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Application of an Input-Output Econometric Model to Investigate the Illawarra Economy

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Description

There are a number of tools that regional analysts apply to analyse and forecast the economy of a region. Two of the most commonly used tools are input-output (IO) modelling and econometric modelling. However, the standalone IO models are static and have restrictive assumptions of constant returns to scale. On the other hand, the econometric models lack the detailed sectoral disaggregation of IO models. As a result the integrated econometric input-output (EC-IO) modelling attempts to consider the timeline of the economy through time series in order to provide a more accurate picture of the dynamic characteristics of structural changes in a regional economy. This paper applies the integrated EC-IO modelling to the Illawarra region of New South Wales, in order to achieve higher level of accuracy in analysis and forecasting the structural changes in the regional economy. JEL Classification: R15, C 53, C67.

Location

Innovation Campus, Building 233, Rm G12

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Introduction

One of the continuing attributes of regional science since its inception some 60 years ago has been on the development of tools for policy analysis. A significant emphasis has been placed on regional socioeconomic models, which covers the topic of regional analysis. The objective of this paper is to highlight the major contributions in the field of regional analysis. This paper focuses on one the most recent modelling developments, the integration of regional IO modelling with regional econometric modelling. In the past three decades, integrated models have been investigated by a number of economists to gain the benefits of both intersectoral details of IO modelling and dynamics of econometric modelling (Isard & Anelin 1982; Moghadam & Ballard 1988; Anselin & Maden 1990; Bertugilia *et al.* 1990; Conway 1990; West 1991; West & Jackson 1998; Rey 1998; Rey 2000; Motii 2005). 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 (Lakshman 1982; Batey & Madden 1986).

To analyse the structure of a regional economy and to examine the potential impacts of policies on the future economy of a region, a regional analyst often applies two key methods[1]. The first method is IO modelling, through which the interactions between economic sectors are examined and the impacts of exogenous shocks on the economy are determined (West & Jackson 1998; Miller & Blair 2009). The multipliers in IO modelling enable analysts to calculate the direct and indirect

[1] Other operational methods of regional analysis are computable general equilibrium (CGE), economic base analysis, shift-share analysis, linear programming, and cost-benefit analysis.

effects of any shifts among various economic sectors and to trace the impacts of intersectoral transactions within an economy. The other method is econometric modelling, through which the growth rate of each sector is forecasted and the effects of a policy on high growth rate industries are evaluated. Nonetheless, each model applied alone ensue some drawbacks. For instance, IO models lack the dynamics of econometric models whilst on the other hand econometric models do not provide a detailed snapshot of intersectoral interactions among economic sectors of a region (Bullard 1977; Klein 1978; West 1991; Israilevich 1996). Given the two methods, applied alone in analysis, the question is if the results of evaluating the potential effects of a policy such as adjustment of overall rate of inflation or adjustment of relative prices of household expenditure commodities are highly accurate? Considering the limitations of each method in isolation, a positive answer to this question is highly doubtful.

West & Jackson (1998) argue that in the standalone IO modelling, an exogenous shock to the economy entails a reaction from final demand to intermediate and primary inputs. Nonetheless, if changes in tax levels impact government expenditure, there is no reaction from primary inputs to final demand. Therefore it is required to implement a dynamic structure to apply time series in order to capture exogenous shocks through time. This feature can be gained by merging an IO model with an econometric model to combine the good properties of both methods (Glickman 1977).

An integrated EC-IO model combines the advantages of both types of modelling, which in turn leads to increased accuracy in forecasting and to improved capabilities in impact analysis for regional planning. 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.* 1991; Israilevich *et al.* 1994; Rey 1998). However, in the Australian context, except for West (1991; 1995), no studies have been found in the literature focusing on the integrated EC-IO 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 New South Wales economy. Due to the economic transitions, as a result of globalization, that have occurred in the Illawarra's economy, an integrated EC-IO analysis on the Illawarra could be a stepping stone to further research on other regions around the globe that are similarly in a transitional phase. This paper explores the potential arising through the application of integrated EC-IO modelling to the Illawarra, a region in transition, to analyse the intersectoral relatedness and forecast structural shifts in the economy.

The Region

Due to globalization and structural adjustments over the last five decades, regions have become paramount factors in development of 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 the Illawarra's. The emphasis on the Illawarra 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 has contributed considerable resources to the economy of Australia as it has been a leading steel and coal exporter. It boasts the largest plant for steel production in the southern hemisphere (IRIS 2008). The Illawarra is nationally acclaimed for metal fabrication and engineering. It has been considered the centre of excellence in research and development (IRIS 2008), playing an integral role in technological advancement. In addition, it is a globally renowned provider of tertiary education (IRIS 2008). According to the Australian Bureau of Statistics (ABS 2011) the Illawarra statistical division[2] has an unemployment ratio of 6.7%. With a population of 436,117 people this indicates that nearly 13,114 of the current labour force are unemployed. Since one of the main objectives of regional planning is to increase employment, gaining higher accuracy in regional economic analysis would be a stepping stone in addressing the unemployment issues.

Modelling Overview

In the integrated EC-IO model for the Illawarra, coefficients of the equations in the model are estimated econometrically while the alternative methodologies are deterministic in nature, based on a single point observation. The model is dynamic in nature, specifying lags in relationships between endogenous variables and exogenous policy instruments, which offer greater consistency in ex-ante forecasting and policy analysis than other methods offer. The overall integrated EC-IO model contains two main modules. The first module is the econometric module and

[2] The Illawarra statistical division contains Wollongong sub-statistical division (SSD) – also known as economy of Illawarra (RDAIllawarra, 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.

subsequently the results of the econometric equations will be applied to close the IO model. The econometric model contains the following three blocks: 1) labour market block; 2) income block; and 3) consumption block (West 1991; Rey 1998; Motii 2005).

In 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 economy welfare of the region. In general, intersectoral economic transactions, output demand, and employment are all influential factors in balancing the regional economy. Thus it is of vital importance to gain more accuracy in terms of forecasting the major intersectoral shifts within the economy of the Illawarra and 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.

Modelling Components

The main objective of the overall model is about the closure or endogenising of the IO model with respect to econometrically estimated income and household expenditure relations. Following West (1991), Rey (1998) and Motii (2005), a typical IO model is depicted based on the following equation:

(1) $$A^{ILW}.GRO^{ILW} + FD^{ILW} = GRO^{ILW}$$

Where GRO is an *n* element vector of industrial gross regional output in the Illawarra; FD is an *n* element vector of aggregate industrial final demand expenditure in the Illawarra; and A is an *nxn* matrix of intermediate input requirements (coefficients) for the Illawarra. The (1) IO equation is then rearranged in the following format to calculate a change in gross regional output as a response to a change in final demand.

(2) $$GRO^{ILW} = (I - A^{ILW})^{-1}.FD^{ILW}$$

Labour Market Block

The labour market block provides a number of important links between a region's economic and demographic structures. To begin with, unemployment rate in the region is modelled stochastically as a function of the national rate and regional unemployment lagged to capture the regional adjustment process:

(3) $$\mathrm{UNR}_t^{ILW} = f_{\mathrm{UNR}}(\mathrm{UNR}_t^{AU}, \mathrm{UNR}_{t-1}^{ILW})$$

Where UNR_t^{ILW} is unemployment rate in the Illawarra in time *t*, UNR_t^{AU} is national unemployment rate in time *t*, and UNR_{t-1}^{ILW} is lagged regional unemployment rate of the Illawarra.

Employment levels in every industry are then estimated from the ratio of gross regional output to employment ratio as following:

(4) $$GRO_{it}{}^{ILW} \Big/ EMP_{it}{}^{ILW} = \beta_{0i} + \beta_{1i} GRO_{it}{}^{ILW} + \beta_{2i} \left(GRO_i{}^{ILW} \Big/ EMP_i{}^{ILW} \right)_{t-1}$$

Where $GRO_{it}{}^{ILW}$ is the gross regional output of sector *i* in time *t* and $EMP_{it}{}^{ILW}$ is the employment in sector *i* in time *t*. Average production per employee can vary with level of value-added, which is composed of gross operating surplus; income payments; over-time; and taxes.

Aggregate regional employment can then be calculated from summation of all sectoral demand equations from employment block as following:

(5) $EMP_t^{ILW} = \sum_{i=1}^{n} EMP_{it}^{ILW}$

Where EMP_t^{ILW} is the total employment in the Illawarra in time *t*. Total labour force is a function of labour demand and it includes both persons working or actively looking for work in the region can be calculated as following:

(6) $LF_t{}^{ILW} = \beta_0 + \beta_1 LF_{t-1}{}^{ILW} + \beta_2\, EMP_t{}^{ILW} + \beta_3\, EMP_{t-1}{}^{ILW}$

Where $LF_t{}^{ILW}$ is the total number in the labour force in time *t*. Labour force participation rate can then be estimated from the following:

(7) $LFPR_t{}^{ILW} = \beta_0 + \beta_1 LFRP_{t-1}{}^{ILW} + \beta_2 Lf_t{}^{ILW} + \beta_3 LF_{t-1}{}^{ILW} + \beta_4 EMP_t{}^{ILW}$

Where $LFPR_t{}^{ILW}$ is the regional labour force participation rate in time *t*. Furthermore, since labour force is the portion of population that is either working or looking for work, working age population can be then estimated from the following:

(8) $PPLW_t{}^{ILW} = \left({LF_t{}^{ILW}} \big/ {LFRP_t{}^{ILW}} \right) \times 100$

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. For the Illawarra region, total population in can be estimated from:

(9) $PPL_t{}^{ILW} = \beta_0 + \beta_1 PPL_{t-1}{}^{ILW} + \beta_2 LF_t{}^{ILW}$

There are three population groups for the demographic block: number of children below 15; number of people on aged or invalid pensions; and number of people who receive unemployment benefits. Number of children less than 15 is derived from the total and working age population:

(10) $PPLCH_t{}^{ILW} = PPL_t{}^{ILW} - PPLW_t{}^{ILW}$

Number of persons who are receiving aged or invalid pension can be estimated from:

(11) $PPLPEN_t{}^{ILW} = \beta_0 + \beta_1 PPLPEN_{t-1}{}^{ILW} + \beta_2 PPL_t{}^{ILW} + \beta_3 PPL_{t-1}{}^{ILW}$

Number of persons who are receiving unemployment benefits can be estimated from:

(12) $UNEMPBEN_t{}^{ILW} = \beta_0 + \beta_1 UNEMPBEN_{t-1}{}^{ILW} + \beta_2 UNEMPBEN_t{}^{ILW} + \beta_3 UNEMP_{t-1}{}^{ILW}$

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

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

Income Block

Wages need to be calculated based on industrial sectors to be implemented in our IO table but income block components can be estimated on aggregate level. Average wage rate in industry *i* in year *t* is estimated from the following:

(14) $$AWR_{it}{}^{ILW} = \beta_0 + \beta_1 GRO_{it}{}^{ILW} + \beta_2 EMP_{it}{}^{ILW} + \beta_3 LF_t{}^{ILW}$$

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 obtained from:

(15) $$W_{it}{}^{ILW} = AWR_{it}{}^{ILW} \times EMP_{it}{}^{ILW}$$

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

(16) $$W_t{}^{ILW} = \sum W_{it}{}^{ILW}$$

Income from dwelling rent deflated by the regional housing price index is estimated from:

(17) $$IDR_t{}^{ILW} / PPL_t{}^{ILW} = \beta_0 + \beta_1 \left(IDR_{t-1}{}^{ILW} / PPL_{t-1}{}^{ILW} \right)$$

And then income from government transfers, which is composed of aged and invalid pensions, family allowances, scholarships, unemployment benefits, etc., can be estimated from:

(18) $$IGT_t{}^{ILW} / PPLBEN_t{}^{ILW} = \beta_0 + \beta_1 \left(IGT_{t-1}{}^{ILW} / PPLBEN_{t-1}{}^{ILW} \right)$$

Then all other income, which is composed of dividend payments, interest payments, third party insurance transfers, grants, transfers from overseas, etc., can be estimated by the following:

(19) $$OI_t{}^{ILW} / PPLW_t{}^{ILW} = \beta_0 + \beta_1 \left(OI_{t-1}{}^{ILW} / PPLW_{t-1}{}^{ILW} \right)$$

Total income before taxes paid are estimated from summation of (18), (19), (20), and (20):

(21) $$TI_t{}^{ILW} = W_t{}^{ILW} + IDR_t{}^{ILW} + IGT_t{}^{ILW} + OI_t{}^{ILW}$$

Total income after taxes are paid can then be estimated from:

(22) $$TIT_t{}^{ILW} / EMP_T{}^{ILW} = \beta_0 + \beta_1 \left(W_t{}^{ILW} / EMP_t{}^{ILW} \right)$$

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

(23)

$$TOTD_t{}^{ILW} / PPLW_t{}^{ILW} = \beta_0 + \beta_1 \left(TOTD_{t-1}{}^{ILW} / PPLW_{t-1}{}^{ILW} \right) + \beta_2 \left(TI_t{}^{ILW} / PPL_t{}^{ILW} \right)$$

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

(24) $$DISI_t^{ILW} = TI_t^{ILW} + TIT_t^{ILW} + TOTD_t^{ILW}$$

Consumption Block

Total household consumption expenditure can be estimated from the following:

(25)

$$\ln\left({CEX_t^{ILW}}/{PPL_t^{ILW}} \right) = \beta_0 + \beta_1 \ln\left({DISI_t^{ILW}}/{PPL_t^{ILW}} \right) + \beta_2 \ln\left({CEX_{t-1}^{ILW}}/{DISI_{t-1}^{ILW}} \right) + \beta_3 \ln\left({CEX_{t-1}^{ILW}}/{PPL_{t-1}^{ILW}} \right)$$

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

(26)

$${CEX_{it}^{ILW}}/{PPL_t^{ILW}} = \beta_0 + \beta_1 \left({CEX_{it-1}^{ILW}}/{PPL_{t-1}^{ILW}} \right) + \beta_2 \left({CEX_t^{ILW}}/{PPL_t^{ILW}} \right)$$

And lastly, total household savings is estimated by subtraction of disposable income and total household consumption:

(27) $$SV_t^{ILW} = DISI_t^{ILW} - CEX_t^{ILW}$$

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.

Application of the Model

In the integrated EC-IO model for the Illawarra, the dynamic characteristic of the time-series is introduced to an IO analysis to improve the accuracy of the static IO model, with an added advantage of policy scenario analysis capability. If the model is to be used for a longer period, equations with short-haul and more linear characteristics are preferred. The results of a set of predictions of the model are shown in Figure 1, Figure 2 and Figure 3.

It is important to mention that the results of this modelling are mainly focused on endogenising the household sector. The rest of the final demand components were treated exogenously and the intermediate coefficients of the IO model were on a ceteris paribus basis in terms of technological advancements. A significant variance is noticed in accuracy of the standalone IO with the actual figures in terms of gross regional product and gross output. In standalone IO model, employment is overestimated while wages are underestimated, emphasising the restrictive assumption of the constant returns to scale. This nullifies the fact that industries can mostly increase production without proportionate increases in employment.

Figure 1

Actual & Estimated Gross Regional Product

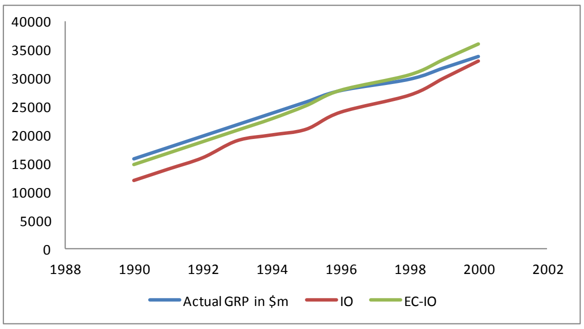


Figure 2

Actual & Estimated Employment ('000)

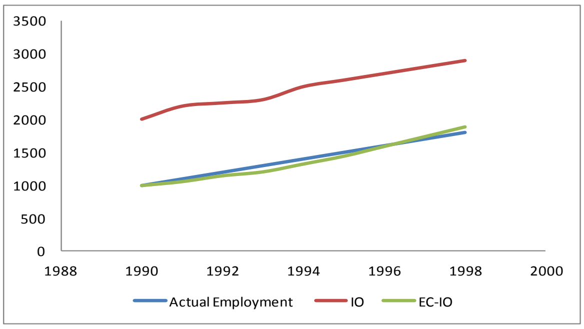
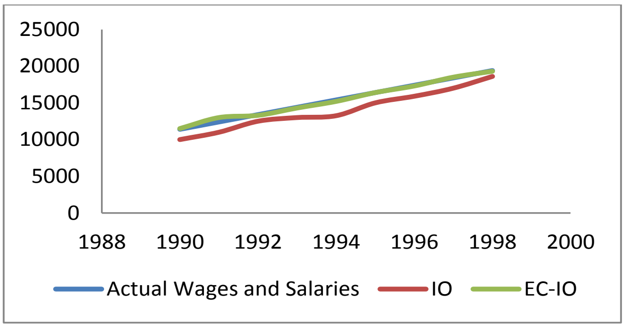


Figure 3

Actual & Estimated Wages and Salaries $M



Source: estimated by the author.

Conclusion

This paper presents a stepping stone towards the construction of an EC-IO model for the Illawarra region of New South Wales. We have examined the theory and practice of integrated EC-IO 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. A brief summary of this paper can be explained in two broad classes:

a) The application of an integrated EC-IO model at the regional scale: Implementation of integrated framework at the regional scale is inevitably a strenuous attempt. 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.

b) The comparative performance of integrated EC-IO model with the standalone IO model: the integrated EC-IO model outperforms the traditional IO model in terms of accuracy regional income and total employment modelling. In terms of disaggregated sectoral employment estimation, the integrated EC-IO model dominated the standalone IO model.

Overall, this paper identifies a finding which has the highest impact on the practice of regional integrated modelling. The integration framework showed superior accuracy as compared to the traditional IO model, which is due to the use of time-series data in order to reduce the variance of the resulting estimates.

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