Development of Integrated Intersectoral-Time Series Strategies to Investigate the Economic Significance of Knowledge Sectors in the Illawarra, New South Wales

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Abstract

Integrating input-output (IO) analysis and econometric model has become increasingly popular for it combines the advantages of both models (Isard & Anselin, 1982; Moghadam & Ballard, 1988; Beaumont, 1990; Coomes et al., 1991; West, 1991; Treyz, 1993; Israilevich et al., 1996; Rey, 1998; Motii, 2005). There are a number of strategies through which an IO analysis is merged with an econometric model. This paper examines two strategies to build an integrated input-output econometric (IO-EC) model, namely coupling and holistic embedding, from both theoretical and practical perspectives. Each strategy is analysed based on their simulation and forecasting performance. Both strategies are applied to investigate the economy of the Illawarra region of New South Wales, Australia. This paper conducts a series of ex-post forecasting experiments. Each strategy is examined based on their forecasting performance and the accuracy of their impact analysis. Each strategy is applied to a hypothetical scenario of increased government expenditure on knowledge sectors, to investigate their significance in terms of sectoral employment, value added, income, and gross regional output.

JEL Classification: R15, C 53, C67.

I. Introduction

Forecasting the time path of economy and sectoral impact analysis are the cornerstones of economic policymaking. Nevertheless, a number of economists argue that the most effective
empirical methods for forecasting and impact analysis, respectively, econometric modelling and IO analysis, have restrictive assumptions when applied alone (Beaumont, 1990; West, 1991; Israilevich et al., 1997; Rey, 1998; Rey 2000; Rickman, 2001; Rey et al., 2004; Motii, 2005). A standalone IO model provides a detailed snapshot of the intersectoral interactions within an economy (Miller & Blair, 2009); nevertheless, it is argued to be static and deterministic (West, 1991; Israilevich et al., 1997; Rey, 1998). In IO analysis exogenous shocks to the economy are traced from final demand to intermediate and primary inputs; albeit, there is no feedback channel from primary inputs to final demand if the changes stem from e.g. impact of shifts in tax levels on government expenditure (West & Jackson, 1998; Rey, 1998). This static characteristic along with the constant average employment are argued to hinder the performance of forecasting structural shifts within the economy (Moghadam & Ballard, 1988; Conway, 1990; Coomes et al., 1991; West, 1991; Rey 1998; Motii, 2005).

On the other hand, econometric models feature dynamic characteristics by tracking the time path of the industrial variables and structural shifts over time (Rey, 1998; West & Jackson, 1998; Rey, 1998). Nonetheless, econometric modelling appears to be exiguous on a twofold basis. Firstly, it does not provide a detailed snapshot of the intersectoral transactions and secondly, a consistent time series data is hardly available to run the model at the regional level (Israilevich, 1997; Rey, 2000).

As a result, many economists believe that these two dominant methods should be integrated into a single model (Moghadam & Ballard, 1988; Beaumont, 1990; Israilevich et al., 1997; Rey, 1998; West & Jackson, 1998). A variety of methodologies have been employed to incorporate the detailed inter-industry relationships into the dynamic time series of the economy (Moghadam & Ballard, 1988; West, 1991; Conway; 1990; Rey, 1998; Motii, 2005). The main objective of the integrated framework is to combine the detailed sectoral disaggregation of the IO analysis with the dynamic features of the econometric modelling, to
improve the forecasting performance and increase the accuracy of the impact analysis (West, 1995; Rey, 1998; Rey, 2000; Motii, 2005). In early attempts, IO models and econometric models were simply linked or conjoined (L’Esperance et al., 1977; Stevens et al., 1981; Kort & Cartwright, 1981; Kort et al., 1986; Lienesch & Kort, 1992).

However, as the integration framework has developed, so have the innovative strategies that either embed the IO coefficients in regional econometric models (Moghadam & Ballard, 1988; Coomes et al., 1991) or couple the two models (West, 1991; Treyz et al., 1992). In his original “integrated multiregional model for systems of small regions” Rey conceptualized taxonomy of strategies in which IO analysis and econometric models relating to particular regions could be integrated to achieve a comprehensive modelling framework (Rey, 1994). Some researchers also used the IO coefficients as guidance in specifying equation of vector auto-regression (VAR) models (Fawson & Criddle, 1994). Moreover, a few researchers have incorporated IO linkages into Bayesian vector auto-regression (BVAR) forecasting models (Magura, 1990; LeSage & Magura, 1991; Partridge & Rickman, 1998).

The focus of this paper is on two of the most popular integration strategies, namely coupling and holistic embedding. Each strategy has been applied separately to one location; however, except for Rey (1998) multiregional research on southern California, no studies have been found to apply both strategies to one region and compare their results. As a result, this paper addresses the twofold gap which appears in the literature. Firstly, we do not know how each integration strategy works in a region with characteristics of Illawarra, such as economic transition and transformation of the economic structure from heavy-industry dependence to reliance on knowledge sector. This paper fills in this gap by applying both integration strategies to investigate the structural shifts in the Illawarra economy. Secondly, we do not how the results of the two integration strategies compare when applied to one region. We address this shortcoming in the literature by comparing:
I. The performance of each strategy, subject to cost and data availability.

II. The results of forecasting and impact analysis of each strategy with a standalone IO analysis of the Illawarra.

This paper leads the way for future studies using an integration framework with a view to building models that fit a more diverse range of applications. Using the two integration strategies, IO components of final demand, export, and sectoral linkages are incorporated into forecasting equations.

II. The Region

Due to globalization and structural adjustments over the last five decades, regional economies have become paramount factors in shaping national economies. A new global environment of floating exchange rates, financial deregulation and globalization of capital markets has taken place over the last half a century. Consequently, the developed nations have entered an increasingly intricate and competitive global economy and in turn, the impact of regional economies on national economies has become vital in forming the dichotomy between the successful and the unsuccessful national economies (Stimson et al., 2007). Since four decades ago nearly all member states of organization for economic co-operation and development (OECD) have witnessed major economic and social shifts (Stimson et al., 2007). These structural shifts indicate the fast pace of technological advancement, importance of knowledge sectors, capital market deregulation, and increased overseas trades (Langworthy et al., 2009). Old industrial regions such as the Illawarra and New Castle in Australia; Lille in France; Liverpool in the UK; and Cleveland, Detroit and Pittsburgh in the US have declined or witnessed structural economic shifts as a result of globalization (Stimson et al., 2007). Regions such as the Illawarra in Australia and Waterloo, Ontario in Canada
have adopted global learning skills and cross training labour characteristics and they heavily rely on skilled labour to adapt to the impact of globalization.

The importance of choosing the Illawarra as a region in this research is reflected in two paths. Firstly the Illawarra regional economy plays a key role in the context of the Australian economy, which is discussed in the following paragraph. Secondly, what adds to the significance of this study in terms of its pertinence to the global context is the application of the methodology in this paper to regions outside Australia, that have the characteristics similar to those of Illawarra’s. The emphasis on the Illawarra’s economy has shifted from heavy industry, steel manufacturing and mining to knowledge sectors and technological advancement, being regarded as city of innovation. This research is applicable to regions with demographics and economy size commensurate with the Illawarra, regions that have adapted to structural shifts in the past five decades as a result of globalization and increased level of competition, and regions that are in a transitional process of economy as a result of structural shifts.

The Illawarra contributes considerable resources to the economy of Australia as it is a leading grain and coal exporter. Until recently, it boasted the largest plant for steel production in the southern hemisphere (IRIS, 2008). The Illawarra was nationally acclaimed for metal fabrication and engineering. It is the centre of excellence in research and development (IRIS, 2008), playing an integral role in technological advancement. Livestock, maritime enterprises, and wood are among the region’s major resources 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, 2011) the Illawarra statistical
division has an unemployment ratio of 6.7%. With a population of 436,117 people this indicates that nearly 30,000 of the current labour force are unemployed. The geographical scope of this paper however encompasses the Regional Development Australia, Illawarra (RDAIlIlawarra, 2009) coverage area, also known as the economy of Illawarra (ABS, 2011), which consists of the three local government areas (LGA’s) of Wollongong, Shellharbour and Kiama. The estimated population of this area was reported 292,190 people in June 2010, up from 269,597 in June 2001 (ABS, 2011).

**III. Theoretical Objectives of Integration**

There are numerous objectives for combining IO and econometric models, of which several have already been alluded to in earlier sections, and arise from both theoretical and pragmatic perspectives. One of the theories about the theoretical benefit is that the integrated model offers the potential for a disaggregated general equilibrium framework that captures market interactions at the sectoral level and thus is considered a closed model involving the simultaneity between supply and demand (Preston, 1975; Chowdhury, 1984). However, the objection to this theory is that both econometric modelling and IO analysis are demand-driven models. As a result combining them does not completely integrate supply and demand (Beaumont, 1990; Rey, 1998).

Nonetheless, the main theoretical objective of the integrated modelling discussed in this paper is to reduce the static and linearity restrictions of IO analysis by superimposing an IO model into a dynamic econometric framework. In IO analysis, household sector contains many large coefficients and is the main component where the highest constant returns to scale is evident (Stevens & Treyz, 1983; Moghadam & Ballard, 1988; Coomes *et al.*, 1991; West,

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1 The Illawarra statistical division contains Wollongong sub-statistical division (SSD) – also known as economy of Illawarra (RDAIlIlawarra, 2009), Wingecarribee SSD and Shoalhaven SSD; and the economy of Illawarra (aka Wollongong SSD) is composed of Wollongong local government area (LGA), Shellharbour LGA, and Kiama LGA.
Albeit in an actual economy, an increase in sectoral output is not necessarily an evidence of a corresponding increase in sectoral labour inputs. Hence changes in income and household expenditure are to be estimated more realistically as functions of output and should track the economy better upon integrating dynamic elements of econometric.

The setback of a regional econometric model is the lack of interconnectedness of the economic structure for impact analysis (West, 1991). A regional econometric model is a set of stochastic behavioural and deterministic identifying equations that represent the important components of a region’s economic and demographic features (West, 1995). A typical model includes equations for demographic processes, industrial employment, output, wage determination, non-wage income, labour market dynamics, and sometimes state, local and federal government expenditure and revenues (Rey, 1998).

**IV. Applied Objectives of Integration**

From an applied approach, there are a number of advantages that an integrated framework can offer. Firstly, the integration process is a tool for further disaggregating the standalone econometric model to generate more accurate results in impact analysis. The importance of this feature is justified because an aggregated IO analysis commonly generates direct effects that are biased and different from the aggregated estimates that are generated by a disaggregated IO analysis (Stevens & Lahr, 1992; West & Jackson, 1998; Rey, 1998). Secondly, combining the IO with the econometric model will result in greater consistency in the treatment of the elements of the final demand vector (L’Esperance, 1981; West, 1991; Rey, 1998; Motii, 2005). A third objective of the integration is the improvement in specifying the econometric equations by conjoining the IO relations in order to enhance the
effectiveness of the estimation of econometric parameters (West & Jackson, 1998; Rey, 1998).

i. **Impact Analysis**

Combining the two models has resulted in the accuracy of the scope and capabilities of impact analysis compared to applying the standalone models (West, 1991; Israilevich *et al.*, 1996; Rey, 1998). The static nature of the IO analysis makes it impossible to temporally estimate the impacts of the economic variables. On the other hand, econometric models present the time series of the economic events as their main feature, albeit much effort is required to disaggregate the dynamic feature of the variables, due to their highly aggregated nature. Therefore, conjoining the two models will result in a dynamic framework featuring sectoral disaggregation, which in turn would generate higher accuracy in impact analysis.

ii. **Forecasting Performance**

A number of economists suggest that the integrated framework is superior in its forecasting performance, compared to the standalone econometric modelling or IO analysis (Gerking, 1976; Glennon *et al.*, 1987; Moghadam & Ballard, 1988; Coomes *et al.*, 1990; West, 1991; Israilevich, 1996; Rey, 1998; Motii, 2005). This enhanced performance is also evident in the econometric models in which Bayesian vector autoregressive (BVAR) equations, using IO information as an *a priori* to determine employment equations, dominate the labour market equations, using vector autoregressive (VAR) method (Magura 1987; LeSage & Magura 1991; Fawson & Criddle 1994; Partridge & Rickman 1998; West & Jackson, 1998; Rey, 1998; Motii, 2005).

iii. **Reduction in Measurement Error**
The final applied objective for the integration framework in the Illawarra region is the matter of accuracy in the regional IO literature. Because of the exorbitance and the small response rate of conducting an industrial survey, a large number of IO tables apply regionalization methods to compute the data (West, 1990; Lahr, 1993; Rey, 1998; West & Jackson, 1998; West 2000; Rey, 2000). A number of the regionalization methods interpolate or extrapolate the regional data based on the national or state-level figures. On that note, a number of economists in the integrated field have suggested that incorporating an econometric module in the standalone IO table to adjust its coefficients will reduce the measurement error resulted from regionalization methods (Moghadam & Ballard, 1988; West, 1990; West, 1995; Rey, 1998; Rey, 2000).

V. Classification of the Two Integrated Strategies

A number of economic modellers have developed integrated models at the national or state scale (Preston, 1975; Conway, 1990; Beaumont, 1990; Almon, 1991; West, 1991; Israilevich et al., 1996; Rey, 1998; Motii, 2005) which derive the main motivation behind the regional integrated framework. Yet the issues prevalent at the regional level engender greater efforts in building these models, in comparison with national/state level models. Regional modellers should grapple with dearth of time series data on final demand elements; treatment of the IO coefficient adjustments, and estimating the parameters while specifying the integrated model equations (Moghadam & Ballard, 1988; Conway, 1990; West, 1991; Rey, 1994; Israilevich et al., 1996). On that note, regional modellers have developed different strategies to address these issues. Rey (2000) has suggested taxonomy of different strategies and classified the integrated studies, available in the literature, in three general groups. This paper borrows from Rey (2000) classification and applies two integrated strategies, namely coupling and holistic embedding, to the Illawarra economy to investigate the economic significance of the knowledge sectors.
i. Coupling

The highest use of time-series data is attributed to the coupled strategy. This strategy respecifies most of the econometric equations prior to incorporating them into the IO analysis. The employment demand block is the first part of integration in coupled strategy and specifies sectoral employment as a function of sectoral gross output and labour productivity trends (West, 1991). Six of the nine final demand elements are endogenized in the coupled strategy. These elements are: changes in business inventories; imports; investment; personal consumption expenditure; state and local educational expenditures; and state and local other expenditures (Rey, 1998). The remaining elements, namely, government defence, non-defence and exports are exogenous variables.

A combined method of the REMI and WPSM models (Conway, 1990) determine the sectoral deliveries to five of the six elements of final demand. The aggregate component is first implemented in an equation as a random variable and is estimated as a function of related determinants. Using a matrix of regional final demand distribution, these aggregate values are then dispersed to individual sectors (Rey, 1998).

Total regional personal consumption expenditures (PCE) are modelled by applying a combined method of the REMI and WPSM (Conway, 1990). The determinants of PCE are regional disposable income net of transfer payment RDI, transfer payments TP, the prime interest rate PIR and the regional unemployment rate RUR:

\[ PCE_t^{ILW} = f_{PCE}(RDI_t^{ILW}, TP_t^{ILW}, PIR_t^{ILW}, RUR_t^{ILW}) \]  

(1)

The TP’s are separated out of RDI to allow for differences in the marginal propensities to consume (MPC) out of the two income streams. The PIR is intended to capture the effects of financing costs on durable goods consumption while the RUR is used as a proxy for consumer confidence.
Regional investment is modelled using a flexible accelerator approach. Net investment $NI_{nt}$ is viewed as moving the regional capital stock from its actual levels in the previous period $RKS_{t-1}$ towards the current desired level $RKS_t$:

$$NI_{nt}^{ILW} = \lambda (RKS_t^{ILW} - RKS_{t-1}^{ILW})$$ (2)

Where $\lambda$ is the speed of adjustment between desired capital stock and the previous period capital stock. The current desired level of capital stock is derived by assuming a fixed capital/output ratio $\mu$:

$$RKS_t^{ILW} = \mu (GRP_t^{ILW})$$ (3)

And substituting (2) into (3) yields:

$$NI_{nt}^{ILW} = \lambda \mu GRP_t^{ILW} - \lambda RKS_{t-1}^{ILW}$$ (4)

To obtain an expression for gross investment ($GI$) requires that a capital depreciation rate $\theta$ be applied to the existing RKS to derive replacement investment. Adding replacement investment to both sides of (4) yields an equation for gross investment $GI$:

$$GI_t^{ILW} = \lambda \mu GRP_t^{ILW} + (\theta - \lambda) RKS_{t-1}^{ILW}$$ (5)

Due to the dearth of regional level data, an alternative form of (5) can be obtained by lagging one time period, multiplying both sides by $(1 - \theta)$ and rearranging to yield:

$$GI_t^{ILW} = \lambda \mu GRP_t^{ILW} - (1 - \theta) \lambda \mu GRP_{t-1}^{ILW} + (1 - \lambda) GI_{t-1}^{ILW}$$ (6)

Not only regional capital stock data is not required, but also (6) allows for the estimation of a deterioration rate rather than assuming a value for $\theta$ a priori. This is due to the estimation of the parameter on the lagged dependant variable identifies $\lambda$, which when applied with the coefficient estimate on $GRP_t^{ILW}$ identifies $\mu$ (Rey, 1998). The values of $\lambda$ and $\mu$ can be employed with the coefficient estimate on the lagged $GRP$ variable to identify $\theta$. 

11
Also, to allow for interest rate sensitivity, the flexible accelerator model is augmented to include the prime lending rate.

Regional changes in business inventories BI are specified as a function of the ratio of GRP over PCE, national BI and a lagged dependent variable:

\[
BI_{t}^{ILW} = f_{CBI} \left( \frac{GRP_{t}^{ILW}}{PCE_{t}^{ILW}}, CBI_{t}^{ILW}, CBI_{t-1}^{ILW} \right)
\]  

(7)

The \( \frac{GRP}{PCE} \) ratio is expected to have a positive coefficient since inventories would grow as consumption expenditures decline relative to total production, while relative increases in personal consumption expenditures reduce inventories (Rey, 2000).

State and local government expenditures on education are derived from levels of income per capita in a region, net migration and a lagged dependent variable:

\[
SLGE_{t}^{ILW} = f_{SLGE1} (IPC_{t}^{ILW}, NM_{t}^{ILW}, SLGE_{t-1}^{ILW})
\]  

(8)

The net-migration variable is intended to capture short-term population demand effects, while the income per capita is a proxy for per capita demands for education in the region. Other state and local government expenditures in the region are modelled as a function of total personal income in the region and a lagged dependent variable:

\[
SLGE_{t}^{ILW} = f_{SLGE2} (TP_{t}^{ILW}, SLGE_{t-1}^{ILW})
\]  

(9)

The income variable is a measure of the size of the service demand of the region and the lagged dependent variable captures historical patterns in the expenditures.

These five aggregate components of final demand are then disaggregated to the sectoral level by applying a distribution matrix of regional final demand. The remaining endogenous element of regional final demand is the total regional import which is obtained in a bottom up fashion. In addition to the sectoral final demand, local demand, and gross output identities
several new identities are introduced in the coupled model. First, disposable income is defined as regional personal income less taxes:

\[
DI_t^{ILW} = RPI_t^{ILW} - TAX_t^{ILW}
\]  \hspace{1cm} (10)

Taxes are defined as the product of the tax rate and the difference between total personal income and transfer payments into the region:

\[
TAX_t^{ILW} = TR_t^{ILW} \times (TP_t^{ILW} - TP_t^{ILW})
\]  \hspace{1cm} (11)

Disposable income net of transfer payments is defined as:

\[
DINTP_t^{ILW} = DI_t^{ILW} - TP_t^{ILW}
\]  \hspace{1cm} (12)

The final endogenous identity added in the coupled model is the ratio of gross regional product to personal consumption expenditures which appears in the CBI equation:

\[
GRPPCE_t^{ILW} = \frac{GRP_t^{ILW}}{PCE_t^{ILW}}
\]  \hspace{1cm} (13)

It is important to note, that because of the openness of regions and the sometimes large level of regional imports, this ratio can be less than one and in general will be larger than the national average value over the sample period.

\textit{ii. Holistic Embedding}

Of the two strategies in the integration framework, the embedded strategy uses the least level of data from the econometric part and is considered an extension to the econometric model. This strategy highlights the interindustry relations which are added to the employment demand block of the econometric model. There is a twostep procedure in the embedded strategy: firstly, the employment demand block is expanded to take on an intermediate demand variable (IDV). Then 20 regional IDV identities will be added to the econometric model, making the overall equations in the embedded model 800.
Eight different versions of the embedded strategy are implemented for the Illawarra region. The different versions are based on a unique definition of the IDV:

1) Static interindustry demand variable (SIDV).
2) Static interindustry employment demand variable (SIEDV).
3) Dynamic interindustry demand variable (DIDV).
4) Dynamic interindustry employment demand variable (DIEDV).
5) Regional SIDV.
6) Regional SIEDV.
7) Regional DIDV.
8) Regional DIEDV.

Versions one to four employ the national IO coefficients in defining the relevant demand variables, while versions five to eight replace the national coefficients with regional IO coefficients that are developed using a location quotients method. The difference between the ID and IED versions (i.e. 1, 3, 5, and 7 versus 2, 4, 6, and 8) is about the latter’s use of the inverse productivity term whereas the former omits any labour productivity adjustment. All coefficients are set equal to their initial year values for the static versions (i.e. 1, 2, 5, and 6). In other words, the IO, productivity, and location coefficients are assumed constant at the 2000-year observed values in defining the interindustry demand variables for all years.

VI. Data Sources

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 products, wages and salaries and employment. The primary data sources include the State Accounts, New South Wales Yearbook, Labour Force Statistics, Manufacturing Statistics, Consumer Price Index, IRIS Annual Publications, plus other miscellaneous publications such
as *Census*. The input-output table was constructed in the School of Economics at the University of Wollongong. The current table uses a hybrid method, which is a combination of survey and estimated data.

**VII. The Empirical Results**

For the first experiment, the two integration strategies, namely the coupled and the holistic embedded, are applied to a dynamic ex-post scenario for forecasting both total and sectoral employment for the period of 2009-2010. The reason for exclusion of standalone IO is that due its static nature, it is not made for forecasting. Each of the two strategies in this experiment is based on parameters estimated over the 1990-2009 sample period. The comparison is made on the basis of mean absolute percentage error (MAPE) for the predicted values of each variable over the last two years of the sample period.

The results of the forecast show that the holistic embedded strategy performs better than the coupled strategy in forecasting total employment. This is due to the even distribution of the estimated values across all sectors, which is the main property of the holistic embedded strategies. As noted on Table 1, the MAPE of the holistic embedded strategy is far less than that of the coupled and the number of sectors with the lowest MAPE is four times that of the coupled.

In terms of sectoral employment forecast, the coupled strategy clearly outperforms the holistic embedded. The MAPE for the coupled strategy is half of that of the holistic embedded and the number of sectors with the lowest MAPE is twice that of the embedded. A likely justification for this is that in a more diversified economy it is critical to avail of intersectoral linkages in defining the employment demand equations. The coupled strategy imposes an exhaustive set of intersectoral relations in each employment equation and an extensive series of final demand equations; it is more sector-specific in terms of forecasting.
The second experiment is a comparison of the impact analysis capabilities of the two integration strategies, namely coupled and holistic embedding, together with the standalone IO analysis. In these experiments, the three different models are applied to estimate the employment impacts on education sector, arising from a hypothetical increase of AU$1 million in government expenditure on three sectors, namely retail, education, and health and social services. Table 2 to Table 4 in Appendix I, show the results of these impact analyses from, respectively, standalone IO, and the two integration strategies, arisen from change in the government expenditure based on 2009 IO table.

The first set of findings pertains to the comparison of the different models. As noted from Table 2, the total estimated impacts generated by IO in the government expenditure increase scenario are below 150 million and the flow-on effects below 65 million. The substantial difference in the estimated results is due to differences in the structure of the employment demand equations across the two strategies. In general, coupled strategies specify sectoral employment as a function of sectoral output and labour productivity. In contrast in holistic embedding, employment is specified in a fashion similar to regular econometric modelling. Accordingly, the estimate variance in the holistic embedded strategy

<table>
<thead>
<tr>
<th>Integration Approach</th>
<th>Coupled</th>
<th>Holistic Embedded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illawarra</td>
<td>5.423</td>
<td>0.167</td>
</tr>
<tr>
<td><strong>Number of Sectors with Lowest MAPE</strong></td>
<td>4</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Integration Approach</th>
<th>Coupled</th>
<th>Holistic Embedded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illawarra</td>
<td>3.756</td>
<td>6.459</td>
</tr>
<tr>
<td><strong>Number of Sectors with Lowest MAPE</strong></td>
<td>18</td>
<td>9</td>
</tr>
</tbody>
</table>

Source: computed by the author.
is more commensurate with the econometric modelling whilst this variance in the coupled strategy is in accordance with the detailed sectoral disaggregation of the IO analysis while retaining the dynamics of the econometric model to a higher extent than the coupled strategy.

The second set of findings pertains to the importance of the sector with respect to its direct and flow-on effects on employment. By virtue of the competitive advantage of coupled strategy, as a result of its exhaustive estimation and its superior accuracy, the sectoral comparison is conducted analysing the results of the coupled strategy. As noted on Table 3, the sector on which the expenditure adjustment has the highest impact is retail trade. A million dollar increase of government expenditure on education sector increases nearly 12 million dollar in total employment. Of this 12 million total impact, 8.4% is the increase on the education sector itself. The highest impact is on retail trade, which is 12.5% increase and the second highest impact is on health and social sector sector with 10.6% increase impact.

**VIII. Conclusion**

This paper has investigated the comparative properties of two strategies for combining IO analysis with econometric modelling. Although integration strategies have proved to be superior in terms of forecasting and impact analysis compared to traditional models, there is a wide variation in the manner each strategy has been developed. It is important to note that this comparative analysis is the modeller’s first step and initial attempt towards regional integration modelling; hence, the models were not fine-tuned and further work needs to be done in this regard.

With regard to the properties of alternative integration strategies, coupled strategy is superior when the objective is forecasting sectoral employment. Nonetheless, coupled strategy does not retain superiority when the objective is on forecasting aggregate employment. This strategy is highly data intensive and, as the results show, there is not a
direct relationship between the complexity of this strategy 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 interindustry structure is highly developed and endogenous forces are dominant in structuring the economy, and data availability is not an issue, coupled strategy appeared to be more effective for forecasting than the other strategy. With respect to impact analysis, the impacts are more fully spread across industries within 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, coupled strategy is more suitable.

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

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 strategies 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 strategy and the extent to which IO components and econometric components are combined. The strategy of the integration 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 strategies 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, modular structure solves the two models separately before their components interact with one another.

The main application of the integrated framework has proven thus far to be superior, compared to the standalone IO or econometric models, for impact analysis and forecasting (West, 1991; West & Jackson, 1998; Rey, 1998). Applying this framework for regional economic analysis has been the forefront of research activity of many regional modellers (Schindler et al., 1995; Schindler et al., 1997; Israilevich et al., 1997).

Appendix I: The Results of the Impact Analysis

TABLE 2
Standalone IO Analysis

<table>
<thead>
<tr>
<th>Sector</th>
<th>Consumption</th>
<th>Total</th>
<th>Percent</th>
<th>Flow-on</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail Trade</td>
<td>9,265.02</td>
<td>18,471.46</td>
<td>12.5</td>
<td>9,636.32</td>
<td>15</td>
</tr>
<tr>
<td>Accom. Cafes and Res</td>
<td>4,790.45</td>
<td>10,153.75</td>
<td>6.8</td>
<td>5,432.64</td>
<td>8.5</td>
</tr>
<tr>
<td>Transport and Storag</td>
<td>1,948.67</td>
<td>7,936.15</td>
<td>5.4</td>
<td>4,644.57</td>
<td>7.2</td>
</tr>
<tr>
<td>Prof. Scientific and</td>
<td>1,673.44</td>
<td>9,002.34</td>
<td>6.1</td>
<td>6,330.02</td>
<td>9.9</td>
</tr>
<tr>
<td>Education and Traini</td>
<td>3,304.96</td>
<td>12,468.96</td>
<td>8.4</td>
<td>3,618.61</td>
<td>5.6</td>
</tr>
<tr>
<td>Health and Social Se</td>
<td>4,400.68</td>
<td>15,664.05</td>
<td>10.6</td>
<td>4,465.60</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>38,414.82</td>
<td>148,297.04</td>
<td>100</td>
<td>64,111.44</td>
<td>100</td>
</tr>
<tr>
<td>Multiplier</td>
<td></td>
<td>1.7615</td>
<td></td>
<td>0.7615</td>
<td></td>
</tr>
</tbody>
</table>

Source: computed by the authors.
### TABLE 3
**Coupled Strategy**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Consumption</th>
<th>Total</th>
<th>Percent</th>
<th>Flow-on</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail Trade</td>
<td>11,118.02</td>
<td>22,165.75</td>
<td>12.5%</td>
<td>11,563.58</td>
<td>15.0%</td>
</tr>
<tr>
<td>Accom, Cafes and Res</td>
<td>5,748.54</td>
<td>12,184.50</td>
<td>6.8%</td>
<td>6,519.17</td>
<td>8.5%</td>
</tr>
<tr>
<td>Transport and Storag</td>
<td>2,338.40</td>
<td>9,523.38</td>
<td>5.4%</td>
<td>5,573.48</td>
<td>7.2%</td>
</tr>
<tr>
<td>Prof, Scientific and</td>
<td>2,008.13</td>
<td>10,802.81</td>
<td>6.1%</td>
<td>7,596.02</td>
<td>9.9%</td>
</tr>
<tr>
<td>Education and Traini</td>
<td>3,965.95</td>
<td>14,962.75</td>
<td>8.4%</td>
<td>4,342.33</td>
<td>5.6%</td>
</tr>
<tr>
<td>Health and Social Se</td>
<td>5,280.82</td>
<td>18,796.86</td>
<td>10.6%</td>
<td>5,358.72</td>
<td>7.0%</td>
</tr>
<tr>
<td>Total</td>
<td>46,097.78</td>
<td>177,956.45</td>
<td>100.0%</td>
<td>76,933.73</td>
<td>100.0%</td>
</tr>
<tr>
<td>Multiplier</td>
<td></td>
<td></td>
<td></td>
<td>2.11</td>
<td>0.91</td>
</tr>
</tbody>
</table>

*Source:* computed by the authors.

### TABLE 4
**Holistic Embedded Strategy**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Consumption</th>
<th>Total</th>
<th>Percent</th>
<th>Flow-on</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail Trade</td>
<td>12,044.53</td>
<td>24,012.90</td>
<td>12.5%</td>
<td>12,527.22</td>
<td>15.0%</td>
</tr>
<tr>
<td>Accom, Cafes and Res</td>
<td>6,227.59</td>
<td>13,199.88</td>
<td>6.8%</td>
<td>7,062.43</td>
<td>8.5%</td>
</tr>
<tr>
<td>Transport and Storag</td>
<td>2,533.27</td>
<td>10,317.00</td>
<td>5.4%</td>
<td>6,037.94</td>
<td>7.2%</td>
</tr>
<tr>
<td>Prof, Scientific and</td>
<td>2,175.47</td>
<td>11,703.04</td>
<td>6.1%</td>
<td>8,229.03</td>
<td>9.9%</td>
</tr>
<tr>
<td>Education and Traini</td>
<td>4,296.45</td>
<td>16,209.65</td>
<td>8.4%</td>
<td>4,704.19</td>
<td>5.6%</td>
</tr>
<tr>
<td>Health and Social Se</td>
<td>5,720.88</td>
<td>20,363.27</td>
<td>10.6%</td>
<td>5,805.28</td>
<td>7.0%</td>
</tr>
<tr>
<td>Total</td>
<td>49,939.27</td>
<td>192,786.15</td>
<td>100.0%</td>
<td>83,344.87</td>
<td>100.0%</td>
</tr>
<tr>
<td>Multiplier</td>
<td></td>
<td></td>
<td></td>
<td>2.29</td>
<td>0.99</td>
</tr>
</tbody>
</table>

*Source:* computed by the authors.
# Appendix II: Industrial Sectors of the Illawarra

## TABLE 5

**Illawarra Industrial Sectors**

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

*Source*: compiled by the author.

## References


