SUPPLEMENTAL FILE

Introduction

This supplemental file contains all the text, equations and tables that may be necessary for the readers but had to be removed from the main manuscript in order to comply with the journal's word limit. The section heading, from which the material is transferred is in bold.

The Region

Horizontal networks are wide-spreading as the main organizational form of production in the region as the economy is transforming. There is high geographical mobility of business, particularly to Sydney, as housing in the Illawarra is more affordable. Labour management relations are collaborative and there is an increasing effort in promoting global learning skills and cross training programs in the region. As the regional economy is emerging from the traditional economic structure, innovation, invention and knowledge intensive initiatives are becoming the sources of competitive advantage and the growth drivers of the economy.The particularity of the Illawarra is justified because of the aforementioned economic transitions that have occurred over the past four decades. The ongoing downturns in industrial employment (Haughton 1990), increased youth unemployment and regional recession instigated new economic alternatives for the Illawarra. More specifically, as a result of the economic transitions, 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. The Illawarra economy has been pressed by the need to find new prospects outside heavy industry production. The challenges that are fuelled by the transition and the economic restructuring have become the main impetus for initiating ideas of cultural regeneration (Gibson & Warren, 2013). Although there is an ongoing decline in heavy industry manufacturing, there has been a constant effort by the education industry to promote professional services, knowledge intensive and innovation based businesses. This is also evident based on the recent conjoint steps taken by local councils and University of Wollongong (UOW)[1] to create programs, such as iAccelerate[2], that promote innovation and accelerate start-ups in the region.

The Objectives for Merging IO Analysis with Econometric Framework

A number of researchers compare the integrated IO-econometric models and regional computable general equilibrium (CGE) models (West & Jensen, 1995) whilst other researchers emphasize on the correspondence between integrated IO-econometric and CGE models (Treyz, 1993). In this study, the reasoning for choosing an integrated IO-econometric framework over CGE is that the latter may present a twofold caveat. First caveat is the perfect market condition, which postulates no increasing returns, many buyers and sellers, who are all price takers (Rose, 1995). This leads to perfect information assumption, which postulates buyers and sellers know all they need to know about what they buying and selling in order to make the right decisions. Consequently, leading to complete market assumption, where there are no externalities or public goods, nor are there transaction costs. Second caveat is the interpretation of results, which requires caution. The second caveat is the inherent complexity in CGE models – which ironically is where the modelling capabilities are built upon. This complexity often redirects the focus of interpretation of the results on magnitudes and direction in a 'perfect market' rather than measuring numeric dynamic changes in the structure of an economy (Rose, 1995). Therefore, results from a CGE model are more appropriate to use as a road map for policy analysis in the context of the Illawarra, rather than forecasting and measuring specific impacts. Henceforth, for this study a review of literature on integration of IO with econometric was

[1] UOW is the university in the south coast of NSW and the key employer in the education sector.
[2] iAccelerate is a UOW business incubator program that helps build and grow new businesses. iAccelerate is built around an educational program, formalised business acceleration monitoring and one-to-one mentoring.

favoured over literature on CGE models. Albeit, building a CGE model to investigate this region is unquestionably considered an apt potential objective to future research.

Theoretical Objectives

Since the inception of the regional science, IO analysis has been a central toolkit for regional modellers. Yet the restrictive assumptions of IO, namely constant returns to scale, homogenous consumption function, lack of price responsiveness, linear production technologies and perfect market equilibrium have brought awareness of the drawbacks of the traditional IO (Rey, 1998; West, 1991; Rose, 1995). In IO analysis the shocks to final demand induces supply adjustments, consequently markets clear whilst prices have no effect in the demand shock.

In comparison, econometric models have not attracted the same level of applicability from regional modellers. This is justified by the higher data requirements and calibration issues of this type of modelling. In contrast, econometric models track the time-path and dynamics of shifts to exogenous shocks within a regional economy.

Although IO is demand driven in essence, one can divert the direction of the analysis to price effects, technological changes, and other economic factors by merging it with an econometric module (Moghadam & Ballard, 1988; Beaumont, 1990; West, 1991; Rey, 1998).

For instance, in an IO model, personal consumption can be derived from:

$$C = \sum_{i=1}^{n} C_i \quad (1)$$

And then total gross regional product is:

$$Y = C + I + G + (EX\text{-}IM) \quad (2)$$

Since personal consumption is an external factor in IO analysis, the role that it plays as an element in merging IO with econometric is critical. Therefore we endogenize personal consumption in the econometric module to generate estimates of consumption, which will then be implemented in the IO analysis (Treyz, 1993; West, 1994; Rey, 2000). In this regard, Kratena *et al*. (2013) and Kim & Hewings (2009) have significantly contributed to consumption estimation methodology. Kratena *et al*. (2013) extends the Luengo-Prado (2006) model by setting up an error correction model instead of dividing all the variables by permanent income and assuming an equilibrium relationship between equity (including durable stocks) and the long-run path of income. Then a linearity assumption in the user cost term of Luengo-Prado (2006) function is applied. This would result in more flexible functions so that the different curvatures can be taken into account. Kim & Hewings (2009) postulates that the total consumption expenditure is a linear function of the total household income, the direct tax rates of the regional and national levels of government, and the marginal propensity to save (MPS). Under Kim & Hewings (2009), total household consumption expenditure (less income tax and saving[3]) is allocated to each commodity group using a Cobb-Douglas utility.

Similarly, other elements of final demand, such as public consumption, government expenditure, state and local government education expenditure, net exports, etc. can be endogenized in econometric equations to capture possible dynamic changes over time. Having said that, there are merged models which apply the traditional IO properties i.e. the components of final demand are treated exogenously (L'Esperance, 1981; Hewings & Jensen, 1986).

Coupling Model

To specify gross investment in the Illawarra at a given time (GI_t^{ILW}) we use θ as depreciation rate for capital and multiply it by RKS_{t-1}^{ILW}(the lagged regional capital stock)

[3] In Kim & Hewings (2009), household saving is a linear function of the household disposable income with a fixed MPS.

to measure new investment. Adding new investment to both sides of (8) yields an equation for gross investment *GI*:

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

Due to the dearth of regional level data on capital stock on a number of industries, we had to resort to measuring gross investment by lagging gross regional product and gross investment by one-time period and multiply both sides by (1 – θ) following the method suggested by Rey (1998):

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

Using (10), not only regional capital stock data is not required, but also one can estimate deterioration rate rather than assuming a value for θ as a *priori* information. This is due to the estimation of the parameter on the lagged dependant variable which specifies λ. When the estimated parameter is applied to the coefficient estimate on $GRP_t{}^{ILW}$, μ can be specified (Rey, 1998). The values of λ and μ can be applied to the estimated coefficients on the lagged GRP variable in order to derive θ. Finally, to take into account interest rate sensitivity, the aforementioned model can be extended by including the national lending rate.

To specify changes in business inventories BI_t^{ILW} we employ the ratio of GRP over PCE, national BI and the lagged regional BI in the following equation:

(5) $$BI_t^{ILW} = f_{CBI}\left(\langle GRP_t{}^{ILW} / PCE_t{}^{ILW}\rangle, BI_t^{AU}, BI_{t-1}^{ILW}\right)$$

If the private consumption expenditure declines relative to total production business inventories would grow. Hence the $\frac{GRP}{PCE}$ ratio is probable to have a positive coefficient. Nevertheless, relative increases in private consumption expenditures would reduce inventories (Rey, 2000).

Government expenditure on education (${GE_t}^{ILW}$) can be derived from levels of income per capita (${YPC_t}^{ILW}$), net migration (${NM_t}^{ILW}$) and lagged government expenditure on education (${GE_{t-1}}^{ILW}$):

(6) $${GE_t}^{ILW} = f_{GE}({YPC_t}^{ILW}, {NM_t}^{ILW}, {GE_{t-1}}^{ILW})$$

We measure short run effects of population demand by applying net migration and apply the income per capita element to measure demand per capita for education in the Illawarra. Assorted government expenditure in the Illawarra is derived from total personal income in the Illawarra (${TPY_t}^{ILW},$) and lagged assorted government expenditure (${AGE_{t-1}}^{ILW}$):

(7) $${AGE_t}^{ILW} = f_{AGE}\ ({TPY_t}^{ILW}, {AGE_{t-1}}^{ILW})$$

The element total personal income is a proxy for the size of the service demand in the Illawarra and the lagged assorted government expenditure element measures historical regional patterns in the government expenditure.

We disaggregate the aforementioned aggregate components of final demand to match the number of sectors in the IO table (30) by applying a distribution matrix of regional final demand. The remaining exogenous elements of final demand, namely exports and imports, are measured in a bottom up method. In addition to the sectoral final demand, local demand, and gross output identities a number of other identities are introduced in the coupled methodology. Disposable income is determined as the difference between regional personal income (${RPY_t}^{ILW}$) and income taxes (${YTX_t}^{ILW}$):

(8) $${DY_t}^{ILW} = {RPY_t}^{ILW} - {YTX_t}^{ILW}$$

Income tax is determined by multiplying the tax rate (${TXR_t}^{ILW}$) and the total personal income less transfer payments into the Illawarra (${TP_t}^{ILW}$):

(9) $${YTX_t}^{ILW} = {TXR_t}^{ILW} \times ({TPY_t}^{ILW} - {TP_t}^{ILW})$$

Disposable income less transfer payments ($DYLTP_t^{ILW}$) is determined by:

(10) $$DYLTP_t^{ILW} = DY_t^{ILW} - TP_t^{ILW}$$

The final identity that is endogenised in this methodology is the ratio of gross regional product (GRP) to personal consumption expenditures (PCE) which appears in the CBI equation:

(11) $$GRPPCE_t^{ILW} = {GRP_t^{ILW}}/{PCE_t^{ILW}}$$

Sometimes this ratio can be less than one. In general it is larger than the national average value over a sample period. This is due to the openness of regions and if the level of regional imports is large.

Description of Characters in Tables 3, 4 and 5

- *NO* refers to the number allocated to each sector for each particular table
- *Final Demand* refers to the direct impact, here would be the AU$1 million expenditure increase
- *Industrial Supply* denotes the indirect impact or the inter-sectoral impact
- *Consumption* represents the induced effect, or the change in consumption of a sector as a result of the indirect impact
- *Total* refers to the total effect on a sector including the initial shock
- *Percent 1* represents the proportion of the total effect on each sector including the initial shock
- *Flow-On* represents the ripple effect less the initial impact
- *Percent 2* denotes the proportion of the ripple effects on each sector
- *Total Row (second to the last row)* displays the total impact on all the 30 sectors, of which only the top seven are displayed on each table for this study

- *Multiplier – Total* is Multiplier Type II, which is direct + indirect + induced effects
- *Multiplier – Flow-On* denotes Multiplier Type I, which is indirect + induced effects

A Note on Estimation Results

The main objective of this study is to apply integrated models for generating more accurate forecasts of regional employment in a transitioning regional economy. In doing so, we aim to shed some light on some key estimation issues, forecasting uncertainty and policy implications.

As with time series data, more realistic regression coefficients can be generated on sectoral employment if a pertinent estimation method is applied to generate the parameters. Generally, in large samples, it makes little difference whether ρ is estimated from the Durbin–Watson, or from the regression of the residuals in the present time on the lagged residuals, or from the Cochrane–Orcutt iterative procedure. They all provide consistent estimates of the true ρ (Gujarati, 2003).

We run monte Carlo simulations to propagate uncertainties in the model inputs into uncertainties in the model outputs. We run To run the simulations, we use the error term for each econometric equation. We assume the error term follows the classical assumptions, namely, $u_t \sim N(0, \alpha^2)$ for the macro equations in the coupled model and $u_{it} \sim N(0, \alpha^2)$ for the sectoral equations in the embedded model. The *i* index refers to sectoral observations and *t* to time series observations, the classical assumption for u_{it} is assumed on the basis that there is no autocorrelation over time. Since our objective is to observe the uncertainty, we do not run any parameter optimization control in our simulation.

The results from the Monte Carlo experiments are presented in Table 6 and Table 7. We use coefficient of variation and process capability to measure the uncertainty associated with the estimates. Observing the macro elements in the coupled model on Table 6, it is evident that the dispersion of data is the least in the estimates for regional net investment ${NI_t}^{ILW}$, followed by business inventories BI_t^{ILW} and regional personal consumption expenditure ${PCE_t}^{ILW}$. The highest variation is observed in the estimates generated for the assorted government expenditure ${AGE_t}^{ILW}$. Observing the results for process capability, the highest is generated by regional gross investment ${GI_t}^{ILW}$, followed by ${AGE_t}^{ILW}$ and government expenditure on education ${GE_t}^{ILW}$. The process capability statistics tell us how close or far our estimates are from the mean by measuring the estimates from the lower specification limit to the upper specification limit. A generally accepted minimum value of Cpk is 1.33. Lastly, the coefficient of determination corresponds well with the coefficient of determination. The results show that the R^2 for the macro elements range from a minimum of 70% for net assorted government expenditure to nearly 90% for net investments regression. The Durbin Watson statistics is between 2.8 to 1.9 for all the elements, which is an acceptable measure indicating absence of serial correlation.

Moreover, as shown in Table 7, the dispersion of estimates for the sectoral employment is evidently higher in the embedded model, ranging from 19% for Other services sector to 43% for Construction sector. The capability process statistic does not quite correspond with the coefficient of variation as Professional, scientific and technical services sector with the 5th lowest dispersion exhibits the least capability, in line with Construction sector, which has the highest dispersion. However, Administrative and support services and Arts and recreation services sectors exhibit the highest capability statistic, despite ranking ninth and fourth in terms of estimate variation. As with autocorrelation, although most of the Durbin Watson statistics are less than the ones for the coupled model, all fit between 1.1 and 2.5, which does not raise any concerns. Lastly, the coefficient of determination varies significantly across sectors, with Other services boasting a 96% R^2 to Construction with only 50%.

Policy Analysis

Furthermore, the results of the impact analysis shown in Tables 3 to 5, indicated that Health care and social assistance sector tops the ranking, followed by Retail trade sector and finally Education with respect to their impacts and total effects. In terms of total impacts on income, education and training, health and social services and lastly administrative services sectors dominate the impact analysis, respectively. In view of the impact analysis results, there are four policy implications that are listed in this section and further elaborated in the section below:

1) Promote transport and infrastructure

Regional infrastructure projects can be funded through the Regional Development Australia Fund (RDAF). As a result, strategic infrastructure will be better developed in the region. Regional infrastructure, economic and community development can be achieved, which will lead to more jobs creation in several sectors, predominantly in the construction, and administrative and support services.

2) Increase expenditure on education and training sector

This policy is directly ratiocinated upon the results of the analyses presented earlier. From a commercial perspective, an increased expenditure in education can effectuate an increment in presence of robust and well-connected business leaders in the region. Furthermore, it can secure a research & development succession plan with a pool of leaders in training. This will bring about 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. This in turn can foster a more agile job-ready workforce with a range of skills and abilities, resulting in a region with adequate communal enterprises to provide employment opportunities for the disadvantaged.

3) 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. The action plan can promote new sectors and thus more employment opportunities. Moreover, sustainable iconic buildings will be retrofitted within the Illawarra and lastly, it would lead off developments on implementing sustainable environmental changes in manufacturing and engineering sectors.

4) Promote the Illawarra as a preferred tourism destination

New tourism related businesses will emerge, triggering economic diversification with less reliance on heavy manufacturing sectors and inevitably resulting in increased employment opportunities.

Conclusion

Due to less data requirements, the embedded model is more favoured, particularly for a less diversified economy, where inter-sectoral structure is not fully developed and the regional economy is not largely dependent on endogenous factors. With respect to impact analysis, the embedded model was not applied to investigate the three largest employing sectors in the Illawarra for this study[4].

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 can be improved by adding further elements and further work can indeed be done in this regard. 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.*, 1996; Motii, 2005; Kratena et al., 2013).

[4] The embedded model has been applied to a case study for a different scenario by the same authors. The study is not cited here as it is forthcoming, yet it would certainly be published in 2017.

TABLE 6
COEFFICIENT OF VARIATION - COUPLED MODEL

2011 Estimated Results - Coupled

NO.	Element	CV	Cpk	DW	R^2
1	*PCE*	6.97%	1.42	2.854	0.765
2	*NI*	4.88%	1.43	1.955	0.897
3	*GI*	8.47%	1.95	2.803	0.720
4	*BI*	6.81%	1.39	2.221	0.802
5	*GE*	7.12%	1.64	2.608	0.735
6	*AGE*	9.73%	1.68	2.316	0.710

TABLE 7
COEFFICIENT OF VARIATION – EMBEDDED MODEL

2011 Estimated Results - Embedded

NO.	Industry of Employment	CV	Cpk	DW	R^2
1	*Agriculture, forestry and fishing*	34.48%	1.49	2.2440	0.650
2	*Mining*	41.00%	1.52	2.1847	0.541
3	*Manufacturing*	20.47%	1.87	1.2354	0.929
4	*Electricity, gas, water and waste services*	41.28%	1.79	1.6579	0.533
5	*Construction*	43.16%	1.34	1.3391	0.503
6	*Wholesale trade*	26.64%	1.70	2.3611	0.826
7	*Retail trade*	30.87%	1.57	2.4195	0.721
8	*Accommodation and food services*	40.85%	1.60	1.6529	0.580
9	*Transport, postal and warehousing*	40.97%	1.85	1.6792	0.577
10	*Information media and telecommunications*	38.05%	1.70	2.1825	0.598
11	*Financial and insurance services*	33.84%	1.67	1.2894	0.717
12	*Rental, hiring and real estate services*	38.94%	1.63	2.4776	0.585
13	*Professional, scientific and technical services*	23.74%	1.34	1.7289	0.897
14	*Administrative and support services*	30.57%	1.91	2.4145	0.760
15	*Public administration and safety*	24.02%	1.48	1.1138	0.858
16	*Education and training*	24.10%	1.38	2.5205	0.852
17	*Health care and social assistance*	22.38%	1.48	1.8978	0.928
18	*Arts and recreation services*	23.05%	1.91	2.2849	0.920
19	*Other services*	18.88%	1.36	1.1681	0.960

Source: computed by the authors.
Note: CV is coefficient of variation. DW is the coefficient of Durbin Watson test.