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A CGE assessment of a university's effects on a regional economy: supply-side versus demand-side effects

by

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Abstract: In recent years many universities have commissioned studies of the effect of their institution on the local economy. Typically these impact studies have concentrated on the demand-side stimuli to the regional economy that the university generates. Normally, the studies are undertaken with comparative-static input-output models. The present study employs a dynamic multiregional computable general equilibrium model to investigate supply-side as well as demand-side effects. There are a range of supply-side effects that have been investigated in the spatial econometrics literature. The supply-side impacts of the university that we examine in particular are a rise in the average skill level of the local workforce, and successful R&D outcomes. CGE modelling allows simulation of the associated productivity effects, while the dynamic features of the model allow for consequent effects on a region's population and capital stock growth rates to be taken into account.

1. Introduction

There is long history of analyses of the impacts of universities on regional economies. Florax (1992, p.86) provides a list of over 40 studies of the economic impacts of expenditures related to universities, stretching back to 1964. Over the last fifteen years or so there has also been quite a number of quantitative studies on what Florax (1992) calls the "knowledge" impact of universities. Examples of such studies are Jaffe (1989), Anselin et al (1997 and 2000) and MacPherson (2002).

Florax (1992) categorizes the economic impact studies of university expenditure into four classes according to the methodology used: economic base models, Caffey and Issacs model, Keynsian multiplier models, and input-output models[1]. Florax (1992, pp. 96-99) also notes that there are a variety of methods for the assessment of knowledge impacts on a region. Quantitative regional studies of knowledge spillovers appear to be, in general, concerned with using surveys and econometric methods to assess the geographical impact of a university on R&D and innovation. Thus university expenditure analyses are concerned with direct and indirect impacts on regional economic variables such as gross regional product, private consumption, employment and sectoral output, while university knowledge analyses are concerned with identifying spillovers to variables like industrial innovation, often disaggregated by sector and geographical area.

In this paper we are concerned with assessing the impact on regional economic variables of a university both in relation to expenditure effects and knowledge effects within a single analytical framework. The framework we employ is a dynamic multiregional computable general equilibrium model. This type of model provides a more complete framework than previous models used to analyse expenditure impact effects. Computable general equilibrium (CGE) models incorporate not only interindustry linkages found in input-output, and endogenous final demand categories as found in extended input-output models, but also supply-constraints and price-responsive behaviour. The CGE framework also allows the impacts of knowledge spillovers on the economy to be modelled via shocks to technical

[1] For a brief explanation of these models, see Florax (1992, pp. 85-90). There have been numerous economic impact studies of universities since Florax conducted his review. Examples are studies of: the University of Waikato (Hughes, 1994); Lancaster University (Armstrong, 1993); the University of Nottingham (Bleany et al., 1992); the University of Portsmouth (Harris, 1997); and the University of Exeter (Coates, 1994). Examples of Australian studies are: Latrobe University (Michael 1996), Southern Cross University (Davis et al. 1996), the University of Western Australia (Greig 1997); the University of New South Wales (Milbourne et al. 1993), the University of Southern Queensland (Temple-Smith and Elvidge 1996), the University of Central Queensland (Zimmer 1992), the three South Australian universities (South Australian Vice-Chancellors, 1996) and the Curtin University of Technology (Cabalu et al., 1999). These studies have typically concentrated on the demand-

change variables. By using a dynamic CGE model we also have the advantage of being able to simulate the year-on-year effects of alternative University growth scenarios.

Impact studies of universities generally have a counter-factual of the university under examination discontinuing its existence (or alternatively, not being built). In some contexts this is a reasonable scenario. However, in other contexts, discontinuance of the university is not a plausible scenario. Such is the case with the university we examine in this paper. We study the University of Tasmania which is the only university in Tasmania, Australia's island state[2]. Instead of a university-closure counterfactual we examine a policy-relevant scenario, namely the effects of a higher growth path compared with the current planned growth path.

Rather than referring to expenditure and knowledge effects (the terminology employed by Florax, 1992), in the rest of this paper, we talk about modelling the "demand-side" and "supply-side" impacts of a faster growing University. Demand-side impacts relate to the *use* of goods, services and primary resources (such as labour and capital). Supply-side impacts relate to the *production* of goods and services. Examples of demand-side impacts include spending by the University on operating and capital budget items, living expenses of international students while studying in Tasmania, and spending by conference delegates while attending conferences organised by University staff. Examples of supply-side impacts include new products or higher productivity arising from R&D undertaken by University researchers, and higher labour productivity arising from the education of students.

Specifically, our modelling of the direct effects of the University's operations incorporate estimates of the following demand-side effects: (i) living expenses of retained Tasmanian students; (ii) living expenses of additional interstate students; (iii) living expenses of additional foreign students; (iv) operating and capital expenditure by the University; (v) spending by conference delegates; and (vi) spending by friends and relatives visiting overseas and interstate students. The supply-side effects modelled are: (i) successful R&D outcomes; and (ii) increasing the skills of the Tasmanian labour force. The above direct effects seemed to be the major ones amenable to quantitative analysis. We leave aside a number of effects

side stimuli provided to regional economic activity by university activities and, as with the pre-1992 studies, they employ relatively basic "comparative-static" input-output or regional multiplier models.

[2] Tasmania is located about 250 km south of the Australian mainland and has an area of 68,000 square kilometres (only slightly smaller than the Republic of Ireland, or a bit larger than the state of West Virginia), but a population of only around 480,000. The University of Tasmania has three campuses, one in each of the major population centres, about 150 to 200 km between each.

that might be considered to contribute to the welfare of the local community, but are difficult to consider in other than qualitative terms.[3]

2. The model

The actual model used is a two-region (Tasmania and the rest of Australia) implementation of the MMRF model of the Australian economy. Details of MMRF, which is a large-scale dynamic multi-regional CGE model, can be found in Peter et al. (1996)[4]. Here we provide just a very brief verbal description of MMRF's key features.

MMRF explicitly models the behaviour of economic agents within and between each region. The model features detailed sectoral disaggregation, with the version employed in this report containing 38 industries and commodities. Familiar neoclassical assumptions govern the behaviour of the model's economic agents. Each of the 38 representative industries operating within each of the two regions is assumed to minimise costs subject to constant returns to scale production technologies and given input prices. A representative utility-maximising household resides in each of the model's two regions. Investors allocate new capital to industries on the basis of expected rates of return. Units of new capital are assumed to be a cost-minimising combination of inputs sourced from each of the model's three sources of supply (the Tasmania, the rest of Australia, and foreign imports). Imperfect substitutability between the imported and two domestic sources of supply for each commodity are modelled using the CES assumption of Armington. In general, markets are assumed to clear and to be competitive. Purchaser's prices differ from basic prices by the value of a variety of indirect taxes and margin services. Taxes and margins tend to differ across commodity, user, region of source and region of destination. Foreign demands for each of the 38 commodities from each of the two regions of domestic supply are modelled as being inversely related to their foreign currency prices. The details of the taxing, spending and transfer powers of two levels of government are modelled: a regional government within each of the model's two regions, and

[3] These additional contributions include the experience of university life enjoyed by those Tasmanians who, without the presence of a local campus, perhaps would otherwise not have attended higher education. The University also supports a critical mass of highly educated intellectuals and professionals whose contributions to the Tasmanian community extend beyond their research and teaching activities. University staff inform and contribute to public debates on political, economic and social issues of importance to the state. They also represent the State – or inform those who do – in the State's dealings with agencies of other State governments, the Commonwealth government, and other bodies whose activities and decisions can have a bearing on the welfare of Tasmanians. University staff appear on hospital boards, professional bodies, economic development councils and the executives of many other community groups. The University itself is the custodian of significant community resources, such as the University library, and the John Elliott classics museum. The University arranges and hosts concerts, music recitals and theatrical performances which are open to the Tasmanian public.

[4] Peter et al. covers the version of MMRF with minimal dynamics. For discussion of the fully dynamic version of the model, see Adams, et al. (2000).

a federal government operating Australia wide. Inter-governmental transfer payments and personal transfer payments to households are also modelled. Dynamic equations describe stock-flow relationships, such as those between regional industry capital stocks and regional industry investment levels. Dynamic adjustment equations allow for the gradual movement of a number of variables towards their long-run values. For example, the national real wage is assumed to be sticky in the short-run, adjusting over a period of about five years to return the level of national employment to its base-case level following some economic shock. Equality of regional real consumer wages across regions is maintained through movements in labour between regions. Regional economic linkages arise from inter-regional trade, factor mobility, the taxing and spending activities of the federal government, and long-run economy-wide employment and balance of trade constraints. The model also evaluates a full set of national and regional income accounts, and associated deflators. The model is solved with the GEMPACK economic modelling software (Harrison and Pearson, 1996).

In order to examine the effects of faster growth of the University of Tasmania we conduct two sets of simulations. The first set of simulations are undertaken to produce a baseline forecast for the Australian economy for the period 2005 to 2020. These MMRF forecasts incorporate a wide variety of information including: macroeconomic forecasts from the Australian Treasury and other analysts; export volume and price forecasts from the Australian Bureau of Agricultural and Resource Economics; forecasts of tourist numbers from Bureau of Tourism Research; forecasts of tariff rates from the Productivity Commission; and forecasts of changes in technology and consumer tastes derived from national trends computed in historical simulations with the MONASH model[5]. Using this information the model generated forecasts for a wide range of variables.

Our forecasts are then repeated under the assumption that the University grows at a faster rate over the period to 2020. This involves the same set of shocks as imposed to generate the baseline forecast, plus an additional set of ("policy") shocks that incorporate the direct effects of the faster University growth. The new forecasts were then compared with the baseline forecasts. Results are reported as deviations (in either change or percentage change terms) of the higher university growth scenario for 2005 to 2020 from the baseline forecasts. Thus the results show the effects on the economy of a scenario in which the University of Tasmania is

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[5] For a discussion of the use of historical modelling to establish trends in unobservable variables, see Giesecke and Madden. The discussion there relates to FEDERAL-F simulations, where the same model is used for both historical and forecast simulations. MMRF is not well-equipped for historical modelling, so for MMRF forecasts, national trends in technologies and tastes uncovered with historical simulations with the MONASH model are used.

able to grow at a faster rate than in its current plan.

In the next section, the estimation of the additional shocks (direct effects of the faster University growth) is discussed.

3. Calculating the direct effects (shocks)

3.1 Demand-side effects

The University of Tasmania sets short and long term goals for student numbers, funding, etc. The University supplied us with their plans for these variables both under a growth-as-usual (or basecase) scenario and under a higher growth rate scenario. Using this information we then had to estimate expenditure figures of the six types of direct demand-side effects (shocks) listed in Section 1 of this paper. Giesecke (2005) provides considerable details (and numerous supporting tables) on these estimation procedures. Here, however, given space-considerations, we review just the main features of estimating the demand-side shocks.

The first three categories of direct effects relate to consumption expenditure (living expenditure, etc, but not fees) of extra Tasmanian, interstate and overseas students. In the case of the first category, the University provided basecase and faster-growth figures for the years 2004, 2010 and 2020 of the number of Tasmanian-schooled university students studying at the University of Tasmania and the number of these students studying at interstate universities. The 2010 and 2020 projections showed that under the growth scenarios less students would leave the state to study elsewhere and instead study at the University of Tasmania. Projections for the years between 2004 and 2010 and between 2010 and 2020 for these extra retained Tasmanian students were inferred by assuming smooth growth. Dollar figures for their consumption expenditure were estimated on the basis of (suitably inflated) consumption expenditure (including that made on their behalf by parents and others) per University of Tasmania student estimates available in CREA (1997)[6]. Estimated spending by the retained students results in increased Tasmanian household consumption of $3.0 million in 2005 rising to an increase of $26.1 million by 2020 (Australian 2004 dollars).

Consumption expenditures by additional interstate and overseas students under the faster-growth scenario were estimated in a similar manner. The University of Tasmania provided 2004 and projected 2010 and 2020 student numbers for both categories under both scenarios,

[6] The CREA estimates are for 10 main expenditure categories. Long and Hayden (2001) also provide data on the average level and composition of spending by all students for Australia in 2000. However, we did not use their figures as cost-of-living in Tasmania is lower than for Australia as a whole, and the Long and Hayden figures relate only to own expenditure. However, estimates with the Long and Hayden expenditure figures are quite similar to the ones based on CREA (1997).

and again the numbers for missing years were inferred assuming smooth growth. It was assumed that interstate students had the same level and pattern of living expenses as Tasmanian students. For foreign students, survey data was available by 15 commodity categories on average weekly expenditure by foreign higher education students from Australian International Education Foundation (1998). The survey was carried out by the Morgan Research Centre in 1997 and we again inflated the estimates to account for rising prices and real expenditure growth. By 2010 it was estimated that as a result of higher growth interstate students would add an extra $6 million to final demand and overseas students would be responsible for an additional $33.2 million. The corresponding figures for 2020 would be $14.1 million and $48.2 million.

The largest direct demand-side effect relates to the University's operating expenditure. Revenue funding this expenditure consists mainly of government grants (almost 60% in 2004), deferred-payment contributions by Australian students (17%) and fees and charges (14%). The University of Tasmania, like nearly all Australian universities, operates under state government legislation, but receives nearly all its institutional funding from the federal government. Although these funds are passed through the state government, we appropriately model them as federal government expenditure on education services. Australian students are required to contribute to their university education costs. Students can pay this contribution up-front (with a 20 per cent discount), but generally choose the option that the federal government makes payment at the time with the student deferring repayment until their income reaches a certain level when the amount is gradually paid off through a tax impost. International students and a small number of Australian students pay full fees. The fees and charges paid by international students are modelled as export demand for education services. Expenditure on university education is estimated to be $58 million above basecase expenditure by 2010, and $109 million above by 2020. The bulk of the estimated additional expenditure is by the federal government and foreign households ($81 million and $18 million respectively in the latter year).

The last two forms of expenditure, that by (interstate and overseas) delegates to university-hosted conferences and by friends and relatives of interstate and overseas students, are estimated to be of a fairly minor nature. Only limited data was available regarding the number and origin of delegates attending conferences organised by University of Tasmania staff in past years. We restricted our estimates to those conferences held in University conference centres or organised by University staff through the private conference organizer, Conference

Design[7]. It was assumed that all conferences had the same pattern of origin of delegates as those conferences for which we had this information. It was then necessary to estimate the effect on conference numbers of faster growth of the University. We assumed that conference numbers were a function of university size for which we used student numbers (equivalent full-time student units or EFTSUs) as a proxy. The ratio of estimated conference delegates to EFTSUs in 2004 was equal to 0.16. However, we doubted that this ratio was invariant to the size of the University and that an elasticity of delegates to EFTSUs of unity would be too high. We based this on our observation that field conferences were more likely to be related to the number of major academic departments which could be expected to vary little with increased size. However, the number of specialised conferences is more likely to vary in accordance with the overall size of the University (and the sizes of the academic departments within it). To reflect these considerations, we assume an elasticity of 0.5 between growth in the number of conferences and growth in the size of the University as measured in EFTSU's. We assume that there will be no change in the average number of delegates attending each conference. The expenditure of the estimated delegate numbers were then computed by using survey data from Tourism Tasmania for the level and expenditure patterns of interstate and overseas conference delegates. Considerable variation to the assumptions used above would not vary our results by any material extent, given that our total estimate for 2004 expenditure by interstate and overseas delegates combined is only $0.23 million.

The higher number of interstate and overseas students under a faster growth rate scenario can be expected to give rise to an increase in the number of interstate and foreign friends and relatives who travel to Tasmania to visit university students. The Bureau of Tourism Research's International Visitors Survey (IVS) contains data on foreigners visiting student friends and relatives - 83,400 in 2002. In that year there were 274,000 on-shore foreign students in Australia[8], which suggests that, on average, each on-shore foreign student attracts approximately 0.3 visitors each year from overseas. Applying this ratio to estimated foreign student increases under faster growth and then multiplying again by average expenditure for the "visiting friends and relatives" category from the IVS yields an estimate for the effect on Tasmanian overseas export demand of foreigners visiting students. A similar procedure was carried out to estimate the effect on Tasmanian interstate exports of interstate residents visiting students. As the Tasmanian Visitors Survey provides no information on the number

[7] We had no information as to the extent of other conferences organised by University staff, and decided to make a conservative estimate by excluding such unrecorded conferences from it.
[8] Australian Education International, Overseas Student Statistics 2002, downloaded January 2004 from: http://aei.dest.gov.au/AEI/MIP/Statistics/StudentEnrolmentAndVisaStatistics/2002/Default.htm

of interstate visitors who were friends and relatives visiting we adopt the same ratio (0.3) as for international students. By 2020 it is estimated that friends and relatives visiting students will increase Tasmania's overseas exports by $0.8 million and its interstate exports by $0.2 million.

3.2 Supply-side effects

3.2.1 Impact of University research activity.

Since there has been little assessment of the supply-side effects of universities in a general equilibrium framework, we cover the estimation of direct effects in more detail. In estimating the spillovers of University of Tasmania research to the State's economy we take a fairly straightforward approach, based on research undertaken by the Centre of Policy Studies in studying the economy-wide impacts of research funded by the Australian Research Council (Dixon and Madden, 2003)[9]. The approach assumes that ARC-funded research adds to a stock of knowledge that generates benefits in the form of higher economy-wide total factor productivity.

The University provided us with figures on its research spending in 2004 and projections for 2010 and 2020 under both the basecase and growth scenarios. These values are reproduced in the first two columns of Table 1. We generated paths for the value of university research spending between 2004 and 2010 and 2010 and 2020 for both the basecase and growth scenarios, by assuming smooth growth. The size of the improvement in primary factor productivity employed by Dixon and Madden (2003) was computed so as to generate a 50 per cent rate of return on the stock of knowledge. This is consistent with econometric work undertaken by Industry Commission (1995) which found that overall Australian R&D yielded a rate of return to the economy of between 50 and 60 per cent. The IC's econometric analysis assumed an obsolescence rate of 10 per cent. Consistent with the Centre of Policy Studies' modelling and Industry Commission (1995) we model the benefits of the University of Tasmania's research by assuming that:

i. the value of the stock of knowledge is measured as the accumulated value of research spending;
ii. the rate of return from the stock of knowledge for Australians is 50 per cent
iii. the return from the knowledge is expressed as an improvement in primary factor productivity in Australia; and

[9] The Australian Research Council (ARC) is the major funding body from which Australian university researchers can apply for competitive grants. The Allen Consulting Group undertook a study for the ARC on the returns arising from the researched it funded. Allen Consulting in turn contracted CoPS to undertake modelling of the economy-wide impact of ARC-funded research.

iv. that the stock of knowledge decays at the rate of 10 per cent per annum.

In the modelling tasks undertaken by Dixon and Madden the improvement in primary factor productivity was assumed to affect all agents nation-wide. However to model the impact on Tasmania of the University's research spending, assumptions must be made about the geographic boundaries within which the returns from the University's research activity accrue. Like the previous study, we assume that the nation as a whole earns a rate of return of 50 per cent from the University's research activity. However we assume that 25 per cent of these benefits are enjoyed only by Tasmanian agents (reflecting a propensity for Tasmanian researchers to investigate local issues) and that 75 per cent of these benefits are enjoyed by all Australians (including Tasmanians).

The calculations to implement the above assumptions are laid out in Table 1. The first two columns show the two time paths for the University's annual research budget. The third and fourth columns show the accumulated value of the stock of resulting knowledge at the beginning of each year (the R&D stock from the previous year, depreciated by 10 per cent, plus the previous year's R&D spending). The fifth column calculates the difference between the value of the stock of knowledge in the growth and basecase scenarios. The final column calculates the Australia-wide benefit from the change in the stock of knowledge. Recall that the rate of return on the stock is assumed to be 50% per annum. By 2010, for example, the change in the value of the stock of knowledge is $11.1 m. This generates a return of $5.6 m. ($11.1 m. x 0.50). As discussed earlier, we assume that one quarter of this benefit is enjoyed only by Tasmanian agents. Hence, in 2010, we calculate an improvement in Tasmanian primary factor productivity sufficient to generate a benefit of $1.4 m. ($5.6 m x 0.25). The remaining benefit ($4.2 m.) is enjoyed by Australians irrespective of where they live. Hence, continuing with our 2010 example, we calculate an improvement in economy-wide primary factor productivity sufficient to generate a national benefit of $4.2 m[10]. Identical calculations are undertaken for all other years in which there are non-zero entries in columns six and seven of Table 1.

[10] Tasmanian agents participate in this national benefit approximately in proportion to their share of national GDP. Hence they capture just under 2 per cent of the national benefit.

Table 1. Calculation of returns from additional research and development activity

Year	R&D spending ($m. 2004) Basecase	Rapid growth	R&D stock ($m. 2004) Basecase	Rapid growth	Stock change (basecase - rapid growth)	Return on Stock ($m 2004) (expressed as increase in productivity) Tasmania	Australia	Total
2004	**35.2**	**35.2**	0.0	0.0	0.0	0.0	0.0	0.0
2005	35.1	35.9	35.2	35.2	0.0	0.0	0.0	0.0
2006	35.0	36.6	66.8	67.6	0.8	0.1	0.3	0.4
2007	34.8	37.4	95.1	97.5	2.4	0.3	0.9	1.2
2008	34.7	38.1	120.4	125.1	4.7	0.6	1.8	2.4
2009	34.6	38.8	143.1	150.7	7.6	1.0	2.9	3.8
2010	**34.4**	**39.6**	163.3	174.5	11.1	1.4	4.2	5.6
2011	34.6	40.4	181.4	196.6	15.2	1.9	5.7	7.6
2012	34.7	41.2	197.8	217.3	19.5	2.4	7.3	9.7
2013	34.9	42.0	212.8	236.8	24.0	3.0	9.0	12.0
2014	35.0	42.8	226.4	255.1	28.7	3.6	10.8	14.3
2015	35.2	43.6	238.8	272.3	33.6	4.2	12.6	16.8
2016	35.3	44.5	250.1	288.7	38.7	4.8	14.5	19.3
2017	35.5	45.4	260.4	304.4	44.0	5.5	16.5	22.0
2018	35.6	46.3	269.8	319.3	49.5	6.2	18.5	24.7
2019	35.8	47.2	278.5	333.6	55.1	6.9	20.7	27.6
2020	**35.9**	**48.1**	286.4	347.4	61.0	7.6	22.9	30.5

3.2.2 Impact on labour market productivity

In this section we consider the possible effect of the University on the productivity of the Tasmanian workforce via its output of graduates. Here, our procedure is to estimate the possible magnitude of this labour productivity effect by making plausible assumptions about:

i. the impact of the presence of the University on the total number of graduates in Tasmania; and

ii. the impact of a university education on an employee's productivity.

Each of these issues is considered below.

3.2.2.1 Estimating the number of additional graduates living within Tasmania

The University provided us with estimates of the number of Tasmanian, interstate and foreign students studying at the University of Tasmania in the years 2004, 2010 and 2020 in both the basecase and the growth scenarios. As before, we estimate numbers for the years between 2004 and 2010 and 2010 and 2020 by assuming smooth growth in student numbers between these dates[11]. For any year after 2005, the additional student numbers represent not only the additional first years accepted in the year, but also some proportion of students accepted in previous years.

Our first goal is to calculate the additional graduates from the University, given the profile of additional student numbers. To do this we need to make assumptions about the average length of time spent at the University by graduates, and the average graduation rate. We assume that

[11] Interested readers can find tables of annual figures for each step of the calculations described below in Giesecke (2005).

graduates spend four years at the University on average, and that an average first year student has a graduation probability of 0.70. A graduation probability of 0.70 over four years implies an average attrition rate of 0.09. Given these assumptions, we can infer the number of additional first year students that are accepted by the University in each year. Using the estimates, and on the basis of our assumptions about the average length of a degree and the probability of successful completion, we can then estimate the numbers of additional graduates in each year.

Not all of the additional graduates will represent a net increase in the number of graduates working within Tasmania. People with university education tend to be highly mobile between regions. The mobility of people with a university education means that there need not be a high correlation between the number of people graduating from universities within a particular region and the number of graduates living within that region. In the case of Tasmania, many of the additional graduates produced in the growth scenario will either leave the state or displace interstate or foreign graduates who would otherwise have worked in Tasmania. Hence we require some estimate of the propensity of the presence of a local university to lift the graduate profile of the local workforce.

This question has been investigated for US states by Bound et al. (2004) and Groen (2004). They find only a modest link between the production of degrees within a region and the number of degree holders within a region. This is consistent with the high mobility of people with university degrees. We assume that the Australian graduate labour market shares this characteristic of the US labour market. Broadly, Bound et al. find that of every 10 additional degrees produced in a region, the stock of degree holders within the region might rise by about 2. This effect declines with time. Broadly, Groen (2004) finds that of every 10 additional degrees produced in a region, after 10 years the stock of degree holders within the region might be higher by only 1. We assume similar, but slightly higher, ratios for Tasmania. We assume a slightly higher ratio because of the greater geographical isolation of the state, and a conjecture that because of the high amenity value of the state, residents of the state will have a slightly above-average local locational preference. For Tasmanian students, we assume that for every 10 graduates, in the year of graduation (year 0) the stock of graduates in Tasmania rises by 3. By year 10 we assume that this effect has halved, to 1.5. We halve these ratios for interstate students: for every 10 interstate students graduating in Tasmania in year 0, the stock of graduates living in Tasmania initially rises by 1.5, however 10 year later, the stock will have only risen by 0.8. For international students we must account for the fact that most will leave Australia after graduation. Surprisingly, there appears to be no readily available data on the proportion of foreign students who remain in Australia as full time workers for a significant length of time after graduation. We simply assume that the number is low, and choose 5 per cent to reflect this. Furthermore, we assume that international students are more mobile that interstate and Tasmanian students. We express this assumption by halving again the graduate flow / stock coefficients: for every 10 international students who remain in Australia after graduating from the University of Tasmania, the immediate impact on Tasmanian graduate numbers is to rise by 0.04 (=1.5 / 2 x 0.05). After 10 years this effect has halved to 0.02. Between the two benchmark years of year 0 and year 10 (post-graduation) we assume smooth rates of decline, and continuing this rate of decline past year 10 gives us estimated ratios for year 11[12]. Applying these ratios allow us to estimate the number of additional graduates living in Tasmania in the growth scenario relative to the basecase scenario.

3.2.2.2 Estimating the productivity effect of higher education

Data from the Australian Bureau of Statistics on graduate and non-graduate incomes at different ages for employees in Tasmania and Australia as a whole clearly shows that across all ages, graduates earn more than non-graduates[13]. The wage premium earned by graduates reflects both returns to innate ability and returns to graduate education. Borland et al (2000) note that a standard assumption is that about 80 per cent of the premium represents returns to higher education and the remaining 20 per cent represents returns to innate ability. We adopt this assumption here. For each age group we calculate the returns to higher education as 80 per cent of the difference between the graduate and non-graduate wage for that age group.

Table 2 shows how this information is used to calculate the number of additional graduates in each age group living in Tasmania in each year. The first column of Table 2 shows our estimates for the weekly wage premium for each year after being awarded a degree[14]. Applying these differentials to the remaining columns (which show the number of years after graduation) allows us to calculate the additional labour income earned in Tasmania due to the additional human capital of the additional graduates living in Tasmania (the final row of Table 2). These are our estimates of the improvement in labour productivity in Tasmania in each year. Expressing these as a proportion of our basecase forecast aggregate Tasmanian

[12] We need ratios for only 12 years (year 0 to year 11), as our assumptions lead to no extra graduates under the growth scenario until 2009.

[13] Australian Bureau of Statistics. 1997. *Survey of Education and Training*. Australian Bureau of Statistics, Commonwealth of Australia.

[14] The estimation procedure assumed that the wage differential in the first year after graduation is equivalent to the wage differential at age 22.

wagebill for each year provides the percentage improvement in labour productivity that we impose as a shock in each year of the growth scenario.

Table 2: Calculation of Tasmanian labour productivity improvement

		Number of graduates in each year by years since graduation											
Years since graduation	Weekly wage premium	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
<1	$43.0	70	79	88	98	158	175	149	161	208	225	212	226
1	$114.7	0	65	74	83	92	147	163	139	150	194	210	198
2	$130.5	0	0	61	69	77	86	137	152	129	140	181	196
3	$143.3	0	0	0	57	64	72	80	128	142	121	131	169
4	$157.5	0	0	0	0	53	60	67	74	119	132	113	122
5	$173.0	0	0	0	0	0	50	56	63	70	111	124	105
6	$176.6	0	0	0	0	0	0	46	52	58	65	104	115
7	$180.3	0	0	0	0	0	0	0	43	49	54	61	97
8	$184.1	0	0	0	0	0	0	0	0	40	45	51	56
9	$188.0	0	0	0	0	0	0	0	0	0	38	42	47
10	$191.9	0	0	0	0	0	0	0	0	0	0	35	40
11	$192.2	0	0	0	0	0	0	0	0	0	0	0	33
Total per year ($m.)		$0.2	$0.6	$1.1	$1.6	$2.3	$3.3	$4.3	$5.2	$6.3	$7.5	$8.7	$9.9

4. Simulation results

4.1 Introduction

Tables 3 through to 9 present detailed tables of results for Tasmanian macroeconomic and industry variables. Tables 3 and 4 describe the impacts of the demand-side effects only. Tables 5 and 6 describe the impacts of the supply-side effects only. Tables 7 to 9 describe the total effects. The total effects are best explained as the combined outcome of the supply and demand side effects[15]. Hence our explanation emphasises the economic effects of the supply and demand side shocks considered in isolation.

4.2 Demand-side effects

Tables 3 and 4 describe the Tasmanian macroeconomic and industry effects of the demand-side stimuli provided by an expansion in the University's operations. The impact of the expansion of the University's operations via the provision of places to additional Tasmanian and interstate students is expressed at the Tasmanian macroeconomic level as an expansion in real federal government consumption spending. This rises steadily over the simulation period, rising to approximately $43 m. by 2010 and $83 m. by 2020. At the microeconomic level, this additional expenditure is expressed as an expansion in the size of the Tasmanian Education

[15] The results in the tables showing total effects are close to, but not precisely equal to, the sum of the results in the corresponding demand-side and supply-side tables. This is because the underlying economic model is non linear.

sector (Table 4[16]). Relative to basecase, the size of the Tasmanian Education sector grows steadily over time. By 2010 the sector is approximately 5.4 per cent larger than it would otherwise have been. The deviation in the size of the sector continues to grow thereafter, so that by 2020 the sector is projected to be approximately 8.4 per cent larger than it would have been had the University not grown rapidly.

Table 3: Demand side effects: Impact of growth in University of Tasmanian on selected Tasmanian macroeconomic indicators
($m (2004) deviations from basecase, unless otherwise specified)

Macro indicator	2005	2006	2007	2008	2009	2010	2011	2012
Real consumption	8.9	17.9	27.0	36.3	45.9	55.9	61.7	67.8
Real investment	5.0	10.6	16.8	23.6	31.0	39.2	43.1	47.3
Real state government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real federal government	7.0	14.0	21.2	28.4	35.8	43.2	46.8	50.5
Real interstate exports	-3.7	-7.9	-12.4	-17.3	-22.5	-27.9	-30.2	-32.3
Real international exports	-0.7	-1.6	-2.7	-3.8	-4.9	-5.9	-6.8	-7.6
Real interstate imports	8.1	16.7	25.8	35.6	46.2	57.7	63.0	68.8
Real international imports	0.8	1.5	2.1	2.7	3.4	4.0	4.3	4.8
Real GSP	7.6	14.9	21.9	28.8	35.7	42.8	47.2	52.2
Employment ('000 FTE)	0.1	0.3	0.4	0.6	0.7	0.8	0.9	0.9
Consumer price index (% change)	0.1	0.2	0.3	0.4	0.5	0.6	0.6	0.6
State government revenue	0.6	1.1	1.8	2.4	3.0	3.7	4.1	4.5
	2013	2014	2015	2016	2017	2018	2019	2020
Real consumption	74.4	81.4	88.8	96.6	104.8	113.5	122.7	132.4
Real investment	51.7	56.3	61.1	66.1	71.3	76.6	82.2	88.0
Real state government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real federal government	54.3	58.1	62.0	66.0	70.1	74.3	78.5	82.9
Real interstate exports	-34.3	-36.2	-37.9	-39.5	-41.0	-42.3	-43.5	-44.5
Real international exports	-8.2	-8.6	-8.9	-9.1	-9.1	-9.0	-8.6	-8.1
Real interstate imports	75.0	81.7	88.7	96.2	104.1	112.5	121.2	130.4
Real international imports	5.2	5.7	6.3	6.9	7.6	8.3	9.0	9.9
Real GSP	57.6	63.6	70.0	76.9	84.4	92.5	101.1	110.3
Employment ('000 FTE)	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.6
Consumer price index (% change)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
State government revenue	4.8	5.3	5.7	6.1	6.6	7.1	7.7	8.2

The expansion of the University's operations leads to a number of positive shocks to Tasmanian interstate and foreign exports. Spending by foreign and interstate students on course fees and living expenses represent increases in Tasmanian export demand. So too does the spending by interstate and foreign conference delegates and other visitors. Hence, on first inspection of the results in Table 3, it is perhaps surprising to find that real interstate and foreign export volumes fall. This reflects the positive impact on Tasmanian prices (and hence export prices) of the domestic demand side shocks represented by the expanded operating and capital budget of the University and the spending by retained Tasmanian students. These tend to lift Tasmanian prices, as can be seen by the result for the Tasmanian CPI, which ends the

[16] In Tables 4, 6 and 8, we omit years 2011 to 2014 and 2016 to 2019 in order to save space. Interested readers can find results for all sixteen years in Giesecke (2005).

simulation period 0.6 percentage points higher than basecase. This causes Tasmanian wages to rise. This raises the costs of traditional Tasmanian export industries, such as primary producers and manufacturers. This explains why these sectors tend to contract as the University expands (see Table 4). The cost-induced contraction in the export volumes of these traditional exporters is greater than the demand-induced expansion in the volume of exports of commodities (typically services) purchased by foreign and interstate students and visitors. Hence, aggregate export volumes fall. Nevertheless, the effect of the spending by these foreign and interstate students and visitors is clear in the industry results. Sectors such as *Culture and recreation*, *Personal services*, *Dwelling services*, *Finance and Communication*, all expand. The output of these sectors figures prominently in the spending patterns of interstate and foreign visitors to Tasmania. *Residential building* does well because investment in *Dwelling services* expands.

Table 4: Demand side effects: Impact on industry output (% deviation from basecase)

Industry	2005	2006	2007	2008	2009	2010	…	2015	…	2020
Agriculture	0.0	-0.1	-0.1	-0.2	-0.3	-0.3		-0.4		-0.5
Agricultural services	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4		-0.5		-0.5
Forestry	-0.1	-0.3	-0.4	-0.6	-0.8	-1.0		-1.3		-1.5
Fishing	-0.1	-0.1	-0.2	-0.3	-0.4	-0.4		-0.5		-0.6
Mining	0.0	-0.1	-0.1	-0.2	-0.3	-0.4		-0.7		-0.9
Mining services	-0.1	-0.3	-0.5	-0.8	-1.1	-1.3		-2.0		-2.5
Food manufacturing	0.0	-0.1	-0.1	-0.1	-0.2	-0.2		-0.2		-0.1
Beverage manufacturing	0.0	-0.1	-0.1	-0.2	-0.3	-0.4		-0.7		-0.8
Tobacco products	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Textile, clothing, footwear	-0.1	-0.3	-0.4	-0.6	-0.8	-0.9		-1.1		-1.1
Wood and wood products	-0.1	-0.2	-0.4	-0.5	-0.7	-0.9		-1.3		-1.6
Paper and paper products	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5		-0.7		-0.8
Printing and publishing	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4		-0.5		-0.5
Petroleum products	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Chemicals	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6		-0.8		-0.8
Non-metallic mineral	0.0	-0.1	-0.1	-0.1	-0.1	-0.2		-0.2		-0.1
Metal product manufacturing	-0.1	-0.2	-0.2	-0.4	-0.5	-0.6		-0.8		-0.9
Machinery and equipment	-0.1	-0.3	-0.5	-0.6	-0.8	-1.0		-1.4		-1.6
Utilities	0.0	0.0	0.0	0.0	-0.1	-0.1		-0.1		-0.1
Residential building	0.2	0.4	0.6	0.8	1.1	1.3		1.9		2.4
Other construction	0.0	0.1	0.1	0.1	0.2	0.2		0.3		0.3
Wholesale trade	0.0	0.0	0.0	0.0	0.0	0.1		0.1		0.2
Retail trade	0.0	0.1	0.1	0.2	0.2	0.2		0.3		0.5
Accommodation, cafes etc	0.0	0.1	0.1	0.1	0.2	0.2		0.3		0.5
Transport	0.0	-0.1	-0.1	-0.1	-0.2	-0.2		-0.2		-0.2
Communications	0.0	0.1	0.1	0.2	0.2	0.3		0.5		0.7
Finance	0.0	0.0	0.1	0.1	0.1	0.2		0.3		0.5
Dwelling services	0.0	0.0	0.0	0.0	0.1	0.1		0.3		0.6
Property & business service	0.0	0.0	-0.1	-0.1	-0.1	-0.1		-0.1		-0.1
Public Admin & defence	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Education	1.0	1.9	2.8	3.7	4.5	5.4		7.0		8.4
Health services	0.0	0.0	0.0	0.1	0.1	0.1		0.1		0.2
Community services	0.0	0.1	0.1	0.1	0.2	0.2		0.3		0.3
Culture & recreation	0.1	0.1	0.2	0.3	0.3	0.4		0.5		0.7
Personal services	0.0	0.1	0.2	0.2	0.3	0.3		0.4		0.6

The deviation in Tasmanian real consumption spending increases over the simulation period. This reflects two effects. Firstly, the expansion in demand for Tasmanian output induces resources to flow into Tasmania. This expansion in the size of the economy is reflected in the result for employment. Tasmanian employment grows steadily over the simulation period. By 2010, the demand side effects of the expansion of the University are projected to lift

Tasmanian employment by approximately 800 positions. By 2020, this has grown to 1,600 positions. The second influence on Tasmanian real consumption is the Tasmanian terms of trade. The increase in foreign and interstate demands for Tasmanian goods allows Tasmanian producers to charge more for their goods. This increases their incomes, allowing real consumption spending to rise further.

4.3 Supply-side effects

Tables 5 and 6 describe the Tasmanian macroeconomic and industry effects from the supply-side benefits of an expansion in the University's operations. Recall from Section 3.2 that the University's supply-side impacts arise from two sources:

1. improvements in Tasmanian and Australian primary factor productivity arising from successful R&D outcomes at the University of Tasmania; and
2. improvements in Tasmanian labour productivity arising from retention of a larger number of graduates in the Tasmanian workforce.

Table 5: Supply side effects: Impact of growth in University of Tasmanian on selected Tasmanian macroeconomic indicators
($m (2004) deviations from basecase, unless otherwise specified)

Macro indicator	2005	2006	2007	2008	2009	2010	2011	2012
Real consumption	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2
Real investment	0.0	0.0	0.1	0.1	0.2	0.4	0.6	0.8
Real state government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real federal government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real interstate exports	0.0	0.1	0.2	0.4	0.6	1.1	1.6	2.2
Real international exports	0.0	0.0	0.1	0.3	0.5	0.8	1.2	1.7
Real interstate imports	0.0	0.0	0.1	0.2	0.3	0.6	0.8	1.2
Real international imports	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5
Real GSP	0.0	0.1	0.3	0.7	1.3	2.1	3.1	4.3
Employment ('000 FTE)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Consumer price index (% change)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
State government revenue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2013	2014	2015	2016	2017	2018	2019	2020
Real consumption	1.5	2.0	2.4	2.9	3.4	3.9	4.5	5.1
Real investment	1.1	1.4	1.8	2.1	2.5	2.9	3.3	3.7
Real state government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real federal government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real interstate exports	3.0	3.8	4.8	5.8	6.8	8.0	9.3	10.6
Real international exports	2.3	2.9	3.6	4.4	5.2	6.1	7.1	8.1
Real interstate imports	1.5	2.0	2.5	3.0	3.6	4.2	4.9	5.6
Real international imports	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
Real GSP	5.7	7.3	9.1	10.9	12.9	15.2	17.5	19.9
Employment ('000 FTE)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Consumer price index (% change)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
State government revenue	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2

The key to understanding the results in Tables 5 and 6 is to note that these improvements in productivity allow the Tasmanian economy to produce more output for any given usage of inputs. This causes Tasmanian real GSP to grow strongly. By 2010 Tasmanian real GSP is projected to be $2.1 m. higher than basecase. This grows to $19.9 m. by 2020.

Table 6: Supply side effects: Impact on industry output (% deviation from basecase)

Industry	2005	2006	2007	2008	2009	2010	…	2015	…	2020
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.1
Agricultural services	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.1
Forestry	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.3
Fishing	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.1
Mining	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.2
Mining services	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.3
Food manufacturing	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.2
Beverage manufacturing	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.2
Tobacco products	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Textile, clothing, footwear	0.0	0.0	0.0	0.0	0.0	0.0		0.2		0.4
Wood and wood products	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.2
Paper and paper products	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.1
Printing and publishing	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.3
Petroleum products	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Chemicals	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.2
Non-metallic mineral	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.1
Metal product manufacturing	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.2
Machinery and equipment	0.0	0.0	0.0	0.0	0.0	0.0		0.2		0.3
Utilities	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1
Residential building	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1
Other construction	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1
Wholesale trade	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.1
Retail trade	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1
Accommodation, cafes etc	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1
Transport	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.2
Communications	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1
Finance	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.1
Dwelling services	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Property & business service	0.0	0.0	0.0	0.0	0.0	0.0		0.1		0.1
Public Admin & defence	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Education	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Health services	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Community services	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Culture & recreation	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1
Personal services	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.1

The rapid growth in the real GSP deviation arises from two sources. Firstly, the simulation is one in which the University is growing more rapidly, hence the University is larger in 2020 than it is in 2010. Secondly, and more importantly, the supply-side effects tend to be cumulative. Successful R&D outcomes add to the stock of productive knowledge (see Section 3.2.1 and Table 1) and retention of students adds to the number of University graduates working in Tasmania (see Section 3.2.2 and Table 2). Notice that the gains in real GSP are almost entirely attributable to the returns from the supply side effects. For example, returns to Tasmania from the stock of additional R&D knowledge (Table 1) are $1.4 m. and $7.6 m. in 2010 and 2020 respectively[17]. At the same time, the labour productivity gains in these years are $0.6 m. and $9.9 m. (Table 2). Hence the sum of these two effects alone adds $2.0 m. and $17.5 m. to Tasmanian real GSP in 2010 and 2020 respectively. The impact on Tasmanian employment is negligible. This is because the productivity improvements have two offsetting effects on Tasmanian labour demand. With labour more productive, firms have a desire to expand output and hence increase their demand for labour. This has a tendency to increase Tasmanian employment. However, workers are now more productive, and so fewer are required to produce the same amount of output as before. This has a tendency to decrease Tasmanian employment. These two effects are very evenly matched in this particular simulation. This leaves Tasmanian employment largely unaffected by the supply side shocks to the Tasmanian economy. Despite employment not changing, Tasmanian households are clearly better off, since real consumption spending and real government revenue are higher.

Table 7: Impact of growth in University of Tasmanian on selected Tasmanian macroeconomic indicators *($m (2004) deviations from basecase, unless otherwise specified)*

Macro indicator	2005	2006	2007	2008	2009	2010	2011	2012
Real consumption	8.9	17.9	27.1	36.5	46.3	56.5	62.5	69.0
Real investment	5.0	10.6	16.8	23.7	31.2	39.5	43.7	48.1
Real state government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real federal government	7.0	14.0	21.2	28.4	35.8	43.2	46.8	50.5
Real interstate exports	-3.7	-7.8	-12.2	-17.0	-21.9	-26.8	-28.6	-30.1
Real international exports	-0.7	-1.6	-2.5	-3.5	-4.4	-5.1	-5.6	-5.8
Real interstate imports	8.1	16.7	25.9	35.8	46.5	58.2	63.8	70.0
Real international imports	0.8	1.5	2.1	2.8	3.5	4.2	4.7	5.2
Real GSP	7.6	15.0	22.2	29.5	37.0	44.9	50.4	56.5
Employment ('000 FTE)	0.1	0.3	0.4	0.6	0.7	0.8	0.9	1.0
Consumer price index (% change)	0.1	0.2	0.3	0.4	0.5	0.6	0.6	0.6
State government revenue	0.6	1.1	1.8	2.4	3.1	3.8	4.1	4.5
	2013	2014	2015	2016	2017	2018	2019	2020
Real consumption	76.0	83.4	91.2	99.5	108.2	117.5	127.2	137.5
Real investment	52.8	57.7	62.8	68.2	73.7	79.5	85.6	91.7
Real state government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real federal government	54.3	58.1	62.0	66.0	70.1	74.3	78.5	82.9
Real interstate exports	-31.4	-32.3	-33.1	-33.8	-34.2	-34.3	-34.2	-33.9
Real international exports	-5.9	-5.7	-5.3	-4.7	-3.9	-2.8	-1.6	0.0
Real interstate imports	76.6	83.7	91.2	99.2	107.7	116.7	126.1	136.0
Real international imports	5.8	6.5	7.3	8.1	8.9	9.8	10.8	11.9
Real GSP	63.3	70.9	79.1	87.9	97.3	107.6	118.6	130.3
Employment ('000 FTE)	1.0	1.1	1.2	1.3	1.4	1.5	1.5	1.6
Consumer price index (% change)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
State government revenue	4.9	5.3	5.7	6.2	6.7	7.2	7.7	8.3

The rise in real consumption spending reflects increasing real wages and greater profitability arising from the productivity improvements. These lift real consumption spending. By 2020 Tasmanian real consumption spending is projected to be approximately $5.1 m. higher than it would otherwise have been. The expansion in Tasmanian economic activity leads to an increase in real state government revenue. By 2020 the increase in real state government

[17] Note that these two figures exclude the approximately 2 per cent of the Australian benefits ($4.2 m. and $22.9 m.) in these years that would accrue to Tasmania.

revenue is projected to be approximately $0.2 m. The increase in government revenue is a benefit to Tasmanian households, since it allows for some combination of higher government consumption, lower taxes, and/or lower government debt.

Table 8: Impact on industry output (% deviation from basecase)

Industry	2005	2006	2007	2008	2009	2010	…	2015	…	2020
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Agricultural services	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Forestry	0.1	0.2	0.3	0.5	0.6	0.8		1.1		1.4
Fishing	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Mining	0.1	0.2	0.3	0.4	0.5	0.6		0.8		1.1
Mining services	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Food manufacturing	0.0	-0.1	-0.1	-0.1	-0.1	-0.2		-0.2		0.0
Beverage manufacturing	0.0	0.0	0.0	0.0	0.0	0.0		-0.1		-0.1
Tobacco products	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Textile, clothing, footwear	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Wood and wood products	0.5	1.1	1.5	2.0	2.4	2.8		3.4		3.9
Paper and paper products	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Printing and publishing	0.1	0.1	0.1	0.2	0.2	0.3		0.5		0.7
Petroleum products	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Chemicals	0.1	0.2	0.2	0.3	0.4	0.4		0.6		0.8
Non-metallic mineral	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Metal product manufacturing	0.1	0.2	0.3	0.4	0.5	0.6		0.6		0.6
Machinery and equipment	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Utilities	0.0	-0.1	-0.1	-0.2	-0.2	-0.3		-0.3		-0.3
Residential building	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4		-0.4		-0.3
Other construction	-0.1	-0.3	-0.4	-0.6	-0.8	-1.0		-1.2		-1.2
Wholesale trade	-0.1	-0.1	-0.2	-0.3	-0.4	-0.4		-0.5		-0.4
Retail trade	0.0	-0.1	-0.1	-0.2	-0.3	-0.4		-0.6		-0.8
Accommodation, cafes etc	-0.1	-0.3	-0.5	-0.8	-1.0	-1.3		-1.9		-2.2
Transport	0.0	-0.1	-0.1	-0.1	-0.2	-0.2		-0.1		0.0
Communications	0.0	-0.1	-0.1	-0.2	-0.3	-0.4		-0.6		-0.6
Finance	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Dwelling services	-0.1	-0.3	-0.4	-0.6	-0.7	-0.9		-0.9		-0.7
Property & business service	-0.1	-0.2	-0.4	-0.5	-0.7	-0.9		-1.2		-1.3
Public Admin & defence	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5		-0.6		-0.6
Education	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4		-0.4		-0.2
Health services	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0
Community services	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6		-0.7		-0.6
Culture & recreation	0.0	-0.1	-0.1	-0.1	-0.1	-0.2		-0.1		0.0
Personal services	-0.1	-0.2	-0.2	-0.3	-0.4	-0.6		-0.7		-0.7

4.4 Per student impacts

The macroeconomic impacts of both the demand and supply side shocks (reported in Table 7) are converted to a per 100 EFTSU basis in Table 9. The results in Table 9 need to be interpreted with some caution, because not all of the direct effects of the University move in strict proportion with EFTSUs. For example, the supply side effects of additional research activity (Section 3.2.1) are directly related to the University's research budget. These supply side effects will be only indirectly related to EFTSU's via the effect that a change in EFTSU's has on the University's research budget. Also, different student types have slightly different levels and patterns of expenditure. However these cautionary notes must themselves be qualified. The results in Table 9 are handy indicators of the effect of marginal changes (measured in units of 100 EFTSU's) in the size of the University, when the nature of that change in the size of the University reflects the proportions of additional research spending, student composition, and induced visitor and conference delegate numbers, modelled in this report.

Table 9: Tasmanian macroeconomic impacts expressed on a "per 100 EFTSU" basis

Macro indicator	2005	2006	2007	2008	2009	2010	2011	2012
Real consumption ($m.)	1.9	1.8	1.8	1.7	1.7	1.7	1.7	1.8
Real investment ($m.)	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3
Real state government ($m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real federal government ($m)	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.3
Real interstate exports ($m)	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Real international exports ($m)	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
Real interstate imports ($m)	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8
Real international imports ($m)	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Real GSP ($m)	1.6	1.5	1.5	1.4	1.4	1.3	1.4	1.5
Employment (FTE)	21.0	30.0	26.0	29.0	26.0	24.0	25.0	26.0
Consumer price index (% change)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
State government revenue ($m)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	2013	2014	2015	2016	2017	2018	2019	2020
Real consumption ($m.)	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2
Real investment ($m.)	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5
Real state government ($m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real federal government ($m)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4
Real interstate exports ($m)	-0.8	-0.7	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6
Real international exports ($m)	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0
Real interstate imports ($m)	1.9	1.9	2.0	2.0	2.1	2.1	2.2	2.2
Real international imports ($m)	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Real GSP ($m)	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.1
Employment (FTE)	24.0	25.0	26.0	26.0	27.0	27.0	26.0	26.0
Consumer price index (% change)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
State government revenue ($m)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

The results in Table 9 suggest that a “balanced”[18] 100 EFTSU expansion in the size of the University will increase Tasmanian real GSP by $1.6 m., Tasmanian real consumption spending by $1.9 m. and employment by 26 FTE positions. On a per student basis, this represents gains of $19 thousand in real consumption spending, $16 thousand in real GSP, and 0.26 FTE positions. These per-student impacts are broadly in line with the national impacts per international higher education student reported in Giesecke (2002). In that study, each international higher education student was found to increase national real consumption spending by an average of approximately $16.4 thousand ($2002) and generate an average of approximately 0.2 jobs in the short run. The per student impacts in the present study are higher than these for two reasons. Firstly, the present study models both demand and supply effects (the earlier study looked at demand-side effects only). Secondly, the present study relates to the regional economy of Tasmania, rather than the national economy (as the earlier

[18] “Balanced” in the sense that the expansion reflects the Tasmanian / interstate / international ratios modelled in this report, and causes a uniform increase in research activity as modelled in this report.

study did). Regional impacts are typically greater than national impacts in studies such as these. This is because, whereas labour and investment resources are able to flow into a small region such as Tasmania from the rest of the country, resource availability at the national level is essentially fixed in the medium to long run.

5 Concluding Comments

In this paper we examine the impact of a particular university on the economy of the region in which it is located, both in respect of its demand-side and supply-side effects. We analyse the economy-wide impacts of both these type of effects within a single analytical framework, a dynamic multiregional CGE model. A comparison of the demand-side macroeconomic impacts (Table 3) and the corresponding supply-side results (Table 5) show the former to be many times the size of the latter.

The results are subject to a considerable number of assumptions. Ideally, for instance, we would have liked to have used spatial econometrics in estimating the direct effects on the regional economy of university research. What our modelling has shown, however, is that superior methods of estimating knowledge spillovers would need to show markedly different direct effects than the estimates made here to substantially alter the picture of the dominance of demand-side over supply-side effects.

However, our results should still be treated with some caution, particularly with regard to how general they are. Our results pertain to a university which is the only one operating in a region that is geographically contained (an island state). The bulk of the funding of the university is from federal government sources, and this form of funding does not significantly crowd out other activities. The University could be a more significant attractor of industries than we have modelled. For instance, we have not considered explicitly any agglomeration effects resulting from the University. Explicitly modelling of such effects would be a useful avenue of future research, as would be an examination of our results in regional economic welfare terms.

To date, analysis of the effects of universities have looked in the main at either demand-side or supply-side effects. Different frameworks are generally used to examine each one. The advance made in this paper is to extend the analysis of supply-side impacts beyond examining just spillover effects, by modelling the economy-wide effects of these spillovers. By doing so within the same framework in which the economy-wide impacts of the demand-side are examined, has allowed the above direct comparison between expenditure impacts and knowledge impacts to be made.

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