An Economic Activity Perspective of South East Queensland and Boundaries of Urban Areas

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Abstract: Cities in general are known as centres of consumption, pulling into their boundaries the natural resources they need. However, simultaneously cities and their regions are centres of production. To ensure the resilience of a region in front of unknown future economic or environmental shocks, it is necessary to take into account both of these functions and search for best fitted local solutions. This paper explores the overarching topic of what are the balanced sustainable options for regional development to build a more resilient and more environmentally sustainable economy in South East Queensland (SEQ), in light of the socio-economic data available. In particular it examines which industries could provide pathways for a resilient and sustainable economy. To do this, it draws on related methods developed for evaluating sustainability of economic activities in a region: the urban metabolism and extended input-output analysis (IOA) in the form of a type of 'triple bottom line' analysis. The paper also explores the issue of relevant boundary setting in this type of analysis based on data from SEQ region. The paper concludes with the identification of the *Manufacturing* and the *Professional, scientific and technical services* sectors as areas of activity needing further investigation. It challenges the view that manufacturing is a dying industry and calls for more in-depth studies of the connections between this industry and others.

Economic resilience: the nexus of the urban metabolism, economic structure and urban form analysis

Economic resilience requires that regions are involved in a sufficiently diversified range of activities and produce goods and services for local and foreign markets). At the same time an economic system puts pressure on the environment. To elucidate the connections and the best points of intervention to reduce impact of economic activities on the environment, an Australian National Sustainability Council report emphasizes the lack of local comparable data and the need to connect indicators of sustainability, alongside natural capital sustainability indicators (Australian Government National Sustainability Council, 2013)[1]. Using a land use planning viewpoint a local community's performance in economic terms could employ spatially detailed information and report back on indicators such as migration figures, employment by industry and location, commuting flows, co-location (agglomeration) benefits for industries, energy efficiency improvements for households and transport (e.g. Department of Infrastructure and Transport, 2013; Newman, 2006). While this type of analysis can reveal information on various factors that impact on the economic system, in order to

[1] Indicators of sustainability such as employment rates, under-employment, unemployment, hours worked and employment to population ratios, and natural capital sustainability indicators such as air quality and GHG emissions, followed by energy intensity, carbon stored in the landscape or observed climate change.

better design desired outcomes and apply them, an understanding of the inter-dependence of local economic (industrial) activity is necessary as well.

A city can function much like a system and the notion of the urban metabolism reflects this (Wolman 1965; Decker et al, 2000; Kennedy et al, 2007)[2]. They are both production and consumption spaces with energy being consumed in both processes. Their environmental impact cannot be considered based on energy use totals alone, but rather in connection with the type of activity where it is used. Some cities or regions are net production centres (industry oriented), while other regions are net consumption centres (service sector predominates), functioning as net sinks for resources embodied in the goods and services they consume. For example, when discussing the impact of a region in terms of its sustainability measured in terms of energy use or GHG emissions, it is necessary to consider whether the region is a net production or a net consumption region (Wiedmann, 2012; Baynes et al., 2011). Cities, regions and countries that are net producers (e.g. export products) can benefit from a consumption-based analysis of natural resources used or GHGs emitted: account only for local consumption. For more efficient energy or water use, reduced GHG emissions, as well as increased government revenue, or more employment and income generation, best planning outcomes can come from identifying the key levers in the production-consumption chain where action would lead to desired results.

While in essence the urban metabolism, as a sub-set of the socio-ecological metabolism, was an analysis of the "closed box", the totality of processes within the city, efforts to unpack this box and understand its processes have given rise to alternative ways to analyse and understand the metabolism: some evolving from the perspective of industrial ecology following the causes of the processes towards a blend of methods including urban form analysis (land use planning), and some from a more 'holistic' economic processes method (based on input-output analysis). The desire to unify these perspectives and draw these local and spatial connections (relevant to policy makers) has brought about theoretical foundation advancements: inclusion of infrastructure[3] as part of the socio-ecological system/metabolism: the socio-ecological infrastructure system (SEIS) (Ramaswami et al., 2012). Agreement is forming in literature that uniform data collection and comparable indicators need to exist on the urban metabolism, relevant economic activities and other connected factors ((Kennedy et al., 2009; Dhakal and Shrestha, 2010; Kennedy et al., 2011; Kennedy and Hoornweg, 2012). In this sense the following sections explore some of the standardized indicators that could be used in evaluating and analysing a regional economy.

Structural analysis of the impacts of growth in one sector to generate additional employment, income or government revenue in other sectors (whether in employment, income, or others) can be done through methods relying on input-output data extended with relevant satellite data. In order to estimate the impact at regional level of policy actions to encourage one industry above another in terms of these factors, first it is necessary to identify local key industries as contribution to gross regional product, their employment, their development over recent periods and so on. A 2005 study developed a method to combine socio-economic and environmental indicators in a form of 'triple

[2] A type of urban sustainability analysis, applied for cities in their various forms, it is a concept developed by industrial ecologists and urban system analysts to account for total materials and/or energy stocks and flows at local community scale (basic concept; Wolman 1965; conceptual development: Decker et al 2000; methodology: EUROSTAT 2001; boundaries: Kennedy et al 2007; applications to urban planning: Kennedy et al 2011).

[3] Infrastructure is not just transport related, but it refers to the various types of infrastructures necessary to provide services in cities including: water / waste management, energy provision, transportation, food, shelter (materials for providing shelter).

bottom line' accounting for almost each industry in the Australian national economy, including full supply upstream environment, financial and social impacts quantified in terms of ten indicators among which are primary energy, employment generation and income (Foran et al., 2005). There are few studies at the local level (sub-national) that have considered the economic interdependence between industry sectors (their activities' impact on other sectors' employment generation, payment of wages, government revenue production) and the connection with environmental factors such as (primary) energy use and GHG emissions in these economic processes. A recent attempt at local level is a study on Wollongong's broader region of Illawarra using input-output data to discuss the multiplier effect of local industries in terms of employment and gross regional product (Harvie et al., 2011). Household related consumption impact studies for cities are more frequent: energy use for Sydney (Lenzen et al., 2004), for Sydney and Melbourne (Baynes et al., 2011), employment, turnover CO_2 emissions and water use for Sydney and Melbourne (Lenzen and Peters, 2010).

For Brisbane or the region of South East Queensland (SEQ), this type of analysis ('triple bottom line') was not yet carried out and if it were, first the relevant activity boundary and definition of metropolitan Brisbane would have to be considered (see next section) [4]. In absence of a 'triple bottom line' analysis at regional level, this paper is carrying out a preliminary analysis using intensity factors calculated for industries at national level. These values are used in absence of more specific local estimates and it is not expected these values will hold when SEQ specific analysis will be undertaken. Other data on Brisbane or the South-East Queensland employment and other indicators were extracted from a literature review of relevant studies and reports. Setting absolute benchmarks of sustainability or economic resilience are not in the scope of this paper, as they depend on the level of economic sustainability that a country and a region as part of a larger system wants to achieve. The discussion here only notes performance in relative terms (i.e. which sectors appear to perform better than others).

This work is focused on drawing connections between methods of analysing economic resilience and sustainability of a region taking into account sociological and environmental considerations into account. In order for IO analysis to be relevant, this paper explores the issue of analysis boundary setting and the information that one particular dataset can reveal on the best boundary options for SEQ[5]. Adding spatial detail to IO analysis and being able to draw connections between economic activities analysis and urban form factors would help the local decision makers (government, planners) to benefit from insight into the underlying causes/trends of processes observed in cities that input-output data can provide (see a summary of current literature and trends in modelling development with regard to environmental sustainability in Baynes and Wiedmann, 2012).

[4] An early attempt at monitoring the SEQ region development based on a range of factors pertaining to metabolism analysis never quite took off: a potential SEQ model was described in Stimson et al (1998) and later in Stimson and Simpson (2001).

[5] Other economic data sets with spatial information were looked for, but not many appear to exist or were not accessible the author at the time this research project was undertaken. The set used here, ABS 8165, has transformed based on the new spatial classifications – the ASGS, making comparisons with older data take longer to perform. Also, energy use data is only reported at state level by the Bureau of Resources and Energy Economics (and previously by ABARE). Discussing household impact, household expenditure data of ABS used to be spatially disaggregated to SD level until 1998-99 sets and then lost this detail in following years. The only spatial distinctions now are between states, capital city dwellers or not and urban versus rural.

The urban system and spatial scale of analysis: Brisbane and SEQ

Geography of economic development matters for future planning of the economy and analysis of its trajectories. Focusing too narrowly on the city, the broader picture of the region and connections between sectors could be missed. For example, (Barles, 2009) found the analysis of Paris' metabolism and its surrounding suburban area was not enough and had to modify the scale analysis to include a level of urban sprawl and agricultural area (Ile de France)[6].

For the urban metabolism the boundary used as the relevant one for urban areas has oscillated between being curtailed at the administrative boundary (e.g. (Niza et al., 2009) for Lisbon and extended to metropolitan level (e.g. Ramaswami et al., 2008), regional (Baccini, 1996; Kennedy et al., 2007; Barles, 2009 for Paris or Paris and surroundings), urbanized – built-up area (Dhakal, 2009) or national (Lenzen and Peters, 2010; Baynes et al., 2011) to include relevant functional information. More recent literature has recommended that when limiting the metabolism or sustainability analysis (e.g. as inventories of energy use or GHG emissions) at the administrative boundary, to add relevant context from partial trans-boundary supply chains information (Baynes and Wiedmann, 2012). This piece of information can come from studies in the style of the 'triple bottom line' accounting for an industry (e.g. Foran et al., 2005), environmental impact only studies (such as Dey et al., 2007) or, studies in a similar manner for a product or group of products (environmental IO-based life cycle assessments): e.g. for concrete or food used in cities the total embodied energy or GHG emissions in production. Examples in literature of this type of EIO-LCA assessments are: for industries the USA (Matthews and Small, 2000)[7] or for particular products in two different countries (Lenzen and Wachsmann, 2004).

Australian cities are not only the home, place of employment, space where goods and services are traded or recreation spaces for 85% of the population, but also economic centres for much of the national economic activity. The city of Brisbane is located in a broader region of tight socio-economic relations, namely South East Queensland (SEQ). While the extent of the SEQ region can be defined in several ways, in this work it is limited by the area under statutory regulation by the SEQ Regional Plan 2009 – 2031 (Queensland Government, 2009). South East Queensland forms a large part of Queensland's economic activity. For SEQ in 2011 the Gross Regional Product (GRP) was of about $170 billion, close to 65% of Queensland's GRP, growing over the previous 10 years, although at a slower pace since 2006 (ibid.). SEQ has about 1.6 million workers (or 70% of the workforce in Queensland) and about two thirds of them work in Brisbane (ibid.).

[6] Results showed the city centre of Paris exports its waste and concentrates food consumption, while the surrounding region (rural and suburban) uses higher levels of construction materials and fuel.

[7] Other examples of EIO-LCA can be founf on the Carnegie Mellon University website on Economic Input-Output Life Cycle Assessment, http://www.eiolca.net, last accessed: 1st of November 2013

The SEQ region is formed out of several local councils, out of which Brisbane Local Council is the smallest geographical unit to which an analysis of Brisbane can be limited (see figure 1). Another way of defining Brisbane is the former metropolitan area or statistical district, or, the current Greater Capital City Statistical Area unit, defined as a socio-economic extent unit for the Australian State and Territory capital cities, without a population criterion. The definition is functional rather than spatial: "includes people who regularly socialise, shop or work within the city, but live in the small towns and rural areas surrounding the city. The GCCSA definition is not that of the built up edge of the city", but apparently it defines distinct labour markets[8]. While the definition of the ABS does not go into further detail, future definitions of Brisbane labour market could be performed to take into account the transport time it takes to get to the place of employment – effective job density (as in the analysis for Melbourne in (SGS Economics and Planning, 2012)).

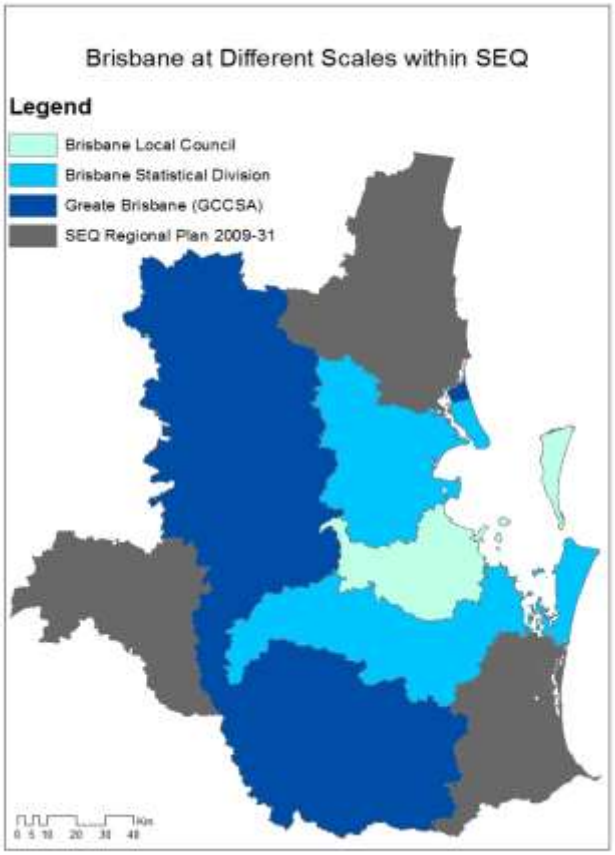

Figure 1. Potential variation in scale of analysis for Brisbane city

Economic resilience needs a variety of sectors developing within an area, but policy-makers also need to identify which sectors within their own regions appear best placed and could lead to further regional growth. In the 2007 State of the Environment report there were nine industries that were identified to have "the capacity to contribute significantly to the state's future economic prosperity": *Information and communication technology*, *Aviation and aerospace*, *Business services*, *Marine industry*, *Environmental technologies, goods and services*, *Creative industries*, *Biotechnology, pharmaceuticals and nutraceuticals*, *Advanced manufacturing*, *Clean coal technologies*[9]. (Queensland Government Environmental Protection Agency, 2007). Five years later, in 2012, the goal for the Queensland state elections was narrower: growing the state economy along "a four pillar economy through focussing on Tourism, Resources, Agriculture and Construction" (Liberal National Party 2012). The diversity of industrial sectors for SEQ remained rather constant over the 2001-06 period (Bureau of Infrastructure Transport and Regional Economics, 2013), yet more recent events might have been prompted by a change of the local economic structure. An extended input-output data analysis in the form of a 'triple bottom analysis' can reveal beyond the current structure of the local

[8] The older geographical standard defined a metropolitan area and set its extent to that of a statistical district for capital cities such as Brisbane (ASGC, (ABS) AUSTRALIAN BUREAU OF STATISTICS 2011. 1216.0 - Australian Standard Geographical Classification. *In:* STATISTICS, A. A. B. O. (ed.).). The new er classification made metropolitan area definition obsolete and has replaced it w ith the Greater Capital City Statistical Area (GCCSA) (the new Australian Statistical Geography Standard (ASGS, (ABS) AUSTRALIAN BUREAU OF STATISTICS 2011. 1270.0.55.001 - Australian Statistical Geography Standard (ASGS): Volume 1 - Main Structure and Greater Capital City Statistical Areas.)

[9] The 2011 State of the Environment report did not identify any particular direction for the future of the economy in Queensland (Queensland Government 2011).

economy, which sectors are better situated for a balanced, sustainable growth of the regional economy.

Analysing key industries evolution: boundary of analysis

Data on the numbers of businesses entries and exists from the market and their turnover can point to industries or sectors that are suffering or are thriving over a period of time. Having data with geographical information is key to local or regional analysis and much economic data unfortunately can overlook or lose spatial detail over time. In this paper, data from Australian Bureau of Statistics was used to explore rises and falls in the numbers of businesses in SEQ, for *Manufacturing*, *Construction* and *Professional, scientific and technical services* over the period of the financial crisis, during 2009-12[10]. There is a focus on *Manufacturing* because of its image as an underperforming sector. The *Construction* sector was a high employer during the previous decade and is also a target sector for economic growth foundations in current policy. *Professional, scientific and technical services*[11] were selected because they tend to be considered as low-impact in environmental terms (total direct and embodied energy use appears lower for these industries), but provide higher than average wages and employ highly skilled services which, if thriving, could indicate the existence of niches (comparative advantage) of local service providers.

Table 1. Change in numbers of businesses at different spatial scales (made by author based on ((ABS) Australian Bureau of Statistics, 2012))

Manufacturing	Brisbane Local Council	Brisbane SD	Brisbane SD remainder	Brisbane GCCSA	Brisbane GCCSA remainder	SEQ	SEQ remainder
2009 Total	4264	8359	**4095**	8643	**284**	13916	**5273**
2012 Total	4052	7801	**3749**	8114	**313**	12891	**4777**
Change 09-12 [no]	-212	-558	**-346**	-529	**29**	-1025	**-496**
Change 09-12 [%]	-4.97	-6.68	**-8.45**	-6.12	**10.21**	-7.37	**-9.41**
Construction							
2009 Total	15300	32833	**17533**	33931	**1098**	57209	**23278**
2012 Total	15212	31688	**16476**	32734	**1046**	54686	**21952**
Change 09-12 [no]	-88	-1145	**-1057**	-1197	**-52**	-2523	**-1326**
Change 09-12 [%]	-0.58	-3.49	**-6.03**	-3.53	**-4.74**	-4.41	**-5.70**
Professional, Scientific and Technical Services							
2009 Total	17157	23571	**6414**	23873	**302**	34884	**11011**
2012 Total	18548	25383	**6835**	25705	**322**	37387	**11682**
Change 09-12 [no]	1391	1812	**421**	1832	**20**	2503	**671**
Change 09-12 [%]	8.11	7.69	**6.56**	7.67	**6.62**	7.18	**6.09**

Brisbane City Council Local Government Area counted a number of 121,564 businesses in June 2011 and the Greater Brisbane a number of 189,212. Using data on business entries and exists from the

[10] Another study found niches of particular sectors (specialisation) in certain areas based on a location quotient (dividing the percentage of employment in the sector of the total employment in the region to the national average employment for that sector), but only focused on the one year data rather than trends (Bureau of Infrastructure Transport and Regional Economics 2013).

[11] Which include scientific research, architecture, engineering, computer systems, design, law, accountancy, advertising, market research, management and other consultancy, veterinary science and professional photography (ANZSIC classification in ABS 2006)

market in the area of SEQ, the change in distribution of registered businesses over the 2009-12 period can be seen (Figure 2 and Table 2). As previously discussed, there are several potential scales of analysis which are relevant at different scales of economic or land-use planning. Here the results of the fluctuations in businesses' numbers are given according to several regions mentioned above and *derived* from the standard definitions: Brisbane SD Remainder stands for the area of Brisbane statistical district excluding (cutting off) the area of Brisbane Local Council; Brisbane Greater Capital Area (GCCSA) remainder stands for the Brisbane GCCSA excluding the area of Brisbane statistical district; South East Queensland (SEQ) remainder stands for SEQ area excluding that in the Brisbane GCCSA.

For *Manufacturing* businesses, Brisbane Local Council area showed a mixed pattern in the evolution of the numbers of businesses, but with a distinct decreasing trend. On the overall in SEQ the number of *Manufacturing* businesses has been decreasing, however the area of Greater Brisbane without the former metropolitan Brisbane (Brisbane GCCSA remainder) shows significant gains in total number of active businesses (see figure 2). The *Construction* businesses numbers appear to have had decreased all over SEQ during the study period. By comparison, *Professional, scientific and technical services* companies' numbers have shown increases in most Brisbane areas of SEQ. There is then scope to consider whether some businesses have re-located, or whether commuting patterns have changed, or whether particular areas form zones of increased business types diversity, pointing to a more resilient local economy. As it will be seen in the next section, particular industries tend to have higher intensities in terms of their socio-economic and/or environmental impact. For example, using the intensity factor for employment it can be estimated how much an industry is likely to contribute to the self-sufficiency of job availability in an area. The intensity together with observed changes in the types and numbers of businesses of one industry can be used to explain and model future changes in the economic structure of the region.

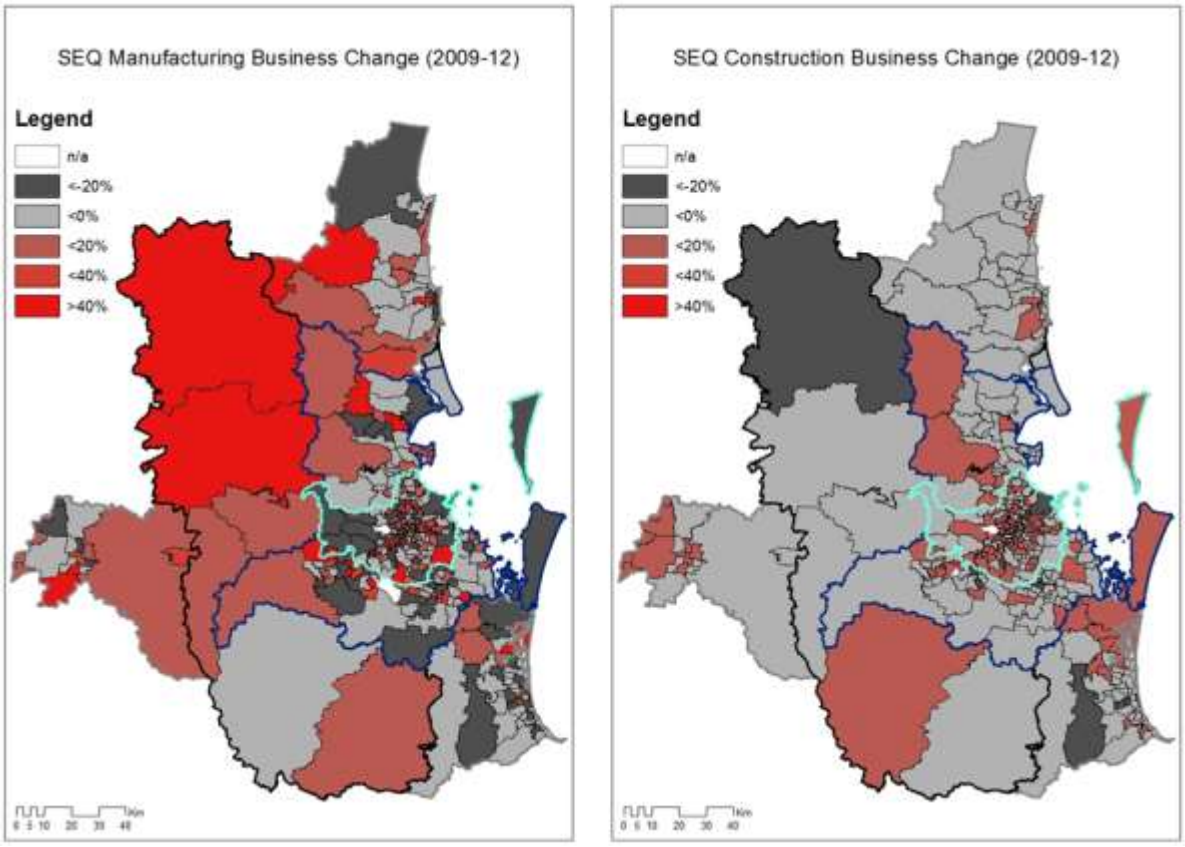

Figure 2. Manufacturing and Construction registered, active businesses' numbers change in SEQ over 2009-12 (analysis made by author based on ((ABS) Australian Bureau of Statistics, 2012).

Industries for economic and environmental sustainable futures in SEQ

In 2006 a cross-sectional analysis showed the **highest employing (top number of employees)** sectors in Brisbane to be *Property and business services* (in the inner suburbs) and *Retail services* (for all others) (Bureau of Infrastructure Transport and Regional Economics, 2013). These two sectors also saw the highest growth in number of jobs during the previous five years for SEQ, although for Brisbane (and for a wider span 2001-2011) *Health care and social assistance* added 19% and the *Construction* sector added 14% new jobs. The picture for SEQ in 2006 was not much more diverse than Brisbane, only West Moreton having *Agriculture, forestry and fishing* as the main employing industry, this industry also the only one to see a decline in employment during 2001-06. Strongholds for employment growth differed across SEQ to a large measure: inner Brisbane growth was driven by *Government administration and defence*, while the middle and outer suburbs were driven by *Health and community services* and *Retail trade* respectively. Gold Coast's growth niche was in the *Construction sector*, for the Sunshine Coast and West Moreton it was *Retail trade* and for Toowoomba it was *Health and community services* (ibid.).

Analysing employment rates, or employment generated by an industry is regularly one of the factors to contribute to setting targets for economic development. Across all major Australian cities over the 2001-11 period, decline in employment in *Retail* and *Manufacturing* was observed, but increases occurred in *Public administration and safety*, and, the *Accommodation and food services* sector (Department of Infrastructure and Transport, 2013). However this period includes an economic boom period and a period of slow-down after the start in 2008 of the Global Financial Crisis. Queensland

economy in particular had a boom period during 2001 – 2006 with growth rates of 27%, while the Australian economy expanded by 15.8% (Queensland Government Environmental Protection Agency, 2007). In terms of rapid growth during 2001-06 *Mining*, *Construction* and *Government Administration* were key sectors in SEQ, with 10.5%, 8.8% and 7.5% per annum employment growth (Bureau of Infrastructure Transport and Regional Economics, 2013). In Brisbane, in 2011, resided 7% of total mining sector employees, fifth largest group of urban dwellers mining sector employees with half of them working in the inner suburbs of Brisbane[12] (Bureau of Infrastructure Transport and Regional Economics, 2013, Department of Infrastructure and Transport, 2013).

Not just the number of jobs, but also the growth rate of employment can indicate how quickly an industry is taking off, collapsing or transforming. A slow-down in some sectors might have occurred during 2006-11, partially due to the global financial crisis and partially due to the extensive flooding in 2011. Brisbane saw the *Construction* and *Professional, scientific and technical services* as the top employment growth sectors between 2001-2006, but *Health care and social assistance* sector climbed to the top during 2006-2011 while the previous two sectors added only 8.5% and 3.8% of their previous five-years figure. A Bureau of Infrastructure Transport and Regional Economics (2013) report found that loss of manufacturing and logistics jobs in inner Brisbane was balanced by a growth in jobs in regions targeted for growth (ibid.) and office-based jobs in business or in the government increased outside the CBD for the 2001-11 period. Manufacturing was also deemed to be undergoing transformation, rather than be in decline becoming more involved in advanced manufacture and customized, knowledge-intensive products (Australian Business Chamber, 2011).

'Triple bottom line' analysis of industries

Additional to the above, the input-output data based 'triple bottom line' analysis can look at the various social, financial and environmental impacts and/or intensities of industries. At national level for Australia the Balancing Act has estimated the intensity of 135 sectors in terms of employment, income, government revenue or primary energy (MJ) (or others) per unit of Australian dollar of final demand and how this compares with the economy-wide average. An extended input-output analysis specific result is the potential to estimate how much employment or income (wages) a sector can generate at supplier level, or how much primary energy is used to cover total production in a particular sector. This type of analysis can be carried out (with appropriate data extensions) for impacts of economic activity on biodiversity (Lenzen et al., 2012), or other ecological aspects as well as other areas of society (e.g. impacts on human health[13] and so on). In Table 1, to keep the discussion focused on social rather than financial impacts of industries only two socio-economic intensity indicators were selected and as a sample of environmental impact, the primary energy use intensity numbers were quoted[14]. Total consumption of energy by fuel for Queensland showed that brown coal and petroleum products supplied about 80% of the energy requirements in both 2001 and 2005, so increased primary energy use can easily be connected to negative environmental impacts (such as GHG emissions). This information is also relevant to the incorporation of trans-boundary environmental impacts of cities (in analyses such evaluating the urban metabolism or urban GHG emission inventories). An illustration of how the data supplied by modelling the SEQ region economic

[12] The inner suburbs of Brisbane were: City Inner, Bowen Hills, Woolloongabba, South Brisbane, New Farm, Kangaroo Point, Highgate Hill, Spring Hill, Fortitude Valley, Newstead, West End, Paddington, Red Hill and others (city Remainder)

[13] Research in progress. See more at the Industrial Ecology Lab website: http://www.isa.org.usyd.edu.au/ielab/envHealth.shtml, last accessed 1st November 2013

[14] Government revenue estimates were recognized by the authors to underestimate or estimate results due to inherent data issues and thus not included here (see Foran et al 2005 for more detail). Also, other the author's focus is mainly on energy use and GHG emissions associated with urban areas, therefore other environmental factors were out of the scope of this preliminary analysis.

structure and the intensity of its various industries can serve to select groups of industries achieving regional goals is in Figure 3 (based on Lenzen, 1998 or Lenzen and Dey, 2002).

Table 2. Primary energy, employment and income (wages) intensity of selected industries (Foran et al., 2005) and average weekly wages ((ABS) Australian Bureau of Statistics, 2013)

	Primary energy: direct [MJ/FD$]	Primary energy: total [MJ/FD$]	Employment intensity: direct [min/FD$]	Employment intensity: total [min/FD$]	Income intensity: direct [$ paid / FD$]	Income intensity: total [$ paid / FD$]	Average weekly earnings
EWAT	7.65		1.75		0.34		1140.3
Black coal	1.53	4.98	0.19	0.59	0.08	0.18	
Iron ores	2.09	5.87	0.34	0.75	0.09	0.2	
Gold and lead	1.42	6.96	0.29	0.72	0.08	0.17	
Other mining	3	6.7	0.4	1.1	0.07	0.22	
Services to mining	0.38	2.67	0.48	1.1	0.16	0.29	2490.9
Household appliances	0.18	7.88	0.86	1.6	0.16	0.32	
Electrical equipment	0.22	7.67	0.9	1.55	0.17	0.31	
Motor vehicles and parts	0.41	6.33	0.67	1.41	0.12	0.27	1238.8[a]
Electricity supply	112.4	125	0.45	0.8	0.12	0.21	1746.4[b]
Gas production and distribution	9.51	11.55	0.59	1.13	0.15	0.27	1746.4[b]
Banking	0.01	1.68	0.92	1.47	0.23	0.34	1446.1[c]
Scientific and technical services	0.13	2.33	1.02	1.62	0.24	0.36	1458[d]
Retail trade	1.64	4.83	2.41	3.25	0.29	0.45	663.8
Accommodation, cafes and restaurants	0.66	5.77	1.4	2.26	0.2	0.37	542.9
Residential building	0.7	5.68	0.67	1.56	0.1	0.28	
Non-residential construction	1.34	5.24	1.63	2.3	0.24	0.38	1462.7[e]

Note: EWAT stands for economy-wide average total; FD is final demand; Average weekly earnings are at national level. a: Equated to *Manufacturing* average in the original set; b: Equated to *Electricity, gas, water and waste* services; c: Equated to *Financial and insurance* services average; d: Equated to *Professional, scientific and technical services* average; e: Equated to the *Construction* sector.

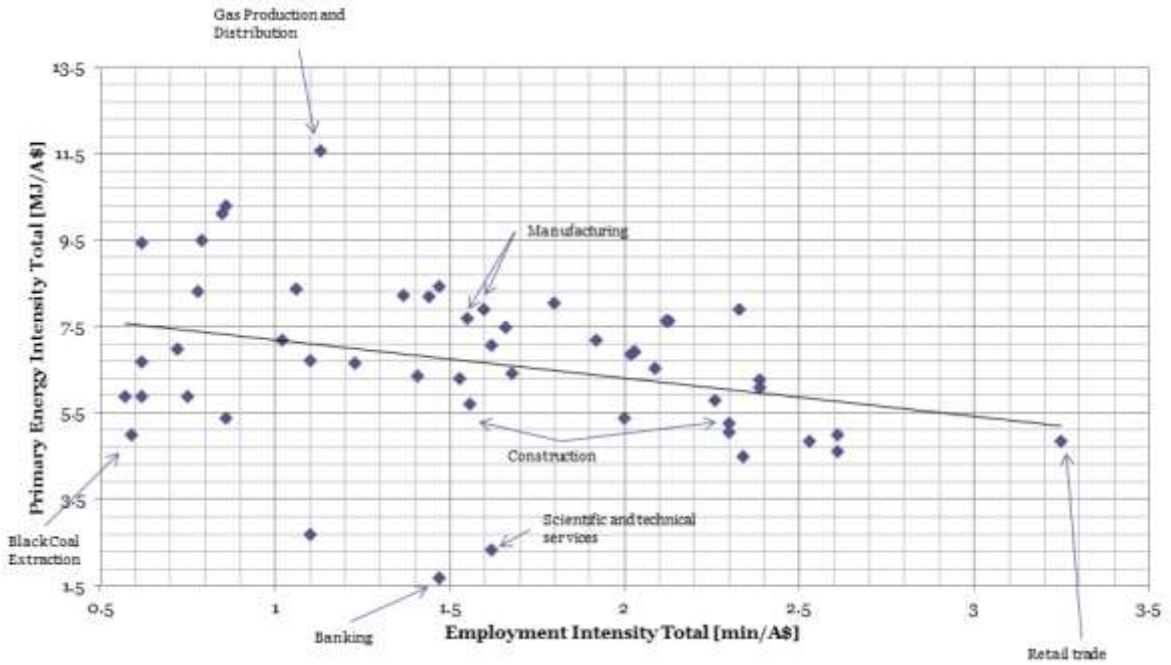

Figure 3. Employment intensity of industries versus primary energy intensity (data source: Foran et al., 2005, based on Lenzen, 1998 or Lenzen and Dey, 2002)

The triple bottom line analysis reveals the extraction industries create employment not only in their own sector, but total employment intensity estimates show that they generate two to three times the amount of minutes of employment in other industries, upstream on the supply chain. However, the average employment rates are quite small when compared to the national average. Industries that create high levels of employment within their sector and outside are *Retail trade* (above national average) and to a lesser degree the *Accommodation, cafes and restaurants*. *Scientific and technical services* industry appears as rather labour intensive industries directly and through its suppliers, as well as in terms of income generated for its employees. Knowledge-intensive jobs were shown to potentially bring about a spill-over effect in terms of job creation (Moretti, 2012). The 2013 State of the Australian Cities report notes an increasing trend in the Australian employment market in knowledge-intensive jobs which also are higher paying jobs, but which still make-up a relatively small proportion of total places of employment and tend to be concentrated in central areas.

Highly relevant for the social well-being of the community are not only the number of jobs created, but also the wages paid and increasing access to higher paying employment. Sectors like *Mining* that could easily be mistaken as mostly creating employment in non-urban areas, actually create high levels of employment and revenue in cities. *Mining* is the fifth largest group of urban dwellers with half of mining sector employees working in the inner suburbs of Brisbane (Department of Infrastructure and Transport, 2013). In Australia, higher paying jobs are concentrated in central areas of cities and inner suburbs were shown to be the most accessible, with accessibility of jobs decreasing radially from the city centre for Melbourne[15]. Taking the analysis beyond each sector's chain of production, the mining sector appears to generate less income (pay wages) per unit of dollar of final demand created than other sectors, the same is valid for suppliers and that the averages are small compared to national averages. Even though *Accommodation and food services* and *Retail trade* are high

[15] Location of jobs with added information, such travel time to the place of employment creates a so-called 'effective job density' indicator, which more accurately assesses the actual job availability ratio (e.g. Melbourne analysed in SGS Economics and Planning 2012).

employers in SEQ, they have some of the lowest weekly average wages. *Manufacturing* industries are not aggregated in the triple bottom line analysis, but the subdivisions show generally higher income intensity than *Mining*, but lower than sectors such as *Banking* or *Retail*.

In a 'triple bottom line' perspective of energy use, many industries are low direct energy users, but surprisingly high in terms of embodied energy use (e.g. the *Household appliances* (part of manufacturing), *Retail*, hospitality services or *Construction* in Table 1). During 1990–2010 direct energy intensity in the economy has declined for services, manufacturing, transport and residential sectors (0.3%, 0.3%, 1.3% and 0.3%) and has worsened (increased) for the mining and agricultural sectors (2.3% and 1.1%) (Australian Government National Sustainability Council, 2013). However, total energy use has increased over the 1980-2010 period for Queensland. The consumption ratio of the direct total net energy use has significantly increased for the electricity generation sector (21 to 36%), remained about constant for transport (26%) and decreased for *Manufacturing* (from 36 to 20%); *Mining*'s share increased from 2 to 6% and *Residential* share stayed about constant at 5% (Bureau of Resources and Energy Economics, 2012).

Discussion and Conclusion

It appears from comparing data on the industries present in the SEQ region that the industries that maximize gross regional revenue can be among the highest earners, but have negative environmental impacts, above average impacts for their supply chain (see mining sector industries in table 2), the highest employers can be some of the worst income earners and have considerably high energy use embodied in their supply chain (*Retail trade* and tourism related services). Low energy users can contain a considerable amount of energy embodied in their supply chain (e.g. Scientific and technical services which are comparable to Services to mining total values). *Accommodation and food services* and *Retail trade* are high employers in SEQ, they tend to employ above average number of people in the industry itself and considerably more in their suppliers, but there appears to be a tendency for *Retail trade* to shed jobs in recent years. *Manufacturing* represents an interesting case for a balanced sector in terms of environmental and economic indicators and perhaps a sector that should be added to the pillars of economic development in Queensland. It has higher than average embodied energy use in its supply chain, but also has seen improvements in its direct energy use; it has seen decreases in employment over the past ten years, but is still one of the highest local revenue earners in SEQ. It pays national average wages and reports indicate a tendency in specialization towards knowledge-intensive, product-service manufacturing which could attract even higher wages in the future. While easily dismissed as a declining sector due to employment figures, detailed localized analysis showed that hinterland areas of Brisbane Greater Capital Area have seen a potential re-location of activity even in the financial crisis years. Further targeted analysis could reveal land-use and economic planning measures that could support further development and competitive advantages of particular regions (increase job self-sufficiency rates, increase efficiency by connecting supplying industry partners or other economic and social benefits with positive environmental impacts). The right spatial boundary of analysis to apply for a city and its surroundings can vary from the administrative one, but geography and urban form (land-use planning) related factors definitely matter in understanding the structure and connections in local economies and plan for the evolution of a community towards resilient futures.

The Balancing Act report employing a form of 'triple bottom line analysis' of the Australian economy was used to explore structural economic linkages in the Australian economy and find their implications in terms of local development for Brisbane or South East Queensland. The concept of doing a 'triple bottom line' analysis is not new, but usually applied to a single corporation. Applications at local, sub-national scale are rare. Illawarra region is an example of how this type of thinking is being developed to support local decision makers. For long-term resilient economic development one option is to focus on industries that tend to be high revenue earners, large size employers (directly or indirectly) and low total energy intensity. However, national level estimates ignore local economic structure, local specialisation and further niches for development. In this type of analysis, physical proximity does not play any role, only the economic transactions create these connections. Sets of socio-economic or environmental intensity factors can be estimated for a specific region's economy, to allow a structural analysis of the industry's likely contribution to set targets.

Cities and their peri-urban areas form complex systems where their socio-economic activities and evolving geography continuously shape their development trajectories. Regions such as South East Queensland are highly urbanized and function as both production and consumption spaces, yet are either net producers or net consumers. Economic and environmental considerations need to blend in the planning of economic or land use development. More urban form linkage needs to be added to methods of urban metabolism analysis or extended input-output analysis to gain insight into the underlying causes/trends of processes observed in cities.

There have been limitations to this study due to the data availability and the labour intensity of necessary additional analysis. Further analysis can reveal whether local SEQ comparative advantages actually exist in industries such as Manufacturing, or services such as research. The effects of agglomeration and positive impacts such as spill-over of knowledge, availability employees and others due to geographic proximity or effects on the social, environmental or financial triple bottom line indicators of one industry growth (changes) over another could also be the focus of a more in-depth study to identify best trajectories for local South East Queensland economy.

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