, dynamic and highly interdependent regional economies. Therefore, the need for innovation and advancement of traditional tools rises in order to meet the aforementioned complex challenges. As the global economy is advancing, national and regional economies are becoming intertwined; industrial linkages are gaining importance in analysing and managing structural changes. As the focus in regional economies is shifting towards competitive advantage, inter-industry linkages alter. Management of such changes and the flexibility to adjust the focus of regional economic activities accentuate the need for analysing the direction and magnitude of structural changes and creating competitive advantage.

Having said that, two of the most popular analytical tools used in regional analysis and economic forecasting, namely, IO and EC, were integrated in this study to investigate the Illawarra economy. In the text that follows the major empirical findings, policy implications, contributions and limitations of the study and the future direction of such studies are presented.

8.2. Summary of Major Empirical Findings

Having examined several practical and methodological issues in the course of this thesis, to summarize, the findings can be placed into one of the following four broad categories: a) the application of integrated econometric and IO models at the regional scale; b) the development of three strategies to integrate econometric and IO models for the Illawarra region; c) the
measurement of multipliers in integrated models and d) the comparative performance of different integration approaches.

With regard to properties of alternative integration methodologies, the composite approach dominates the other two approaches when the objective is forecasting sectoral employment. Nonetheless, the composite approach does not retain the same superiority when the objective is on forecasting aggregate employment. This approach is highly data intensive and, as the results show, there is not a direct relationship between the complexity of this approach and its performance. Hence, the trade-off between the cost of developing the model and its performance appears to be ambiguous. In an overly diversified economy where inter-industry structure is highly developed and endogenous forces are dominant in structuring the economy, and data availability is not an issue, the composite approach appeared to be more effective for forecasting than the other two approaches. With respect to impact analysis the impacts are more fully spread across industries within a regional economy. The estimated impacts also tend to vary less across industries. Thus, when a detailed view of the distributional effects across industries is important, the composite approach is more suitable.

The embedded approach is more favoured for less diversified economies, where inter-sectoral structure is not fully developed and the regional economy is shaped by exogenous forces. With respect to impact analysis the embedded approach generates estimated impacts that are highly varied and concentrated in specific industries within the region.

The linked approach has an inherent flaw of increased overestimation of the impacts. In cases where a qualitative comparison of the results from different scenarios are analysed, using the linked approach appears to be effective. Nonetheless, use of the linked approach as a basis for estimating the quantitative policy impacts is not recommended, until further research and improvement is made in this regard to address the overestimation problems.
A plethora of integration strategies for regional analysis tools have been developed since the inception of regional science as a field, yet a comparison of the fundamental properties of the different approaches towards integration has not been addressed. In integrating IO analysis and econometric modelling there are two critical factors worth the modeller’s attention: a) integration regime and b) integration structure.

The integration regime defines the approach and the extent to which IO components and econometric components are combined. The integration approach can be mathematically recursive or simultaneous, while the extent of the integration relates to the number of conjunctures that occur between the two models which in turn is a function of the level of sectoral and spatial aggregation of the two models.

The integration structure is about applying the numerical account and the mathematical algorithm to run the model. Two main approaches are identified for this phenomenon: composite and modular. A composite structure combines selected components of the two models in a series of linear and/or nonlinear equations. In contrast, a modular structure solves the two models separately before their components interact with one another.

8.3. Policy Implications

As economic transformation is taking place in the Illawarra economy the focus is shifting from heavy industry manufacturing to highly skilled labour and knowledge sector orientation. Therefore, it is required to create economic activities that escalate the growth of knowledge and innovation related sectors and create jobs for the skilled labour, in order to address such a shift. The four broad area of focus on policy implications centre on activities that promote transport and infrastructure, increase expenditure on education and training sector, promote green jobs action plan and promote the Illawarra as a preferred tourism destination.
The economic policies and programs need to focus on employment growth and job diversity, addressing the shift to high skilled labour and innovation orientation. It is also critical to develop the economic base of the region through increasing the institutional linkages, inducing location factors and improving the regional infrastructure. To summarize the policy framework suggested for the Illawarra, it was decided to suggest a movement supported by Blakely (1994). There can be two dimensions to the Illawarra economic development, sectoral economic dimension and spatial policy dimension. General economic policies, sectoral policies, and structural policies can be categorized under policies that focus on general economic development. Economic policies that impact on regional economy, structural policies that indirectly support certain sectors, and regional structural policies and local business assistance can measure the implicit spatial dimension of policy. One the other hand, regional policies, regional development policies focused on certain sectors, local economic development at the sectoral level and finally firm and plant specific structural policies measure the explicit dimension of policies. Table 8.1 summarizes the aforementioned classification of policies.

### Table 8.1
**Process of Regional Economic Development**

<table>
<thead>
<tr>
<th>Sectoral Economic Dimension</th>
<th>Spatial Dimension Of Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Industrial Policy</td>
<td>None</td>
</tr>
<tr>
<td>General Economic Policies</td>
<td>Economic Policies with Regional Implications</td>
</tr>
<tr>
<td>Some Sectors Supported Indirectly (e.g. Steel, Agriculture)</td>
<td>Sectoral Policies</td>
</tr>
<tr>
<td>Industrial Supports</td>
<td></td>
</tr>
<tr>
<td>By Sector</td>
<td>Structural Policies</td>
</tr>
<tr>
<td>By Firm/Plant</td>
<td>Non Existent</td>
</tr>
</tbody>
</table>

*Source*: configured by the author.
Also, as discussed in Chapter 2, there is a new wave of regional economic development that is replacing the old regional economic development. As supported by Blakely (1994), under the former economic development process policy makers focused on growing employment by increasing the number of firms, whereas under the new process, the strategy should be focused on creating firms that build quality jobs that match the local population. With respect to the development base, policy makers should emphasise building new economic institutions instead of economic sectors. Policies should highlight the essence of competitive advantage based on a quality environment to measure location assets and focus on knowledge as the main economic generator instead of the available workforce. Table 8.2 summarizes the regional economic policy process suggested above.

<table>
<thead>
<tr>
<th>Component</th>
<th>Old Concept</th>
<th>New Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment</td>
<td>More Firms = More Jobs</td>
<td>Firms That Build Quality Jobs That Fit The Local Population</td>
</tr>
<tr>
<td>Development Base</td>
<td>Building Economic Sectors</td>
<td>Building New Economic Institutions</td>
</tr>
<tr>
<td>Location Assets</td>
<td>Comparative Advantage Based On Physical Assets</td>
<td>Competitive Advantage Base On Quality Environment</td>
</tr>
<tr>
<td>Knowledge Resource</td>
<td>Available Workforce</td>
<td>Knowledge As Economic Generator</td>
</tr>
</tbody>
</table>

*Source: configured by the author.*

### 8.4. Contributions of the Study

This thesis presents a stepping stone towards the construction of an IO-EC model for the Illawarra region of New South Wales. We have examined the theory and practice of the integrated IO-EC framework at the regional level. The integration framework is applied to determine the functionality and accuracy of integrated modelling in comparison with the traditional IO modelling. Although the sectoral disaggregation and dynamic advantages of IO and econometric models are combined in the integrated framework, the integrated model is
still demand driven. Several methodological issues have been analysed in the course of the main research.

The key objective of this research has been to examine the properties of integrated IO-EC models for regional analysis. In this respect the study has contributed to the examination of the relative strengths and limitations of the different strategies for integration. Some methodological issues have been addressed; it is also useful to summarize three particular conclusions which would appear to have the most direct essence on the application of the integrated framework.

Perhaps the second most important conclusion is the superior simulation accuracy of the integrated models as a class compared to the traditional econometric approach. This is mainly reflected on the use of a priori information in the integrated approaches which, as discussed in Chapter 5, decreases the variance of the resulting estimates. Nevertheless, if the a priori information is erroneous, then the restricted estimators\textsuperscript{118} would be biased. The superior performance of the integrated framework is contingent on reduction of variance by using the a priori information. As long as the a priori information applied in the integrated model is free from substantial errors, performance of these models would be superior over the traditional models.

Within the family of integrated methodologies the choice of merging methodology is not of the same magnitude as the choice between an integrated model and a standalone model. Applying an embedded model for forecasting experiment was found to be relatively easier and less complex compared to the composite methodology. The theoretical reasoning for this comparative convenience was provided in Chapter 5 by interpreting the different embedding structure with respect to their components. An analysis of the structure of the methodologies

\textsuperscript{118} As well as the coefficients in the integrated models.
using alternative merging methodologies indicated the similarity among regional and national models and provided more clear interpretations of the intermediate demand variables (IDV).

As mentioned in Chapter 6, the results of the forecasting and industry significance analysis indicate a wide variation between performances of each model. This suggests that selecting one methodology to integrate IO and econometric should be based on the specific policy analysis or forecasting requirements of a given application. Therefore, the results brought forward in the earlier chapters indicate a good measure of the advantages and drawbacks of each methodology applied to any given region.

**8.5. Limitations of the Study**

Implementation of an integrated framework at the regional scale is inevitably a strenuous effort. The central task to carry out was construction of the econometric modelling and IO table for the regional economy. Data collection, availability and accuracy of data at the regional scale are significant undertakings at this step.

A second important limitation relates to the role of spatial effects in the specification of the regional econometric model for the Illawarra. Due to the lack of data availability, spatial heterogeneity and spatial dependence were neglected in this study. As a result the simulation and forecasting performance did not yield highly superior results relative to state-level studies that incorporate these spatial effects in the literature. This outcome does not infer that these spatial effects are ubiquitous, because the findings are of course particular to the Illawarra space economy. Nevertheless, this indicates that ignoring spatial effects when they are present may result in inferior modelling performance. At this time, in several prominent operational integrated models (Harris & Nadji, 1987; Treyz, 1993; Motii, 2005) spatial effects are omitted. This omission is based not on the results of rigorous testing for the
presence of spatial effects (Anselin & Hudak, 1992), but instead the untested assumptions of spatial homogeneity and spatial independence.

**8.6. Areas for Further Research**

There are three main parts that require attention for future research: methodological, practical and theoretical improvements.

**8.6.1 Methodological Improvements**

The first methodological work would be a study on employing a Bayesian methodology for embedding the IO module into the econometric framework. The advantage of Bayesian methodology is the enhanced measurement of error in a priori information. The second methodological work would be employing Folmer (1986) tools. Folmer (1986) methodologies are acceptable for the embedding methodology when the accuracy of regional input-output coefficients is unknown.

Furthermore, designing a set of tests to pinpoint potential sources of misspecification in all the models would be advantageous. Such tests can be applied either partially, i.e. testing one industry and the rest of the economy, or overall, i.e. testing the whole economy.

**8.6.2 Practical Improvements**

From a practical perspective, assimilating the econometric equation, the IO identities and the integrated model into a geotechnical and land-use model would of added advantage. Specifically, it would be useful to code the model equations in a language and apply it to a more user-friendly domain. This would help make the model more popular, similar to IMPLAN, which will result in more marketability and higher demand with respect to forecasting and impact analysis projects.
8.6.3 Theoretical Improvements

Similar to the future methodological directions, there are several areas of future theoretical improvements on these models. Areas such as extending the econometric model, incorporating more blocks, fine-tuning the models, including more variables, and developing decomposition tools would all contribute to higher accuracy of the model. Conducting comparative analysis between embedded methodology, composite methodology and CGE would certainly entail a plethora of interest and attention.


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