An investigation into the economic contribution of the University of Waikato to the Waikato Region

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Abstract

The Waikato region is home to approximately 16% of New Zealand's total population, and is the country's fourth largest regional economy. The region contributes 9.1% of the nation's GDP and 10% of New Zealand exports. The industries which are most important to the Waikato region are dairy farming, electricity generation and distribution, mining and quarrying, forestry and logging, and education and research services.

The University of Waikato has been contributing to the Waikato regional economy since 1964. It employs 2000 staff and has 13,000 enrolled students. Of the University's domestic students, 74% come from the Waikato and Bay of Plenty regions. Thus the University creates employment for residents and attracts students from both within and outside the Waikato region. The expenditure of students in the region creates wealth for local businesses and other flow on effects, resulting in higher regional GDP. It is because of this influx of students into the region that the University provides the local economy with additional wealth. Thus there is motivation to further investigate the economic contribution of the University to the Waikato region's economy.

The main objectives of this study were to quantify the economic contribution of the University of Waikato to the Waikato region. By building a single region input-output model it can be seen how great an impact the University has on the Waikato region. Details of local student spending were ascertained to allow multiplier effects to be determined. The larger these multiplier effects, the more valuable the University is to the local economy. This study adds to the current academic literature on this subject, and also gives a more detailed understanding of a University's role within its local economy. This is because it includes not only the direct impacts of the University's and its students' activities, but also the indirect flow-on effects.

The methods this paper used to construct an input-output table for the Waikato region were to create a national input-output table from the 2007 supply and use tables for New Zealand using the industry technology method. This table was then downsized to portray the Waikato region using an augmented GRIT method, which allowed for

the inclusion of superior data into the table. The resulting input-output table was then used to conduct an impact analysis of the University of Waikato on its local economy.

This paper has used input-output analysis to show that the University of Waikato is important to the Waikato Region both in its contribution to regional GDP and in the benefits it provides to the community such as the use of the University grounds and higher-skilled labour force it brings. The University contributes 3.4% of the Waikato Region's GDP and provides employment both directly through its delivery of services and indirectly through its operations and spending of staff and students. If the University were to close it would have a significant negative impact both on regional GDP and more intangible losses to its local community.

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1. Introduction and Background

The University of Waikato has been contributing to the Waikato regional economy since 1964. The University creates employment for residents and attracts students from both within and outside the Waikato region. The expenditure of students in the region creates wealth for local businesses and other flow on effects, resulting in higher regional GDP. It is because of this influx of students into the region that the University provides the local economy with additional wealth.

The main objectives of this study were to quantify the economic contribution of the University of Waikato to the Waikato region. The methods this paper used to construct an input-output table for the Waikato region were to create a national input-output table from the 2007 supply and use tables for New Zealand using the industry technology method. This table was then downsized to portray the Waikato region using an augmented GRIT method, which allowed for the inclusion of superior data into the table. The resulting table was then used to conduct an impact analysis of the University of Waikato on its local economy. The analysis provides a complete picture of the importance of student spending to the Waikato region because information from an online student survey and financial information from the University of Waikato were used in conjunction with the multipliers derived from the input-output table.

1.1. University of Waikato

The University of Waikato was founded in 1964, when it was officially opened by Sir Bernard Fergusson and now covers about 68 hectares of land (The University of Waikato, 2009a). It currently has 13,000 students and employs 2000 academic and support staff (The University of Waikato, 2010a). The number of Waikato University students that complete a qualification annually is 4800 (The University of Waikato, 2010a). In the 2008 year there were 9973 domestic students and 2041 international students enrolled at the university, 8729 of which were enrolled in undergraduate qualifications and 3122 who were enrolled in graduate/postgraduate and Mphil/doctorate qualifications (The University of

Waikato, 2009b). Of the University's domestic students, 74% came from the Waikato and Bay of Plenty regions (The University of Waikato, 2009c).

Enrolments at the University of Waikato were 9.5% higher in 2009 than in 2008, due to the recession and associated trends (The University of Waikato, 2009c). These increased enrolments were expected to continue in 2010 as New Zealand emerged from recession and people looked to safeguard against unemployment (The University of Waikato, 2009c). The University earned $190.5 million in total revenue in the last financial year, wherein $57 million came from fees and $86.5 million came from government funding (The University of Waikato, 2009b). It paid a total of $111 million in salaries, of which $69 million were academic salaries and $42.5 million of which were general salaries (The University of Waikato, 2009b). However, a challenge facing the University in coming years is the capped funding environment implemented by the government in 2010. Around 40% of the University's new domestic students are school-leavers, coming from 433 schools across New Zealand (The University of Waikato, 2009c). In the 2009 year, 69% of these new domestic students came from schools in the Waikato and Bay of Plenty and 18% came from schools in the Auckland, Northland and Counties Manukau areas (The University of Waikato, 2009c). The capped funding for the University poses a threat to student numbers as the University has tightened admission, and re-enrolment, requirements for students.

The University's mission is "to combine the creation of knowledge through research, scholarship and creative works with the dissemination of knowledge through teaching, publication and performance" (The University of Waikato, 2009c, p. 9). In line with this, the University of Waikato's achievements include connecting New Zealand to the internet in 1989, with help from NASA, thus becoming the first New Zealand University to have cyber-graduates (The University of Waikato, 2009a). In 1998 the University expanded into Tauranga, forming an alliance with the Bay of Plenty Polytechnic (The University of Waikato, 2009a). This aided the improvement of tertiary education in the Western Bay of Plenty. The first students from the University of Waikato Tauranga campus to graduate did so in 2001 (The University of Waikato, 2009a).

Many different qualifications are offered at the University of Waikato due to the number of different faculties. These include the Faculty of Arts and Social Sciences (FASS), the Faculty of Computing and Mathematical Sciences, the Faculty of Education, the Faculty of Law, the School of Maori and Pacific Development, the Faculty of Science and Engineering and the Waikato Management School. These numerous faculties have attributes which make them desirable for future students. FASS is the result of a merger of two faculties (the Faculties of Humanities and Social Sciences) which occurred in 1999 and FASS is now the largest faculty on campus (The University of Waikato, 2004). The Faculty of Computing and Mathematical Sciences was placed first in the *Computer Science, Information Technology, Information Sciences* subject area and in the *Pure and Applied Mathematics* subject area in the nation-wide Performance-Based Research Fund research assessment exercise, which was last carried out in 2006 (The University of Waikato, 2007). The Faculty of Education is rated number one in educational research (The University of Waikato, 2010b). Within the Faculty of Law, the Bachelor of Laws degree is recognised for professional purposes by the Council of Legal Education. Its standards are moderated by the Council, and by external assessment among the New Zealand law schools, meaning it is moderated against the regimes of other New Zealand law schools to ensure that students receive a qualification which matches that of students elsewhere in New Zealand (The University of Waikato, 2010c). The Waikato Management School is one of three business schools in Australasia with triple-crown accreditation, confirming the school as world-class (The University of Waikato, 2010d).

1.2. Waikato Region

The wider Waikato region has a population of 517,000, approximately 16% of New Zealand's total population (Statistics New Zealand, 2009). Table 1 below shows the populations of all of the Territorial Authorities in the Waikato region at the last population census in 2006. It can be seen from this table that 141,000 people reside in Hamilton city where the University is located.

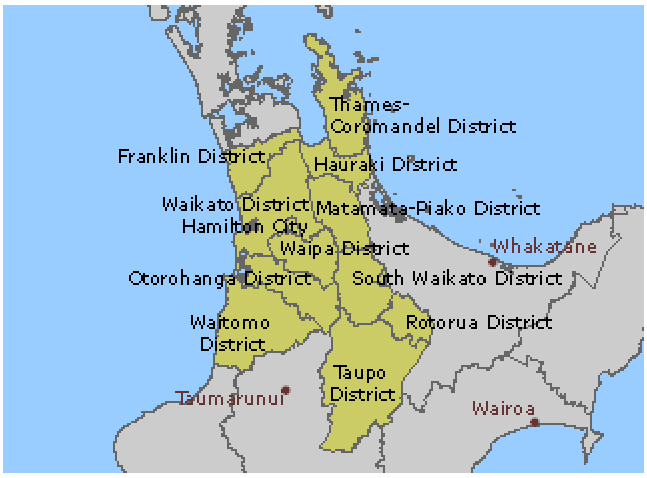
Table 1

Population Estimates 2009	
Franklin District	64,200
Thames-Coromandel District	26,800
Hauraki District	17,800
Waikato District	47,600
Matamata-Piako District	31,600
Hamilton City	140,700
Waipa District	45,100
Otorohanga District	9,250
South Waikato District	22,800
Waitomo District	9,620
Taupo District	33,600
Rotorua District	68,200
Total Waikato Region	517,270

Source: (Statistics New Zealand, 2009)[1]

Figure 1 illustrates the geographical area which the Waikato Region covers. It can be seen from this illustration that the region covers much of the Central North Island, and much of the West coast.

Figure 1: Map of the Waikato Region



Area within region

Major town/city within region

City/district boundary lines within region

[1] The total population estimate for the Waikato region includes only parts of the Waitomo, Taupo, Rotorua and Franklin districts, not the whole regional total as shown in the table.

The Waikato region is the fourth largest regional economy in New Zealand and grew 5 per cent per year between 2004-2007, which was above the national average of 3.2 per cent (Phillips, 2009). GDP of the Waikato region is $16.241 billion, which is 9.1% of the New Zealand economy (Hughes, 2009). The region also contributed 10 per cent of the nation's exports (Phillips, 2009). The Waikato region employs 171,000 workers or 8.7% of the New Zealand workforce (Hughes, 2009).

The industries that are particularly important to the Waikato region are dairy farming, electricity generation and distribution, mining and quarrying, forestry and logging, and education and research services (Market Economics Ltd, 2006a). These industries are also noted as having high importance in the Waikato region by Hughes (2009). However, as stated in the Waikato Economic Report (Phillips, 2009), the largest sectors in the Waikato economy in 2007, determined via value-added, were dairy cattle farming, business services and real estate. The sectors which grew the most in real terms were real estate, dairy product manufacturing and business services.

The Waikato is also part of the "golden triangle" of population and economic growth, where the net migration gain over the period 2001-2006 was 6,117 people (Phillips, 2009). In the year ended March 2007 Retail trade had the highest contribution to the Waikato labour force, employing 12 percent, while business services employed 10 percent (Phillips, 2009). Dairy cattle farming employed 6 percent and is the sixth largest employment industry, and when dairy manufacturing is included the proportion increases to 7.3 percent (Phillips, 2009).

2. Motivation and Aims

Given the University of Waikato's reputation as a well-known and respected education provider, the University attracts an influx of both international and New Zealand students to study in Hamilton. Therefore, the University provides the Waikato region with additional wealth to its local economy. Since the population of Hamilton increases due to this influx of students, there is motivation to further investigate the economic contribution of the University to the Waikato region's economy. Of particular interest is the nature of students' spending within in the region and how much additional wealth this creates within the region's economy.

The main objectives of this study are to quantify the economic contribution of the University of Waikato to Hamilton city and to the Waikato region. In doing this it can be discovered how important the University of Waikato is to the Waikato region. In investigating how much students and staff are spending, multiplier effects can be determined and it can be seen exactly how valuable the University is to the local economy.

How much students are spending locally will also be ascertained. Further investigation into student spending will allow multiplier effects to be determined, which occur because of the existence of the University of Waikato in Hamilton. The larger these multiplier effects, the more valuable the University is to the local economy.

This study will add to the current academic literature on this subject, and will also give a more detailed understanding of a University's role within its local economy. This is because it includes not only the direct impacts of the University's and its students' activities, but also the indirect flow-on effects. The results from this study will be more detailed than the current literature in New Zealand because it will include estimates from a regional input-output model including estimates of linkages within the region. This will give a richer interpretation of the impact of the University of Waikato on its local economy.

3. Literature Review

3.1. Background of Input Output Analysis

3.1.1. Origins of Input-Output Analysis:

Input-output analysis found its origins in 1936 when Wassily Leontief successfully attempted to construct a *tableau economique* of 41 sectors from 1919 statistical data (Leontief, 1936). The *Tableau Economique* was published by Francois Quesnay in 1758 and was the first model to describe the workings of the economy in an analytical way. Its objective was to exhibit, by means of certain formulas, the way in which the products of agriculture would, in a state of perfect liberty, be distributed among the several classes of the community (Quesnay, 1972). The fundamental assumptions underpinning this were that only agriculture produces a surplus and that the economy's demand for market output depends on the expenditure of the agricultural surplus by landlords (Eltis, 1975). Leontief's input-output table, using data from 1919, was the first table to effectively summarise the inter-dependence between the different parts of the economy, and advanced the theory of general equilibrium (Leontief, 1936). In a later article, A. Phillips (1955) presented Quesnay's *Tableau Economique* as an input-output model which made Quesnay's analysis clearer and concluded that Quesnay's work can be viewed as a static, closed Leontief system. Leontief's input-output framework also contained elements of the work of Leon Walras, who was one of the first to consider general equilibrium theory. A set of production coefficients was developed by Walras in 1874 that related the quantities of factors required to produce a unit of a particular product to levels of total production of that product (Walras, 1954). These coefficients are very similar to the coefficients in Leontief's input-output model (Miller & Blair, 1985).

Wassily Leontief was the main pioneer in the development of Input-Output analysis, recruiting many emerging economists who would later make huge contributions in other areas of economics while they studied at Harvard, for his research (Carter, A. & Petri, 1989). From his first input-output table of 1919 statistical data, Leontief constructed another 41 sector table using 1929 data and published both tables in *"The Structure of the American Economy"* in 1941. This publication was among the first which explicitly set out the theory of input-output analysis, following Leontief's (1937) article which developed the theory on which the 1919 table was based. *"The Structure of the American Economy"* also showed how questions related to interdependence could be conveyed in a robust mathematical form, and demonstrated with numbers that input-output was a useful, practical tool (Carter, A. & Petri, 1989).

During World War Two, Leontief supervised the compilation of a 92-sector input-output table based on 1939 data, which became the first official input-output table (Polenske, 1999). Leontief published a book in 1951 *"The Structure of the American Economy 1919-1939"* which included his input-output tables from 1919, 1929 and 1939 data. In his third book, *"Studies in the Structure of the American Economy"* (1953), Leontief established a method for distinguishing the effects of changes in final demand from changes in inter-industry structure and simulated the effects of changes in particular subsets of coefficients. The Bureau of Labour Statistics (BLS) took over the compilation of input-output tables in 1949 and a 500-sector table was developed by the BLS which was based on 1947 data (Evans & Hoffenburg, 1952).

During the 1950's and 60's "input-output was the most celebrated quantitative macroeconomic model, intensely researched in theory and widely applied in practice" (Augustinovics, 1995, p. 271). The Office of Business Economics (now the BEA) was the first to integrate the national income and product accounts and the input-output accounts in the publication of the 1958 input-output table (Polenske, 1999). Leontief had stressed that by integrating the accounts, flows to each of the final demand components would be identical in the two sets of accounts, and he was correct (Goldman, Marimont, & Vaccara, 1964). In 1959 all input-output work was published as "sales-purchases" (Polenske, 1999). Government preparation of input-output tables was discontinued when officials in the Eisenhower administration began to appreciate the potential of input-output analysis for government planning, and believed that government planning was communistic (Augustinovics, 1995; Carter, A. & Petri, 1989; Polenske, 1999).

3.1.2. The Basic Model:

The input-output methodology provides a bridge between theory and facts in economics because the effect of a single event at any one point is transmitted to the rest of the economy step by step through a chain of transactions, linking the whole system together (Leontief, 1985). It is a very flexible and versatile model, and can be applied in many different situations and for various purposes. Input-output can be applied to small area models at county and community levels as well as larger scale models at national and global levels (Rose & Miernyk, 1989). This versatility makes it possible to calculate the consequences that result from the introduction of changes at both regional and national levels, and to measure both direct and indirect effects (Leontief, 1985). It has also been extended to include trade flows between regions in multiregional/interregional input-output models (Rose & Miernyk, 1989). The model is flexible in that it can be used to analyse a multitude of issues, ranging from economic development to impacts on income and employment. IO analysis has been used in simulating economic development, and where data has permitted, the construction of tables for the measurement of income and employment multipliers (Rose & Miernyk, 1989).

The central concept of Input-Output analysis is the idea that there is a fundamental relationship between the volume of the output of an industry and the size of the inputs going into it (Leontief, 1985). It is a method of systematically quantifying the mutual interrelationships among various sectors of a complex economic system (Miller & Blair, 1985). An input-output table classifies and aggregates numerous individual transactions into groups, and can be presented in as fine or coarse detail as data permits and the purpose requires (Leontief, 1985). The static, open input-output model developed by Leontief is based on a transactions table of sales and purchases between sectors which can be expressed as a system of linear equations:

$$X_i = X_{i1} + X_{i2} + \cdots + X_{ij} + Y_i \qquad (i = 1 \dots n) \qquad (1)$$

Where

X_i = total gross output of sector *i*

Y_i = final demand for the products of sector *i*

X_{ij} = sales from sector *i* to each of the endogenous sectors *j*

Each one of these linear equations describes the distribution of a sector's product to all other sectors in the economy over one or several periods of time (Miller &

Blair, 1985). In order for this system of equations to be useful, some assumptions must be made. The first is that each commodity or service is provided by a single production sector and there are no joint products (Richardson, 1972). The second is that each sector's inputs bear a direct proportional relationship to that sector's output ($X_{ij} = a_{ij}X_j$, where X_j is the output of sector *j*), and the last is that there are no external economies or diseconomies (Richardson, 1972). The linear input functions assumption means that there are constant returns to scale and no substitution between inputs, and, finally, there are no capacity constraints so that the supply of each good is perfectly elastic (Richardson, 1972). The assumption that each sector's inputs are directly proportional to that sector's output is required to define the shape of the production function, and because there is often limited statistical information this strict assumption must be imposed (Leontief, 1937). This relationship is the same as the "coefficients of production" originally used by Walras in his first formulation of general equilibrium theory (Leontief, 1937). Given these assumptions, the basic IO model is:

$$X_i = \sum_{j=1}^{n} a_{ij}X_j + Y_i \qquad (i = 1..n) \tag{2}$$

The structure of each sector's production process is represented by a vector of structural coefficients that describes in quantitative terms the relationship between the inputs it absorbs and the output it produces (Leontief, 1985). Therefore, Equation (2) can also be expressed in matrix form:

$$\boldsymbol{X} = \boldsymbol{AX} + \boldsymbol{Y} \tag{3}$$

The terms $\boldsymbol{A}$ and a_{ij} in Equations (2) and (3) denote the technical coefficients of the model, which measures the requirement of some input per unit of output (ten Raa, 2005). It describes the quantity of the output of sector *i* which is absorbed by sector *j* per unit of its total output X_j (Leontief, 1985). In other words, a technical coefficient shows the proportion of total output X_j which is supplied by a particular industry *i*. It is given by the endogenous elements of Equation (2):

$$a_{ij} = \frac{X_{ij}}{X_j} \tag{4}$$

The technical structure of the entire system can be represented by the matrix of technical input-output coefficients of all its sectors (Leontief, 1985). These structural matrices are usually constructed from input-output tables which are presented in value terms (Leontief, 1985). It should also be noted here that the more aggregated the input-output table, the less empirical importance the variable technical coefficients of production will have (Leontief, 1937).

With a table of technical coefficients for the economy as a whole, it is possible to calculate the secondary demand on the output of the industries that supply and industry's suppliers and so on through the successive inputs and outputs until the effect of the final demand for a good has been traced to its last reverberation in the farthest corner of the economy (Leontief, 1985). In order to determine the final demand, we can solve equation (3) for annual gross output:

$$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{Y} \qquad (5)$$

These final demand values show sales from each sector to final markets for their production, such as personal consumption purchases, investment purchases, exports and sales to the federal government (Miller & Blair, 1985).

Also included in the input-output model are 'value-added' coefficients, which are the difference between the revenues per unit of output (the price of the commodity) and the material costs per unit of output (ten Raa, 2005). These include other inputs that sectors use in production such as labour, capital, government services (taxes), profit, inventoried items and imports (Miller & Blair, 1985).

This system of equations which creates a table of technical coefficients is subject to two mathematical constraints. The first is that no column of the A matrix can be greater than unity and at least one column sum of the A matrix must be less than one (Rose & Miernyk, 1989). However, since technical coefficients are calculated for processing sectors only and these do not include taxes, imports or households this constraint causes no problem (Rose & Miernyk, 1989). The second is that there may be no negative elements in the Leontief inverse, $(\boldsymbol{I} - \boldsymbol{A})^{-1}$. This is because negative elements imply that as a sector expands its output, ceteris paribus, it requires fewer and fewer inputs (Rose & Miernyk, 1989). This second assumption is a major implication of the Hawkins-Simon condition, which states that in order for the x_i which satisfies the system of linear equations stated above to be positive, all principal minors of the matrix $\|a_{ij}\|$ must also be positive (Hawkins & Simon, 1949). This condition is a clear-cut condition which distinguishes the matrices that have a non-negative Leontief inverse (ten Raa, 2005).

The table of technical coefficients can be transformed into an input-output table which describes the flow of goods and services between all the individual sectors of an economy over a stated period of time (Leontief, 1985). This table can be as aggregated or disaggregated as the purpose requires, although a less aggregated table permits a more specific qualitative identification of all the individual entries (Leontief, 1985). The figures in each column of the table describe the input structure of a sector, which shows how much material from other sectors is required to produce that sector's output (Leontief, 1985; Miller & Blair, 1985). The figures in each row of the table describe the output structure of a sector, which shows how much of total output for that sector goes to other sectors (Leontief, 1985; Miller & Blair, 1985).

Table 2 below illustrates the structure of the input-output table. Each column in the table represents purchases and each row represents outputs. Matrix 1 shows the sales and purchases of industries from other industries for use in intermediate production (Poot, 2000). Matrix 2 shows sales by industries to purchasers of final products, such as consumers, government and exports (Poot, 2000). Matrix 3 links matrices 1 and 2 together through labour and capital inputs, and matrix 4 shows the expenditure items which are not part of the operating costs of industries, such as imports of final goods and services by consumers, GST and excise taxes (Poot, 2000).

Table 2

	Intermediate Demand	Final Demand
Intermediate Inputs	1	2
Primary Inputs	3	4

3.1.3. Early Extensions of IO Models:

3.1.3.1. Prices

The basic input-output model can also be represented in value terms based on the assumption that all prices are available. This approach to calculating prices is based on the same technical coefficients that are used to calculate quantities, and was developed by Leontief (1937). Representing the input-output table in value terms is useful because the physical quantities of different inputs absorbed by each sector cannot be meaningfully added to give column totals (Leontief, 1985). Because of the assumptions of the basic model, the price model has been successfully refined to incorporate output responsiveness to prices and vice versa (Rose & Miernyk, 1989). The price version of IO is based on an identity where the price of a good is equal to the cost of the intermediate good plus the value of primary factors involved directly in its production, given by the following price balance equation:

$$\boldsymbol{P} = \boldsymbol{A}'\boldsymbol{P} + \boldsymbol{V} \tag{6}$$

where

$\boldsymbol{P}$ = A vector of commodity prices

$\boldsymbol{A'}$ = the transpose of the A matrix

$\boldsymbol{V}$ = A vector of value-added (returns to non-reproducable primary factors of production)

This balance equation is solved using the solution system:

$$\boldsymbol{P} = (\boldsymbol{I} - \boldsymbol{A}')^{-1}\boldsymbol{V} \qquad (7)$$

The open price model involves n commodity prices and value-added, while the closed price model prices are computed endogenously where there are an infinite number of solutions (Stone, R, 1979). The solution to the closed model yields a unique proportionality relationship between all prices and allows at least for the calculation of relative prices (Bjerkholt, 1986). Equation (7) provides insights into the overall composition of prices in that elements of the transposed inverse $(I - A')^{-1}$ give information on the direct, indirect and induced effects of the price of one commodity on another price (Rose & Miernyk, 1989).

In empirical work most input-output tables are constructed in value terms rather than quantities, tabulating expenditures values. This has the advantage of translating entries in a table into a common denominator of monetary units which facilitates checking accounting balances and intersectoral comparisons of input intensities (Leontief, 1985). However, there are some complications in doing this. Since technical coefficients are all expressed on a per dollar basis, the price of each commodity is equal to unity, which poses the problem that the price is an index number for each sector in one interpretation of the model (Rose & Miernyk, 1989). This problem can be rectified by calculating base year prices separately from the IO model, or obtained as a statistical series (Rose & Miernyk, 1989).

Another complication arises in that each technical coefficient z_{ij}, which is calculated from a value-based table, is equal to the corresponding coefficient of the physical quantities table, a_{ij}, multiplied by the ratio of input and output prices P_i and P_j:

$$z_{ij} = a_{ij}\frac{P_i}{P_j} \qquad (8)$$

The problem here is that the coefficient of the physical quantities table a_{ij} is multiplied by relative prices. Moses (1974) noted that many of the studies about the stability of empirical input-output coefficients are expressed in terms of technical stability, and neglect the presence of relative price terms. This can have a stabilising effect, as when they offset technical change (Moses, 1974).

The price model has been applied to wide range of topics, one of the first of which was Leontief's (1941) study of the basic price structure of the US economy. Leontief (1970b) investigated the effects of environmental regulation on prices, where a key issue was raised. While environmental regulations may raise the price of producing goods and services, they do not need to represent a decrease in economic welfare if the non-market value of a cleaner environment is considered (Leontief, 1970b). Many environmental issues have been addressed using the price model, including Giarratani's (1974) application to pollution control at the regional level to examine consumption pattern effects, and Yan, Chung & Verzilli's (1975) application at the national level. Miernyk, Giarratani, and Socher (1978) studied the effects of higher energy prices, and Catsambas (1982) examined the economy-wide price increases caused by the imposition of a gasoline tax. Melvin (1979) raised an important issue about the use of price mark-ups in a comprehensive study of the price effects of the corporate income tax and its potential effects on the terms of trade between the USA and Canada. Some of the other explorations into a dynamic IO price model have been undertaken by Solow (1959); Leontief (1970a); Haig & Wood (1976) and Duchin (1984).

3.1.3.2. Dynamic Models

Leontief's dynamic input-output model is an extension of the basic model in which time is incorporated explicitly through a lagged vector of total gross output (Miller & Blair, 1985). It was intended to be employed in the description and analysis of the process of economic growth (Leontief, 1985). The advantage of the dynamic model was that it could make investment activity endogenous to the system (Richardson, 1972). It incorporates time dimensions and so can describe the real situation more accurately, while maintaining computational simplicity (Liew, 2000). The most general form of the dynamic model is a set of indifference equations:

$$\boldsymbol{Y}_t = \boldsymbol{X}_t - \boldsymbol{A}_t\boldsymbol{X}_t - \boldsymbol{D}_t\boldsymbol{X}_t - \boldsymbol{B}_t(\boldsymbol{X}_t - \boldsymbol{X}_{t-1}) \tag{9}$$

where

Y_t = A vector of final demand by sector at time *t*

X_t = A vector of total gross output by sector at time *t*

A_t = A matrix of direct input requirements per dollar of output at time *t*

D_t = A matrix of replacement capital coefficients, and

B_t = A matrix of expansion capital coefficients

This balance relationship (Equation 9) is based on the assumption that a good added to the capital stock in year *t* is put to use in the year $t + 1$ (Leontief, 1985). In this model there is a capital coefficient where there is a fixed per unit requirement of capital needed to produce an additional unit of capacity; the main component of the accelerator investment equation which calls for capital stock changes in direct proportions to output capacity over time (Miller & Blair, 1985). Leontief's model is dynamic from both an economic and a mathematical view. It is dynamic from an economic perspective in that production in one period is dependent on production in another period, and dynamic from a mathematical perspective because the model is formulated as a set of difference equations (Rose & Miernyk, 1989).

There are multiple solution approaches to the dynamic model, the most general of which is Leontief's (1970a) solution which involves a simultaneous equation solution and a dynamic inverse. This dynamic inverse shows how an exogenous change in the final demand for a good stimulates direct and second-order demands in several previous time periods (Leontief, 1970a). There has been much empirical work on the dynamic IO model on a variety of topics. Stable versions of early empirical models where the lag structures of the systems of difference equations accurately reflect the differences in gestation periods of specific additions to the stock of capital as it expands have been contributed by Almon (1966), Emerson (1969), Leontief (1970a) and Miernyk et al. (1970). The effects of environmental regulations on the long-run growth of the US economy were studied by Carter (1974), while Leontief & Duchin (1986) estimated the economic impacts of automation in the USA. For industrialised regions and developed nations which produce a significant volume of capital goods, the dynamic input-output model is useful and can be a powerful analytical tool (Bulmer-Thomas, 1982).

However, Sargan (1958) argued that the dynamic model was inherently unstable after examining the behaviour of the model in three special cases, but Leontief (1961) countered with examples that showed "well-behaved dynamically stable linear models with technological or behavioural lags can indeed be easily constructed" (p. 668). Dorfman, Samuelson & Solow (1958) also revealed some instabilities in the dynamic model when one assumes full capacity utilisation when they characterised the dynamic IO model as a special case of the von Neumann growth model. Solow (1959) showed how this problem could be eliminated through generalising Leontief's dynamic model by removing the full capacity utilisation restriction and allowed prices to change and be expected to change.

3.1.3.3. Interregional Models

Interregional input-output models were first developed by Isard and Leontief in the 1950's. Isard (1951) developed a pure interregional model which was constructed by developing a set of regional tables, while Leontief (1953) developed a balanced interregional model which was constructed by disaggregating a national table into a set of component regions. Rose & Miernyk (1989) have suggested that the Leontief balanced model is useful for determining regional implications of national projections, while Isard's pure model is useful for determining national implications of regional projections.

Some other early efforts to construct interregional input-output tables were made by Chenery et al. (1953) and Moses (1955), although these attempts were more conceptual than empirical. Moses found that trade coefficients are sufficiently stable to be evaluated on various levels of regional and commodity aggregation, and if capacity considerations are satisfied and regions are appropriately selected then the model can prove a useful device for analysing short run problems. These early models demonstrated that it is possible to estimate the impacts of changes in one region on others.

Polenske (1980) constructed an operational multiregional input-output model which was an extended and modified version of Leontief and Strout (1963), who considered space through the use of gravity constants, thus permitting the identification of cross-hauling where it exists. Leontief (1977) also constructed a global interregional model with the objective of studying the environmental aspects of the future world economy. Some of the topics in the vast interregional input-output analysis literature include regional development (see Miernyk, Shellhammer, & Brown, 1970), location decisions (see Kim, Boyce, & Hewings, 1983), and regional energy management (see Blair, 1979).

3.2 Supply and Use Tables

Input-Output tables can be constructed from supply and use tables. Since this is the way in which the input-output model will be constructed in this study, this section will explain what supply and use tables are and how they portray a certain economy. National supply and use tables are a statistical system which describes, in detail, the domestic production processes and the transactions in products of the economy (Avonds, Hambye, & Michel, 2007; Piispala, 2000). They are a set of industry-by-commodity matrices which show how the output of industries is broken down by types of products, and how the domestic and imported supply of goods and services is allocated among various intermediate and final uses (Avonds, et al., 2007). However, these tables do not give information on the input-output structure of the economy in terms of industry by industry (de Boer, van Nunspeet, & Takema, 2000).

Supply and use tables show the structure of the costs of production and income generated in the production process, as well as the flow of goods and services produced within the national economy and the flows of goods and services with the rest of the world (De March & Beutel, 1998). The supply and use tables give an integral picture of the flows of commodities through the economy (Konijn, de Boer, & van Dalen, 1997). Therefore, commodity flows are described more accurately, thus resulting in maximum transparency due to available data being optimised (de Boer, et al., 2000; Konijn & Steenge, 1995). However, while the supply and use system is more accurate, a choice now has to be made between several options to derive a traditional input-output table from the system of supply and use matrices in order to calculate multipliers to analyse direct and indirect effects of changes in final demand (Konijn & Steenge, 1995).

In the supply table, the supply of goods and services is broken down by product and by origin, making a distinction between domestic output by industries and imports (Avonds, et al., 2007). In other words, it shows the value of production in each industry and the total value of imports for each product (Van Den Cruyce, 2004). Conversely, the use table shows the industry structure of production costs and income generated (Avonds, et al., 2007). It shows the use for immediate consumption in each industry as well as the use for final consumption, gross fixed capital formation and exports for each product (Van Den Cruyce, 2004).

Generally the supply table is valued at basic prices while the use table is valued at purchasers' prices, so they are incomparable. The purchasers' price is the price actually paid by the purchaser for the product and includes the basic price plus any distribution margins and any net taxes on products (Avonds, et al., 2007). Therefore, in order to make them useable, supply and use tables must be converted to basic prices to eliminate the distorting impact of margins, taxes and subsidies on prices (Avonds, et al., 2007).

Since the supply and use tables are balanced (the supply and demand sides are equal), two identities are fulfilled (Piispala, 2000). The first identity is that total supply by industries is equal to total use by industries such that a complete description of the flows of a commodity in the economy is given (Konijn, et al., 1997; Piispala, 1999, 2000). The second identity is the commodity identity where total supply by commodities is equal to total use by commodities (Konijn, et al., 1997; Piispala, 1999, 2000). These two identities ensure that the whole system is balanced and consistent (Piispala, 2000).

3.3. Converting Supply and Use to Input-Output Tables

In order to convert the supply and use tables into an input-output table, a transactions table of intersectoral trade is constructed. If sectors can be identified with their primary commodity outputs (i.e. the supply table is diagonal) then the transactions table can be constructed simply (ten Raa, 1994). However, in reality this is not normally the case due to sectors producing a mixture of outputs, so it must be altered to make it diagonal (ten Raa, 1994). This problem is dealt with using different technology assumptions such as the commodity technology assumption, industry technology assumption, activity method, by-product technology method, transfer method or the mixed technology method. The choice of method is made on the basis of the reasonableness of the assumptions as judged by the economist, and the transactions table and matrix of technical coefficients comes out of it and is used in input-output analysis (ten Raa, 1994). The two most commonly used technology assumptions are the commodity technology assumption and the industry technology assumption.

3.3.1. Commodity Technology Method:

The commodity technology method assumes that each commodity has its own input structure such that industries are independent of commodities (ten Raa, Chakraborty, & Small, 1984; van Rijckeghem, 1967). This means that a given product is made with the same inputs no matter which industry it is made in and therefore its production process is technically separate from the product (Almon, 2000; Viet, 1994). Since industries are independent of their input structures, industry *j* needs a total amount $a_{ik}v_{jk}$ of input *i* for its production of v_{ik} units of output *k* (Rueda-Cantuche & ten Raa, 2009; ten Raa, et al., 1984; van Rijckeghem, 1967). The matrix form of the input-output coefficients under this method is given by:

$$\boldsymbol{A} = \boldsymbol{U}(\boldsymbol{V}')^{-1} \quad (10)$$

However, this method works only if the number of commodities equals the number of industries (ten Raa, et al., 1984).

3.3.2. Industry Technology Method:

The industry technology method assumes that the input structures of industries are proportional to their outputs and there are fixed commodity market shares of industries (Almon, 2000; ten Raa, et al., 1984; ten Raa & Rueda-Cantuche, 2003). Therefore, each industry has the same input requirements for any unit of output and every commodity has different technologies depending on which industry produced it (ten Raa, et al., 1984; ten Raa & Rueda-Cantuche, 2003). These two assumptions mean that the inputs associated with each unit of secondary output can be separated and reclassified to the sector where it is produced as the characteristic product (Viet, 1994). The matrix form of the input-output coefficients under this method is given by:

$$A = U\widetilde{Ve}^{-1}V\widetilde{V'e}^{-1} \quad (11)$$

3.3.3.Activity Technology Method:

The activity technology method proposed by Konjin and Steenage (1995) disaggregates current commodity classifications in supply and use tables and assigns commodities to activities with regard to their input structure. An activity-by-activity matrix is then developed and input-output tables are derived by distinguishing between goods which are "use for transformation" and goods which are "final use" (Konijn, et al., 1997). This activity method was later illustrated by Konijn, de Boer & van Dalen (1997) with an application to the flows of iron, zinc and steel. Konjin and Steenage (1995) also note that since this method requires a large amount of information regarding production processes, where there is limited information available the best alternative is to set the activity equal to the industry such that all output from an industry is produced by one activity. Therefore, following these assumptions, the industry technology method is the best alternative if the activity technology method cannot be applied (Konijn & Steenge, 1995).

3.3.4. By-Product (Stone) Technology Method:

The by-product technology method assumes that each industry produces outputs in a fixed proportion (Fukui & Seneta, 1985; ten Raa, et al., 1984). Under this method all secondary products are by-products and are entered as a negative input in the industry where they are produced (Viet, 1994). An input-output table is produced in which an industry's output represents only primary products and so does not express all outputs produced in the economy (Viet, 1994). It should be noted that with the by-product technology method the number of commodities must equal the number of industries as with the commodity technology method (ten Raa, et al., 1984). The matrix form of the input-output coefficients under this method is given by:

$$A = (U - \widetilde{V}')\widehat{V}^{-1} \quad (12)$$

where $\tilde{\boldsymbol{V}}'$ is the off-diagonal of the transposed V matrix, and $\hat{\boldsymbol{V}}^{-1}$ is the diagonal of the inverse of the **V** matrix (Fukui & Seneta, 1985; Jansen & Ten Raa, 1990; ten Raa, et al., 1984; Viet, 1994).

3.3.5. Transfer Method

The transfer method assumes that secondary products are sold by the industry that produces it to the industry to which it is a primary product (ten Raa & Rueda-Cantuche, 2003; Viet, 1994). The matrix form of the input-output coefficients under this method is given by:

$$\boldsymbol{A} = \left(\boldsymbol{U} + \tilde{\boldsymbol{V}}\right)\left(\widehat{\boldsymbol{V}\boldsymbol{e}} + \widehat{\boldsymbol{V}'\boldsymbol{e}} - \hat{\boldsymbol{V}}\right)^{-1} \qquad (13)$$

The inclusion of a transfer distorts the input structure of the industry to which the secondary products are primary products, and as a result an increase in the final demand of those secondary products would lead to an increase in demand for the primary outputs of the industry that actually produces them, which does not need to be true (ten Raa & Rueda-Cantuche, 2003; Viet, 1994). This method also produces an input-output table where sector output can be either industry output or commodity output, and the input structures of industries that produce secondary products can be altered if the proportion in which they are produced changes (ten Raa & Rueda-Cantuche, 2003; Viet, 1994).

3.3.6. Mixed Technology Method:

The mixed technology method, developed by Gigantes (1970), combines the commodity technology and industry technology methods. This method relies on the assumptions that industries' output of primary products and ordinary secondary products fulfil the commodity technology assumption and that outputs of by-products fulfil the industry technology assumption since by-products have the same input structures as the industries producing them (ten Raa, et al., 1984; ten Raa & Rueda-Cantuche, 2003).

Ten Raa, Chakraborty, & Small (1984) later developed a modified version of Gigante's mixed technology model where instead of assuming that by-products fulfil the industry technology assumption, it is assumed that by-products fulfil the by-product assumption. They derived a closed form expression:

$$\boldsymbol{A} = (\boldsymbol{U} - \boldsymbol{V}_2')\boldsymbol{V}_1^{-1} \qquad (14)$$

where V is split into a table V_1 of primary products and ordinary secondary products and a table V_2 of secondary products (ten Raa, et al., 1984).

3.3.7. Comparison

The different methods for deriving input-output coefficients discussed above have been evaluated by Jansen & ten Raa (1990) using axioms for material balance, financial balance, price invariance and scale invariance. The material balance axiom requires that the input requirements of total output must match observed total input and the financial balance axiom requires that the input cost of output must match the observed value of input (Jansen & Ten Raa, 1990). Price invariance exists when the choice of base year prices doesn't affect the results in a scaling fashion (Jansen & Ten Raa, 1990). The scale invariance axiom requires that there are constant returns to scale (Jansen & Ten Raa, 1990). Using these axioms, Jansen & ten Raa found that the commodity technology method satisfies all four axioms and so is the best method to use, while the industry technology method only satisfies the material balance axiom, and the mixed technology method satisfies the scale invariance and price invariance axioms. The transfer method satisfies none of these axioms.

Ten Raa and Rueda-Cantuche (2003) also examined the different methods using the four axioms proposed by Jansen and ten Raa, but transform the material and financial balance axioms so that they are presented in terms of the commodity technology method. They concluded that the material and financial axioms will be fulfilled under some restrictions on the data, and that the transfer and industry technology methods need restrictive conditions in order to fulfil all axioms.

Ten Raa, Chakraborty, & Small (1984) also compared the different methods for deriving input-output coefficients, and rejected all of the models they studied. The commodity technology method often produces negatives and assumes that no industry's outputs are technologically related, while the by-product method was criticized because of its rigid output proportionality assumption (ten Raa, et al., 1984). The negative elements in the commodity technology method occur when the input structure of the secondary products is not the same as that of the characteristic product produced elsewhere, and the input which is transferred out is larger than the input that is actually consumed (Avonds, 2005; Avonds & Gilot, 2002; Viet, 1994). The commodity technology method is also rejected by others on this basis, such as Viet (1994) and de Mesnard (2004). Bohlin and Widell (2006) solve this problem of negative coefficients and show how the commodity technology method can be applied with a rectangular matrix so the number of commodities does not have to equal the number of industries. This is done using a minimisation problem with the constraint that the quantity of commodity i used in industry k must be equal to the sum of the use of commodity i for all commodities produced in industry k. Almon (2000) also proposes an algorithm for the construction of commodity-by-commodity input-output matrices that solves the problem of negative elements by allowing deviations from the small commodity technology assumption or, viewed from another perspective, by correcting the Use matrix.

As mentioned above, the by-product method produces an input-output table that does not fully express all outputs produced in the economy (Viet, 1994). Also, elements of the derived A matrix may be negative which results in outputs calculated from the Leontief inverse becoming negative when the demand for the primary product is large and the demand for its secondary product is very small (Viet, 1994). However, this method yields operation levels which are identical to those obtained from the linear productive system, and allows the true levels of direct and indirect requirement to be recovered (Fukui & Seneta, 1985).

The industry technology method is also rejected on the basis that no base year prices objectively underlie the representation of technology since instead of being just a scaling device, they influence technological relationships (ten Raa, et al., 1984; Viet, 1994). The mixed technology method proposed by Gigantes (1970) is rejected for the same reason (ten Raa, et al., 1984). The industry technology method also violates the assumption in input-output economics that cost is equal to price because costs associated with either primary or secondary products are assumed to be the same (Viet, 1994). Also, the industry technology method implies the attribution of industrial inputs to wholesale activities, which does not make sense (Avonds, 2005). However, the industry technology method is found to be more realistic and flexible than other methods, and is therefore used most often (Almon, 2000; De Mesnard, 2004; ten Raa, et al., 1984; Viet, 1994). Because of this, the industry technology method will be used to construct the national level input-output table in this study.

3.4. Regionalising Input-Output Tables

3.4.1. Survey Methods

The most straightforward way to produce regional input-output tables is to survey firms in the region and construct a survey-based table (Miller & Blair, 1985). These tables are assembled on the basis of surveys of firms, consumers and government institutions, as well as on the basis of experts' judgements about each sector (Sargento, 2009). This approach attempts to identify the elements of a transactions table from a collection of primary data by surveys of industries and final consumers, concerning both sales and purchases (Bonfiglio & Chelli, 2008). In constructing the input-output table this way the product-mix problem at the regional level, wherein firms in the same industries produce different sets of products, is solved (Miller & Blair, 1985). In constructing a survey-based table the survey questions can be written in a less exacting fashion in order to produce the true regional technical coefficients which better reflect production practices in the region (Miller & Blair, 1985). Regional input coefficients based on inputs supplied from firms within the region must be calculated in order to address the question of how much of a good is imported and how much is produced in the region (Miller & Blair, 1985).

However, this approach relies on careful craftsmanship to avoid bias in estimating transactions from survey data (Jensen, 1990). This requires professional judgement by the team of analysts and the respondents, based on educated guesses and sometimes simply the estimates of people in a better position to form judgements (Miernyk, 1976). This can result in different research teams achieving different input-output tables even with the same set of data (Sargento, 2009). As reviewed by Jensen (1980), survey methods are widely regarded as the preferred method despite their heavy reliance on professional judgement rather than statistical analysis of survey data, which appears to defy the conventions of economic analysis. This is because errors can arise from incorrect definition of the sample, poor design of questionnaires, hiding of information or lack of concern in answering the questionnaires (Jensen, 1980). Also, since some questions included in the surveys require very detailed information to which some respondents may not be able to answer, even official agencies collecting statistics are forced to use some hypotheses in order to complement the information they cannot obtain directly from surveys (Sargento, 2009).

3.4.2. Non-Survey Methods

Alternatives to survey methods for the construction of regional input-output tables are numerous non-survey methods, such as location quotient techniques and iterative balance techniques (e.g. RAS technique and commodity balance techniques). These non-survey methods are used to derive smaller regional input-output tables from a larger region, most often a national input-output table. They can be defined as a set of procedures that aim to fill the components of a regional table on the basis of values, which are comprised in a similarly structured national table (Jensen, 1990). The values from the national table are used as a starting point, and then specific regional indicators are applied to regionalise them (Lahr & Stevens, 2002; Sargento, 2009).

The accuracy of non-survey regional input-output tables is determined by the industrial mix, technology and external trade; each of which assumes a different influence in the table’s accuracy (Lahr, 1993). Differences in industrial mix often occur between the region and the nation since national structures are applied to regional industries in which the proportion of each sub-industry is different from the national one, but this can be partially solved by using a high degree of disaggregation when regionalising the national table (Goldman, 1969). If the regional technical coefficients matrix is set to equal the national matrix (the national technology assumption), the implicit hypothesis is that technology is spatially invariant within the same country (Lahr, 1993). However, this is an empirical issue which depends greatly on the similarities and differences in the specific national and regional economies under study (Sargento, 2009). For example, Harrigan et al. (1980a) compared a survey-based regional coefficient matrix of Scotland with a constructed non-survey matrix based on the matrix for the United Kingdom and found large differences between them, whereas Boomsma and Oosterhaven (1992) conducted the same experiment in the Netherlands and concluded that the non-survey matrix was a close approximation even for subsectors that were specific to the region. Finally, two types of external trade must be distinguished in a regional economy; namely imports and exports between it and other countries, and imports and exports between it and other regions (Isserman, 1980). The more difficult aspect of estimating external trade is estimating interregional trade flows because of the lack of reliable data on interregional flows (Czamanski & Mazilia, 1969).

The aforementioned empirical difficulties in accurate regional table construction have been well-documented in the literature (see, for example, Hewings & Romanos, 1981; Jensen, 1980; Jensen & West, 1980; Stevens & Trainer, 1976; West, 1981). Non-survey methods for regionalising input-output tables will fail to reflect those technological differences between national and regional aggregate sectors that are caused by regional variations in the industrial mix (Lahr & Stevens, 2002). This will cause differences between the regional and national aggregate technologies that are calculated by using regional or national outputs as weights (Lahr & Stevens, 2002).

3.4.2.1. Location Quotient Techniques

3.4.2.1.1. Simple Location Quotient

The simple location quotient approach is a single-step method which produces regional tables which are "mini-versions" of national tables (Jensen, 1990). It is the simplest of the location quotient techniques and is often used in practice, mostly because it requires little data and analytical skill, and can be carried out quickly and inexpensively (Isserman, 1977). The objective of these location quotient methods is to determine export or import orientation of regional industries, or the spatial direction of intersectoral flows (Round, 1983). It is a measure of the size of industry i in a region relative to its size in the nation, where size may be measured in terms of employment, personal income, earnings, value added, or output (Sawyer & Miller, 1983). The location quotient is defined as:

$$LQ_i = \frac{x_i/x}{X_i/X} \qquad (15)$$

where x_i is the regional output of industry i, x is the total regional output, X_i is the national output of industry i and X is the total national output (Flegg, Webber, & Elliott, 1995; Harrigan, McGilvray, & McNicoll, 1980b; Isserman, 1977; Round, 1983; Sasaki & Shibata, 1984; Sawyer & Miller, 1983; Schaffer & Chu, 1969). If the location quotient is equal to one then the region is self-sufficient in the industry in question, and if the location quotient is greater than one then the region exports some of its output in the industry (Bonfiglio & Chelli, 2008; Round, 1983; Sasaki & Shibata, 1984; Schaffer & Chu, 1969). In either of these cases, the regional technical coefficient is equal to the national technical coefficient (i.e. $a_{ij} = A_{ij}$), and regional interindustry flows can be computed as

$$x_{ij} = a_{ij}x_j = X_{ij}\frac{x_j}{X_j}. \qquad (16)$$

and exports of industry i are then computed as a residual

$$e_i = x_i - \sum_j^s x_{ij} - \sum_f^t y_{ij} \qquad (17)$$

(Isserman, 1977; Schaffer & Chu, 1969).

However, if the location quotient is less than one, the region imports some of its needs of output i, i.e. local production is assumed to be inadequate to supply local needs (Bonfiglio & Chelli, 2008; Schaffer & Chu, 1969). Therefore, no exports can be made and imports are necessary, so the regional production coefficient is

$$a_{ij} = LQ_i A_{ij}, \qquad (18)$$

and regional gross flows are

$$x_{ij} = a_{ij}x_j = X_{ij}LQ_i\frac{x_j}{X_j} \qquad (19)$$

(Schaffer & Chu, 1969).

This procedure allocates the local sales of an industry producing insufficient output to meet local demand as multiples of national gross flows weighted by the relative sizes of purchasing industries (Schaffer & Chu, 1969). Imports of product i are computed as the amounts necessary to satisfy production requirements

$$m_{ij} = A_{ij}x_j - x_{ij} \qquad (20)$$

(Schaffer & Chu, 1969).

This simple location quotient method is only effective when the local industry structure closely resembles the national structure because it only incorporates the relative size of the supplying industry and the relative size of the region (Flegg, et al., 1995; Isserman, 1977; Schaffer & Chu, 1969). It assumes that regional coefficients can never be larger than the equivalent national coefficients, and, as well as this, no account is taken of the relative importance of the purchasing sector (Harrigan, et al., 1980b). The simple location quotient involves a constant domestic share coefficient such that each intermediate user of product i imports an equal proportion of that product from outside the region (Harrigan, et al., 1980b). There is no cross-hauling; each sector is either an exporter or an importer, not both (Harrigan, et al., 1980b). Since quotients are used asymmetrically, the strength of export orientation plays no part in the determination of trade coefficients (Round, 1983). Therefore, it is not guaranteed that the sum of net exports for each small region is equal to the exports of the large region when the location quotient method is applied separately to each of the small regions (Sasaki & Shibata, 1984).

3.4.2.1.2. Cross-Industry Location Quotient

The cross-industry location quotient method compares the proportion of national output of selling industry i in the region to that for the purchasing industry j:

$$CILQ_{ij} = \frac{x_i/X_i}{x_j/X_j} \tag{21}$$

(Flegg, et al., 1995; Harrigan, et al., 1980b; Schaffer & Chu, 1969).

If $CILQ_{ij}$ is greater than or equal to one, then the regional technical coefficient is equal to the national coefficient for cell ij and we assume that local industry i can provide all of the output required by local industry j(Schaffer & Chu, 1969). Regional gross flows are then defined as the local purchasing industry's share of national gross flows,

$$x_{ij} = a_{ij}x_j = X_{ij}\frac{x_j}{X_j} \tag{22}$$

(Harrigan, et al., 1980b; Hewings, 1969; Schaffer & Chu, 1969).

If $CILQ_{ij}$ is less than one, then the regional technical coefficient is equal to the national technical coefficient multiplied by $CILQ_{ij}$ which shows the national distribution coefficient for industry i weighted by the ratio of the regional size of the selling industry to that of the purchasing industry (Schaffer & Chu, 1969). Regional gross flows are then defined as the local selling industry's share of national gross flows,

$$x_{ij} = a_{ij}x_j = \frac{X_{ij}}{X_i}\frac{x_i}{x_j}x_j = X_{ij}\frac{x_i}{X_i} \quad (23)$$

(Flegg, et al., 1995; Harrigan, et al., 1980b; Schaffer & Chu, 1969).

Under this method, imports and exports are computed as residuals. Exports are computed as

$$e_i = x_i - \sum_j^s x_{ij} - \sum_f^t y_{if} \quad (24)$$

and imports are computed as

$$m_{ij} = A_{ij}X_j - a_{ij}x_{ij} \quad (25)$$

(Schaffer & Chu, 1969).

Under this method there is no guarantee that e_i will be greater than or equal to zero. If e_i is negative then the sales of industry i are greater than its output in the region, and gross flows must be adjusted downward (Schaffer & Chu, 1969).

The cross-industry location quotient allows a variable domestic share coefficient; for each product i the share coefficient can differ according to the user industry (Harrigan, et al., 1980b). This method takes no account of the size of the local region and yields multipliers which are higher than the simple location quotient (Flegg, et al., 1995; Schaffer & Chu, 1969). However, it yields the best estimates of imports and exports by industries alone because there is cross-hauling such that a sector can export and import simultaneously (Harrigan, et al., 1980b).

3.4.2.1.3. Purchases-only Location Quotient

The purchases-only location quotient method was first suggested by Charles Tiebout for the CONSAD Corporation to use in constructing state input-output models, and yielded consistent results in the setting studied (CONSAD Research Corporation, 1967). It is a modification of the simple location quotient approach,

$$PLQ_i^{'} = \frac{x_i/x^{'}}{X_i/X^{'}} \quad (26)$$

where the prime indicates that the summation only includes the outputs of those industries which purchase from industry i (Hewings, 1969; Schaffer & Chu, 1969). This approach differs from the simple location quotient approach in that the values of the location quotients are not the same, so the determination of export-producing industries will be different (Schaffer & Chu, 1969). However, when $x/X = x'/X'$ for industry i, then PLQ_i' and LQ_i are the same (Schaffer & Chu, 1969). In practice, this type of quotient only marginally impacts the results when compared to the simple location quotient (Morrison & Smith, 1974).

3.4.2.2. Commodity Balance Technique (or Supply-Demand Pool Approach)

The commodity balance technique (also known as the supply-demand pool approach) uses the national input-output table to estimate the regional input requirements (Round, 1983; Sargento, 2009). It is based on the balance, b_i^r, between the local output of each commodity i and the local requirements, i.e.

$$b_i^r = -\sum_j a_{ij}^N X_j^r - Y_i^r + X_i^r \qquad (27)$$

(Harrigan, et al., 1980b).

A matrix of sales by each regional sector (Y_i^r) as well as a matrix of requirements ($\sum_j a_{ij}^N X_j^r$) are calculated, where both matrices are based on the structure of the national flow matrix (Round, 1983; Sargento, 2009). The input requirements matrix shows the total regional demand for products without a designation of sources of supply, but it indicates whether the region is expected to export or import each product (Schaffer & Chu, 1969). This matrix is extended to get an input-output table via the supply-demand pool technique which allocates local production to meet local needs (where local production is inadequate, each purchasing industry j is allocated its' share of regional input i) (Schaffer & Chu, 1969).

When $b_i^r \geq 0$ there is a commodity surplus and local supply is assumed to be sufficient to fulfil local requirements (Harrigan, et al., 1980b). This is treated as net exports, and the regional trade coefficients for that commodity are equal to the national trade coefficient (Round, 1983; Sargento, 2009). There is a commodity deficit when $b_i^r < 0$, indicating net imports, and the regional trade coefficient is given by the ratio of regional output to regional requirements;

$$a_{ij}^r = a_{ij}^N \frac{X_i^r}{d_i^r} \qquad (28)$$

where d_i^r is the local requirements of commodity i (Round, 1983; Sargento, 2009).

3.4.2.3. Iterative Balance Methods

The iterative balance procedure is similar to the commodity balance approach because the iterative element is simply introduced as a mechanism for achieving a final balance (Round, 1983). These iterative procedures were first developed by Czamanski and Mazilia (1969) and Schaffer and Chu (1969). The general principle behind these methods is to find the matrix which is closest to an initial matrix but with respect to the column and row totals of a second matrix (de Mesnard, 2003). It assumes that the national production technology applies but also attempts to distribute local production according to both the national sales pattern and local needs (Schaffer & Chu, 1969). This differs from the pool technique above in that it attempts to follow the national sales patterns to distribute local output and in reallocating sales from one cell to another as necessary to best satisfy local needs (Schaffer & Chu, 1969). This method uses a national coefficient iteration where national coefficients and interindustry requirements are combined with an observed requirements column vector (Hewings, 1969).

The iterative procedure developed by Czamnski and Mazilia (1969) was a fore-runner of the RAS method, and adjusts individual, pre-assigned elements to conform with known constraints (vectors of total intermediate sales and purchases within the region). McMenamin and Haring (1974) suggested an alteration to Czamanski and Mazilia's method where the entire matrix, including final demand and value added, is adjusted to conform to gross output and outlay vectors for the region. These methods are therefore more precise than the quotient techniques and the commodity balance techniques because more is assumed known about the matrix to be estimated (Round, 1983).

3.4.2.3.1. RAS Technique

The RAS technique was developed by Stone and Brown (1962), and is a type of iterative procedure that is applied when the researcher wants to find the values to fill in a specific matrix on the basis of another matrix, which can be considered as a good indicator to the first one, and with regard to specific prior restrictions (Harrigan, 1990). It is conceivably the most widely used partial survey technique

(Sawyer & Miller, 1983). RAS is popular because it has the advantages that it is a very simple technique and it requires a minimum amount of data (Lahr & De Mesnard, 2004; Möhr, Crown, & Polenske, 1987). Also, many empirical studies which assess the relative performance of alternative matrix adjustment methods conclude that RAS produce the best results because of the inclusion of some survey data (see, for example Czamanski & Mazilia, 1969; Harrigan, et al., 1980b; Jackson & Murray, 2004; Oosterhaven, 1984).

This method requires the addition of regional data to simulate regional technical coefficients from national coefficients to conform with predetermined regional row and column constraints (Harrigan, et al., 1980b). It implies knowledge of final and intermediate imports, both from the rest of the world and from other regions as well as knowledge of sectoral regional exports (Harrigan, et al., 1980b). It also requires information about total interindustry sales, total interindustry purchase and total outputs by industry in the regional economy (Sawyer & Miller, 1983). An advantage of the RAS technique is that it contains no explicit or implicit assumptions about the determinants of trade flows (Harrigan, et al., 1980b). Therefore it is a reasonable prior expectation for RAS to perform better than other nonsurvey methods because it is assumed that more information is available (Round, 1983). However, it depends on the choice of a pre-assigned matrix of technical coefficients on which the iterations run, which may not be a good choice for a regional input-output matrix, especially if it is true that large import coefficients tend to be associated with large technical coefficients (Round, 1983). This finding was discovered from the results of Harrigan and McNicoll (1981) who conducted a regional input-output study on Scotland based on the UK input-output table.

In carrying out the RAS technique, the regional coefficients in the matrix that is being adjusted is set equal to the base matrix such that the intermediate transactions matrix for the region is given by

$$\boldsymbol{Z}^{I} = \boldsymbol{A}^{n}\hat{\boldsymbol{X}}^{r} \tag{29}$$

Where $\hat{\boldsymbol{X}}^{r}$ is a diagonal matrix with total industry output for the nation in the main diagonal (Morrison & Smith, 1974; Sargento, 2009). Calculated row sums are then compared with the known row sums (total output by industry) such that the new technical coefficient matrix is given by

$$\boldsymbol{A}^{I} = \hat{\boldsymbol{r}}^{I}\boldsymbol{A}^{n} \qquad (30)$$

where $\hat{\boldsymbol{r}}^{I}$ is the known intermediate transactions divided by the calculated intermediate transactions, given by

$$r_i^I = \frac{z_{i.}^r}{(z_{i.}^r)^I} \qquad (31)$$

and represents a quotient which indicates the sign and value of the error implicit in the hypothesis of equal regional technical coefficients (Sargento, 2009). This quotient can also be thought of as the result of a substitution effect (Stone, R, 1961). In this step of the RAS, all row elements are multiplied by r_i^I to sum exactly $z_{i.}^r$. A new intermediate transactions matrix can then be calculated where the row sums must equal the know values $z_{i.}^r$;

$$\left(Z^{r\,II}\right) = A^I \tilde{X}^r \qquad (32)$$

(Morrison & Smith, 1974; Sargento, 2009).

The calculated column sums must also be compared to the known column sums, so another quotient is defined;

$$s_j^{II} = \frac{z_{.j}^r}{(z_{.j}^r)^{II}} \qquad (33)$$

which can be interpreted as the result of a productivity effect (Stone, R, 1961). This quotient is used to uniformly adjust all elements of column j in order to obtain a new set of technical coefficients (Morrison & Smith, 1974; Sargento, 2009). Once these technical coefficients are multiplied by the industry outputs they will sum exactly $z_{.j}^r$. Another intermediate transactions matrix is then calculated,

$$\left(Z^{r\,III}\right) = A^{II} \tilde{X}^r \qquad (34)$$

and the consistency between the corresponding row and column totals and the known values is checked again (Morrison & Smith, 1974; Sargento, 2009). This process is repeated iteratively until convergence between the calculated and known totals is achieved (Morrison & Smith, 1974). When the difference between the known margins and the estimated ones is very small, the iterative process should stop but the difference should not exceed 0.005 (Miller & Blair, 1985, p. 286).

3.4.2.4. Other Non-survey Methods for Regionalising Input-Output Tables

3.4.2.4.1. Semi-Logarithmic Location Quotient

The semi-logarithmic location quotient incorporates the properties of both the SLQ and CILQ methods because it takes account of the relative importance of the region (Flegg, et al., 1995; Round, 1978). This quotient includes both SLQ_i and SLQ_j such that the relative size of both the selling and purchasing sectors is considered (Bonfiglio & Chelli, 2008). The semi-logarithmic location quotient is given by

$$RLQ_{ij} = \frac{SLQ_i}{\log_2(1+SLQ_j)} \tag{35}$$

The RLQ produces values which mediate between the SLQ and CILQ techniques, and when SLQ is equal to one, the RLQ method produces values identical to those of the SLQ and CILQ techniques (Harrigan, et al., 1980b).

3.4.2.4.2. Flegg et al. Location Quotient

Flegg et al. (1995) developed a new quotient method in an attempt to overcome the major problem with the existing location quotient methods: the overstatement of multipliers. The objective of this new method was to retain the merits of the ELQ (an adjustment of Round's semi-logarithmic quotient which adjusts the technical coefficient for its relative size using employment data) and the CILQ, whilst avoiding their shortcomings (Flegg, et al., 1995). The Flegg et al. location quotient is given by the following formula:

$$FLQ_{ij} = CILQ_{ij} \times \lambda_r^{\beta} \tag{36}$$

where the regional scalar, $\lambda_r^{\beta} = \frac{TRE/TNE}{\log_2(1+TRE/TNE)}$ has a range from $\log_2 \approx 0.693$ to unity and it is assumed that $\beta \geq 1$ (Flegg, et al., 1995). TRE/TNE is the ratio of total regional employment to total national employment.

This quotient has a greater allowance for regional imports, the smaller the region in question (Flegg, et al., 1995). The need to specify the value of β does create complications, although from the Flegg et al. case studies of Peterborough and Scotland a value of at least 4.5 is suggested in order to offset the tendency of the conventional CILQ to overstate regional multipliers (Flegg, et al., 1995). This is especially important where there is a significant difference between regional and national technologies.

Flegg and Webber (2000) developed an augmented version of the FLQ with the objective of incorporating a measure of regional specialisation. This new formula is given by;

$$AFLQ_{ij} = CILQ_{ij} \times \lambda^{*} \times \left[\log_2(1 + SLQ_j)\right] \qquad (37)$$

where $\log_2(1 + SLQ_j)$ is included to allow for the effects of regional specialisation (Flegg & Webber, 2000). If this term is only operable for $SLQ_j > 1$, then we will have $AFLQ_{ij} > FLQ_{ij}$ for $SLQ_j > 1$ and $AFLQ_{ij} = FLQ_{ij}$ for $SLQ_j \leq 1$ (Flegg & Webber, 2000). Also, where $SLQ_j > 1$ and $CILQ_{ij} \times \lambda^{*} = 1$ the national coefficients will be scaled upwards (Flegg & Webber, 2000). However, this augmented version of the FLQ does not yield more accurate results than those of the FLQ in Flegg et al. (1995) (Flegg & Webber, 2000).

3.4.2.4.3. Regional Purchase Coefficient

The regional purchase coefficient (RPC) is the proportion of regional demand fulfilled from regional production and is based on substitution between extra- and intra-regional sources in response to relative delivered costs (Stevens, Treyz, Ehrlich, & Bower, 1983). This RPC is used along with the national input-output technology (Stevens, et al., 1983). The regional purchase coefficient is estimated using;

$$R_i^L = \left(\frac{Q_i^L}{D_i^L}\right) P_i^L \qquad (38)$$

where Q_i^L is the amount of commodity i produced in region L, D_i^L is the total use of commodity i in region L and P_i^L is the proportion of commodity i produced in L that is shipped to destinations in the region (Stevens, et al., 1983).

However, the authors found that most manufacturing RPCs for most states are somewhat underestimated by the RPC estimating equation, which was due to shortcomings in the Census of Transportation data that was employed (Stevens, et al., 1983). The conclusion from this study was that the RPC can provide models that are acceptably accurate for use in regional impact analysis (Stevens, et al., 1983).

3.4.2.4.4. Regionalising Commodity-by-Industry Accounts

An alternative method for constructing a regional input-output table is to regionalise the national commodity-by-industry accounts (also referred to as supply and use tables). Jackson (1998) discussed a methodology for doing this, as well as others (see, for example Lahr, 2001a; Madsen & Jensen-Butler, 1999; Piispala, 2000; Sargento, 2009). Under this method the national technology assumption is adopted where the regional technical coefficients matrix is set to equal the national matrix (Jackson, 1998; Lahr, 2001a; Madsen & Jensen-Butler, 1999).

The ability of the region to supply its own needs (regional output) is estimated using the region's share of national employment in industry j to obtain the region's share of national output (Jackson, 1998). The assumption behind this is that the weight of product i in total output of industry j is the same in the region and the country (Lahr, 2001a). The use table is regionalised using a similar method where the elements of the matrix at the regional level are derived from the national matrix using the proportion of total intermediate consumption as the regionalising factor (Sargento, 2009). Alternatively, if this information is not available then the proportion of total output can be used as the regionalising factor instead (Sargento, 2009).

Final demand in the use table is regionalised by identifying two categories; local supply-dependent activities and local demand-dependent activities. Regional shares of national output are applied to the corresponding commodity final demand values to regionalise local supply-dependent activities, and to regionalise local demand-dependent activities the national final demand values are multiplied by the region's share of the national total (Jackson, 1998). Imports are regionalised by applying a nonsurvey approach discussed above, for example the supply-demand pool approach or location quotient methods to get import coefficients (Jackson, 1998). Assuming that value-added is proportionate to industry size, and that value-added per dollar of output within industries is invariant across regions, then the regional value-added is computed as:

$$VA_{ij}^{r} = VA_{ij}^{n} \times \tau_j \qquad (39)$$

where τ_j is the region's share of the nation's value-added in the total output of activity j.

Jackson (1998) concluded that regionalising these accounts instead of the technical coefficients in the national input-output table is more accurate and reliable because even if quotient-based methods were applied to implement the regionalisation, there is a critical difference between interindustry table derivation based on conventional versus modified make matrices in that the former leads to overestimated multipliers.

3.4.3. Hybrid Methods

A third method of regionalising national input-output tables is the construction of hybrid tables, which are based on some mixture of survey and nonsurvey methods and attempt to capture the advantages of both approaches (Jensen, 1990). These methods emphasise secondary data but use survey data to supplement the information already in the table (Henry, Leholm, Schaible, & Haskins, 1980). The most common nonsurvey methods used in practice are those that trade-adjust technology coefficients, and of these techniques the regional purchase coefficient approach is the only one that is truly a nonsurvey approach since quotient and iterative procedures usually require some survey data (Lahr, 1993). Therefore, in reality most input-output tables are hybrid tables because purely survey tables are too expensive to construct and purely non-survey tables are too inaccurate for conducting input-output analysis (Dewhurst, J, 1992).

Hybrid tables are typically constructed by semi-survey techniques, employing primary and secondary sources to a greater or lesser extent (Round, 1983). These tables rely on an accurate set of nonsurvey regional input-output accounts (Lahr, 1993). The process of constructing a hybrid regional input-output model consists of modifying a sequence of intermediate models, with each step in the sequence improving the quality of the regional table (Greenstreet, 1989). This property of hybrid input-output models makes them well-suited to continuous updating and adaptation (Greenstreet, 1989). Other advantages of hybrid models are that they have a uniform data base between sectors and a low cost when compared to the survey approach (Henry, et al., 1980). The hybrid sequence also provides a framework for discussing relationships among the various modification procedures and accounting conventions used to build input-output models, including logical compatibility, complementarities in improving model accuracy and effect on data management and collection costs (Greenstreet, 1989). It is for these reasons that hybrid tables are said to be a compromise between the survey and nonsurvey approaches (Bonfiglio & Chelli, 2008). Also, there is sufficient agreement in the literature stating that hybrid methods perform better than nonsurvey techniques in their ability to replicate true multipliers (Bonfiglio & Chelli, 2008).

It has been suggested that direct information should always be included in input-output tables, at least for sectors which the region is highly specialised in or for sectors where technological differentiation is more likely because they are more likely to have a regionally differentiated industrial mix (Lahr, 1993). In doing this researchers are constructing the most accurate non-survey model of the region as possible. For this reason nonsurvey techniques are widely employed within hybrid procedures to derive a first estimate of coefficients that are then adjusted to conform to the direct information (Jensen, Mandeville, & Karunarante, 1979; Lahr, 2001b). These adjustments are usually made by optimisation techniques (such as RAS) which minimise the difference between indirectly estimated coefficients and final coefficients, under constraints represented by accounting identities and direct information (Bonfiglio & Chelli, 2008).

The accuracy of nonsurvey models are more critical for many advanced hybrid techniques since researchers are likely to use information from the nonsurvey model to identify the superior data that needs to be obtained (Lahr, 1993). To ensure the accuracy of the regional model, sectors which have technologies that vary greatly from the national technology will need superior data incorporated so that their technology is properly represented (Lahr, 1993). These sectors are generally those that are resource based, and those traditionally considered to be part of final demand, such as household and government consumption (Lahr, 1993). The incorporation of this data into the regional model should lead to significant changes in the magnitude and relative rank of impacts measures from nonsurvey models and, if a model already exists for the region, inserting this data can be accomplished with relative ease (Ralston, Hastings, & Brucker, 1986). The importance of obtaining superior data for the remaining sectors of the region depends on the relative size of any effects caused by them for all likely applications of the model (Lahr, 1993).

Some early hybrid techniques include the Hansen-Tiebout "rows-only" approach, the Harmston-Lund "columns only" approach and the imports only approach used by Su (Schaffer, 1972). These approaches follow the survey approach, but the rows-only approach is only concerned with the sales distribution, while the columns-only approach is only concerned with the purchases distribution (Schaffer, 1972). The imports-only approach, however, contains survey information which gives the percentage of local versus non-local inputs, and a national table is redefined using the import coefficients (Su, 1970). This is the equivalent of a regional purchase coefficient which is unique for each cell (Su, 1970).

The GRIT method of constructing regional input-output tables was also developed around the same time, in 1977 and was the first large sale application of a hybrid technique to regional input-output analysis (West, 1980). It emerged from research that was completed by a research team at the University of Queensland commissioned by the Queensland Government to produce regional input-output tables for the state of Queensland and its regions (Jensen, et al., 1979). This method employs a number of mechanical means to obtain initial estimates of regional input-output tables from national tables, and allows for operator interference to introduce survey-based or other superior estimates into the table (West, 1980). However, this method is subject to the same disadvantages as the nonsurvey method used to obtain the initial regional estimates (West, 1980).

An example of a hybrid model constructed more recently is the Clark County input-output model constructed by Guaderrama et al. (1999). The authors started with a model generated by the IMPLAN database and then modified it extensively with a combination of surveys and Idaho Extension data sources in order to improve the accuracy of the original nonsurvey model (Guaderrama, et al., 1999). Other efforts include those of Ralston, Hastings & Brucker (1986), who incorporated primary data about the location of specific input purchases into an existing Delaware input-output model which was estimated using the supply-demand pool method, and Henry, Leholm, Schaible, and Haskins (1980) who employed a method of integrating tax department data with field survey data for the construction of an input-output table at a relatively low cost and with data base uniformity for a wide range of business and agricultural activities.

3.4.4. Overall Comparison

In comparing the various nonsurvey techniques for regionalising input-output tables it has been found that although it has many flaws, the simple location quotient is the most successful (Cartwright, Beemiller, & Gusteley, 1981; Morrison & Smith, 1974; Schaffer & Chu, 1969). This is partly because the simple location quotient method is easy to apply and requires little additional information. As well as this, in estimating regional technical coefficients, industry outputs and multipliers for a region in Eastern Finland, Eskelinen and Suorsa (1980) found that the simple location quotient provided the closest estimate. The cross-industry location quotient overcomes the shortcomings of the simple location quotient by taking account of the relative size of the supplying sector i and the relative size of purchasing sector j (Tohmo, 2004). Therefore the cross-industry location quotient method and iterative balance procedures (such as RAS) are also among the most successful of the nonsurvey methods because they yield the best estimates of imports (Schaffer & Chu, 1969).

However, there is no theoretical reason why any location quotient system should provide consistently acceptable proxies for the regional technical structure of the economy (Stevens, et al., 1983). The major problem with location quotient methods is that they tend to overestimate regional multipliers (Schaffer & Chu, 1969; Tohmo, 2004). This arises from the fact that conventional location quotients do not take sufficient account of interregional trade (Harrigan, et al., 1980b; Tohmo, 2004). Therefore, location quotients tend to overstate regional multipliers because they reduce the size of technical coefficients for sectors which are under-represented, and increase the size of import coefficients by a corresponding amount (Bonfiglio & Chelli, 2008; Harris & Liu, 1998; Isserman, 1977; Oosterhaven & Polenske, 2009; Sawyer & Miller, 1983; Tohmo, 2004). Smith and Morrison (1974) and Harrigan et al. (1980b) noted that the inaccuracy of technical coefficients in the location quotient techniques is systematic such that models based on this technique will tend to produce overstated regional multipliers, a problem which is compounded by the use of inappropriate aggregation methods.

An improvement on these traditional location quotient techniques is the Flegg et al. location quotient (FLQ) and its augmented version (AFLQ) because they produce closer estimates of regional multipliers (Bonfiglio & Chelli, 2008). The FLQ formula allows for relative regional size such that it overcomes the systematic tendency of other adjustment formulae to overstate regional multipliers (Tohmo, 2004). However, the results of the FLQ and the AFLQ depend on the choice of an exponent β where higher values represent the best compromise among estimating multipliers (Bonfiglio & Chelli, 2008; Tohmo, 2004).

The regional purchase coefficient method proposed by Stevens et al. (1983) is similar to the commodity balance technique, but the latter fails to take into account the fact that all of the output of a good in a region is not actually available to supply that region. However, it does explicitly take into account of actual regional demands for each commodity using calculations similar to the regional purchase coefficient method (Stevens, et al., 1983).

Because of the incorporation of partial survey information, techniques such as RAS have performed better than purely nonsurvey methods such as the location quotient and commodity balance techniques (Harrigan, et al., 1980b; Morrison & Smith, 1974). However, purely nonsurvey methods such as the simple location quotient are still widely used because of their simplicity and ease of application. Nonsurvey approaches contain major theoretical and logical flaws (Jensen, 1990). Because of their simplicity they cannot be expected to represent adequately the complex interrelationships in a regional economy (Jensen, 1990; Round, 1983). However, in sectors where the regional technical structure is similar to the national structure, nonsurvey approaches such as the location quotient technique could predict superior estimates than those produced by an inadequately funded or poorly executed or designed survey (Jensen, 1990).

Round (1983) suggests that in spite of apparent dissimilarities between quotient and balance methods, all of these methods generate tables which are similar to each other. Comparisons of the different nonsurvey techniques have found that all such techniques provide very similar measures of 'closeness' to the actual matrix, so the general conclusion is that there is no unique beset among nonsurvey techniques (Harrigan, et al., 1980b). Round (1983) added to this conclusion, noting that it is highly unlikely that simple constructs such as location quotients can adequately reflect the complex pattern of relationships that create the structure of regional and interregional linkages and commodity flows. Schaffer and Chu (1969) and Oosterhaven and Polenske (2009) also came to a similar conclusion, that there is no substitute for a good survey-based study.

With regard to trade and technical coefficients in nonsurvey and hybrid models, even if strong spatial industrial linkages exist, large within-region trade coefficients may not be associated with the largest technical coefficients because they are not independent of the choice of units (Round, 1983). Also, technical coefficients will change during periods of rapid technological and structural change in an economy, and because of graphical specialisation these changes will be more pronounced at the regional level (Carter, A., 1974; Rose, 1984). Therefore, using unadjusted national input-output coefficients to illustrate the regional technology structure loses insights into the basic structure of the regional economy, as well as proving inefficient for regional input-output applications (Harrigan, et al., 1980b).

Therefore, if nonsurvey or hybrid methods are to be used to generate regional coefficient matrices, they will need to be sufficiently sensitive to capture certain essential features of the regional structure (Harrigan, et al., 1980b). Round (1983) noted that hybrid methods and especially reconciliation methods are showing considerable promise. This is because of the considerable accuracy gains that can be obtained from using selective survey information (Jensen & West, 1980; West, 1981). However, more direct information implies higher costs, which leads to a cost-benefit analysis were the equilibrium occurs when the marginal benefit of substituting estimated for direct information in the table equals the marginal cost of obtaining this direct information (Sargento, 2009; West, 1990). From the above comparison it can be concluded that the limitations of the input-output framework are transcended by its two main strengths; it is a fundamental tool for economic analysis and it is a considerably detailed statistical instrument (Oosterhaven & Polenske, 2009; Sargento, 2009).

3.5. Methods for building interregional tables

One of the acknowledged weaknesses of regional input-output tables is that they view the regional economy in isolation, which ignores interdependencies across boundaries (Miller, 1969). As globalisation increases and markets become more integrated around the world, the need for theories of interregional and multiregional analysis of markets and economies increases (Oosterhaven & Polenske, 2009). In order to overcome this problem, interregional input-output tables can be constructed, which illustrate the linkages between a number of different regions. As has been mentioned in Section 4.1.3.3, interregional input-output models were first developed by Isard (1951) and Leontief (1953) with other early efforts made by Chenery et al. (1953) and Moses (1955). These early interregional input-output models demonstrated that it is possible to estimate the impacts of changes in one region on others. The literature on interregional input output analysis is vast because of the breadth of applications of it. Some of the topics include regional development (see Miernyk, Shellhammer, & Brown, 1970), location decisions (see Kim, et al., 1983), and regional energy management (see Blair, 1979).

3.5.1. Early efforts in Interregional Input-Output Analysis

Isard (1951) developed a pure interregional model which was constructed by developing a set of regional tables. This is the most general of the interregional models, and is an extension of the classic single region model developed by Leontief, based on the assumption that the sectoral and geographical origin of each delivery can be specified (Batten & Martellato, 1985). This model addressed the changing regional and interregional structure problems of space economies by imposing a set of restrictive assumptions where there are constant production coefficients, mean unchanging supply channels and the economy is viewed interregionally. These assumptions hold the underlying structure of the space economy rigid such that the resulting model is static. However, these assumptions are frequently implicitly contained in many other models which aggregate on a national scale output (such as income and other economic magnitudes) and so do not cause problems (Isard, 1951). Isard noted that the interregional framework could be extended to apply to interregional and regional analysis at an international level where stability in relative supply prices may be anticipated, and this was later accomplished by Leontief (1977). This model can assess the interregional impact of any regional change which affects regional structure in terms of output, employment, income etc through three "regional reaction paths":

1) "that associated with the diverse industrial compositions of regions;
2) that associated with the finely interwoven and interlaced network of heterogeneous as well as homogenous market and supply areas of a space economy; and
3) where data are directly available and do not need to be estimated, that associated with different production practices and consumption patterns in different geographic areas" (Isard, 1951, p. 328).

Therefore the economic impact is calculated both in terms of the different regions and in terms of the different industries because the interregional trade flows comprised in the model specify both the region of origin and the region of destination as well as the industry of origin and of destination (Isard, 1951). This is illustrated by the matrix of trade coefficients for each region (Batten & Martellato, 1985).

Leontief (1953) developed a pure interregional model as part of the Harvard Economic Research Project using a different method to Isard, by disaggregating a national table into a set of component regions. This model combined the simple input-output framework with the observation that some commodities are produced not far from where they are consumed, but others travel long distances between the place of their origin and that of their actual consumption (Leontief & others, 1953). These models were studied by using the national matrix of technical coefficients and diagonal matrices which showed the proportion of each commodity produced in a region, but regionally varying input-output matrices are not directly constructed. Leontief (1977) also constructed a global interregional model with the objective of studying the environmental aspects of the future world economy. This model consisted of 15 regions and 45 industries, 22 of which were manufacturing industries, and the general features of it allowed Leontief to apply it to other problems of economic development. Also, since the model's purpose was to analyse the environmental aspects of the world economy, emissions of eight types of major pollutants and five types of pollution-abatement activities were described (Leontief, 1977). The regions of the global economy were linked together in an interregional system through a complex linkage mechanism which included imports and exports, capital flows, aid transfers and foreign interest payments (Leontief, 1977). Leontief's model does not require knowledge of the region which inputs come from, only knowledge of the production technology being used in each sector and so requires considerably less information than Isard's model (Oosterhaven & Polenske, 2009).

Chenery et al. (1953) constructed a bi-regional input-output model with the North and South of Italy as the two regions of interest to estimate the effect on each region of an investment programme which was carried out in the South of Italy. They then address the problem of structural unemployment and possibilities of economising in the use of capital by estimating the average unit requirements of labour and capital for 16 main industries (Chenery, et al., 1953). This study was one of the first attempts in applying interregional input-output analysis, though the statistical evidence that the study was drawn from was too fragmentary to produce reliable results (Henderson, P., 1955).

Moses (1955) studied interregional relationships based on trade in commodities and services using a three-region, eleven industry interregional input-output model of the United States. Regions were selected using aggregations of the census regions. He evaluated the stability of trade coefficients by performing an analysis on the errors in the balances of trade, which indicated that the selection of regions was not adequate. This was due to a high proportion of large errors associated with region three (West) which is not the equal of the other two regions economically (Moses, 1955). Moses concluded that although there existed some year to year variations in the trade coefficients, they exhibited sufficient stability to warrant their being subjected to further statistical evaluation on various levels of regional and commodity aggregation. He also stated that for any predictions three conditions should be satisfied in order to justify constant costs so that the stable trade patterns assumption is reasonable:

1. “There is excess capacity in the transport network between every pair of regions.
2. Each industry in each region has excess capacity.
3. There is a pool of unemployed labour for each region.”

(Moses, 1955)

More recently, Polenske (1980) constructed an operational multiregional input-output model (MRIO) which was based on a combination of regional and 1963 national tables and contains the assumption of stable trade coefficients. The model is an extension of Leontief and Strout’s (1963) model, which explicitly considered space through the use of gravity constants to permit the identification of cross-hauling where it existed. This original model included 44 regions and 78 industries as part of the Harvard Economic Research Project (Polenske, 1972). An expanded set of MRIO accounts with 120 industries and 51 regions was published in 1982, based on 1977 data (Rose & Miernyk, 1989). The MRIO has the advantage of being a fully consistent set of accounts and if all data used were available at the regional level from the same source, then it would be a truly bottom-up model which would reduce the problems of disaggregation (Rose & Miernyk, 1989).

The models developed by Moses and Chenery represent the trade theory of demand for products distinguished by region of origin, and the industry of destination is deemed unimportant (Batten & Martellato, 1985). The Leontief model differs to that of Moses in that it adopts a pooling approach where an even stronger assumption is made in that the geographical origin of imports and destination of exports is irrelevant (Batten & Martellato, 1985).

3.5.2. Interregional trade coefficients

The assumption of stable trade coefficients on which the above models are based is more restrictive than the classical one of stable technical coefficients implemented in regional input-output models (Batten & Boyce, 1986; Batten & Martellato, 1985). This means that when a shift in final demand occurs the trading patterns remain unaltered (Sargento, 2009). For example, in Isard’s interregional model each interregional input coefficient is split into a regional technical coefficient, a_{ij}^{s}, and an interregional trade coefficient, t_{ij}^{rs}, to give the following system of equations;

$$x_i^r = \sum_s \sum_j a_{ij}^s t_{ij}^{rs} x_j^s + \sum_s y_i^{rs} \qquad (40)$$

which illustrates that the stability of technical coefficients does not imply the stability of trade coefficients (Batten & Martellato, 1985; Oosterhaven, 1984). The variability of trade coefficients over time has been demonstrated by Riefler and Tiebout (1970), Beyers (1972) and Emerson (1976). However, Moses (1955) noted that trade flows are influenced by "cost-price relationships and regional capacities for production and distribution" such that trade coefficients are only stable if regional costs of production are constant, unit costs of transportation are fixed and the capacity of production can be easily increased. The first two conditions are very restrictive but they are generally adopted in input-output models, creating a general limitation of the models and not a specific problem for interregional models (Sargento, 2009). The last condition's reasonableness depends on the elasticity of production factors such as labour which implies that it would be preferable to apply this model to long-run periods because it would facilitate the adjustment of production capacities (Sargento, 2009). Yet in doing this the probability of regional technical changes increases which affects the stability of both the trade coefficients and the technical coefficients (Sargento, 2009). Moses (1955) concluded that the model is best suited to short-run impact analysis because factors of production are below full employment situation.

The above early models apply two theories; the theory of demand for products distinguished by place of production, and the concept of a trade pool. The first is related to the concept of market share where each competing product is classified by origin within a given market (where the market is the group of competing origins) and is the theory on which the Moses model is based (Batten & Martellato, 1985). The market share is given by t_i^{rs} in Equation (40). The second theory has the underlying principle that the regional origin of a shipment of goods absorbed by its users in one particular region is as irrelevant to them as the ultimate regional destination of this output to a producer (Batten & Martellato, 1985; Leontief & Strout, 1963).

A distinct limitation in estimating interregional trade flows for each industry in each region is that only the commodity shipments from and to each region are computed (Sargento, 2009). This is unavoidable for the construction of a multi-regional input-output table because of the minimum amount and detail of data required concerning interregional trade (Sargento, 2009). However, this reduces the theoretical model to a statistical estimation problem based on varying degrees of available trade information, allowing it to be handled using methods of statistical inference, such as the principle of minimum information (Batten & Martellato, 1985). Trade hypotheses using *a priori* restrictions or linear constraints on the trade share estimates can be used to quantify trade flows between regions (Batten & Martellato, 1985). The basic equation system normally associated with the principle of minimum information produces an interregional trade pattern which is consistent with Isard's model, but by adding theoretically-based restrictions in the form of linear constraints it is possibly to replicate all of the models discussed in the previous section (Batten & Martellato, 1985).

3.6. Applications in Regional Input-Output Analysis

3.6.1. Applications of Interregional tables

Interregional input-output analysis has proven to be a useful way of modelling relationships between regions. This is because interregional models account for the effects caused by interregional linkages (Sargento, 2009). The different models which have been applied in this category reflect different attitudes and assumptions concerning the trade-off between the degree of detail in describing interregional linkages and the demands for trade data (Sargento, 2009). For example, Oosterhaven (1984) constructed a number of interregional input-output tables using both square and rectangular matrices, and discussed the issue of reconciliation which has been widely debated for single-region models. Her main conclusion was that no one single format should be used to construct interregional tables because all of these formats strive to answer the same classical question of input-output analysis: "what is the impact on production if final output changes?" (Oosterhaven, 1984, p. 580). Because of this it has been widely applied in topics such as impact studies, regional development, location decisions and regional energy management. There have also been many inter-country input-output models constructed to illustrate linkages between countries.

3.6.1.1. Regional Development

Beals and Menezes (1970) used an interregional programming model to investigate the relationship between labour migration and agricultural production in Ghana. The interregional model was solved for two sets of initial conditions which were chosen to represent two periods of post-war development, and the authors attempted to show optimal agricultural production and resource allocation for the years in question, given estimates of the commodity prices and input requirements that actually prevailed during those years (Beals & Menezes, 1970). The study found that there is a close relationship between farming and migration patterns, and also that roads linking the north and south of Ghana have resulted in sizeable benefits because of road investment and the consequent availability of road transport (Beals & Menezes, 1970).

China and Japan have collaborated to construct multi-regional input-output accounts for 1987 for the Chinese economy which includes seven regions and nine sectors (Ichimura & Wang, 2003; Okamoto & Ihara, 2005). These tables are used to examine many important regional topics in the rapidly growing economy of China, including factors creating regional differentials in income (Oosterhaven & Polenske, 2009). Japan also has full interregional input-output accounts for every five years since 1960 which include 42 districts, as well as originally for nine regions and 10 sectors (Okamoto & Ihara, 2005). A 47-region interregional input-output table covering all of Japan was also constructed using hybrid methods which illustrated the characteristic features of the regional economy (Ishikawa & Miyagi, 2004). This model was then used to analyse regional relations among all prefectures and to calculate the effects of an increase in demand for automobiles in the Aichi prefecture on each prefectural economy in Japan (Ishikawa & Miyagi, 2004).

As well as this, Akita and Kataoka (2002) used the extended growth-factor decomposition method based on a Japanese interregional input-output model using the regions Kyushu, Kanto and the rest of Japan to examine the effects of changes in economic conditions and government policies on the output growth of the Kyushu region between 1965 and 1990. They found that the emergence of the processing and assembling sector, along with the construction of new transport and communications networks promoted closer interregional linkages between Kyushu, Kanto and the rest of Japan (Akita & Kataoka, 2002).

Benvenuti & Martellato (1995) constructed a 20-region input-output model for Italy which includes all of the administrative regions using a pool approach. The paper aimed to analyse interdependence between the Italian regions and to report preliminary results regarding the impact of fiscal policy (Benvenuti & Martellato, 1995). The authors conducted a number of simulations regarding fiscal policies, and found that fiscal policies are able to induce significant effects on the relative performance of single regions.

3.6.1.2. Location Decisions and Regional Energy Management

Migration has been described as one of the primary factors in Ghana's economy, and Beals and Menezes (1970) found that there is a close relationship between the farming calendar and migration. However, both of these depend on the stage of development of the cocoa industry where migration increases when the cocoa industry expands (Beals & Menezes, 1970).

It has been argued that regional and multi-regional input-output analysis has much to offer in providing a framework to integrate water resource needs and water development programs with forecasts of regional activity (Carter, H. & Ireri, 1970). Carter and Ireri (1970) used a multi-regional input-output table in an attempt to link California and Arizona, who, at the time were in legal conflict over water allocation rights from the Colorado river. They found that California had more efficient water-use patterns than Arizona.

3.6.1.4. Multi-Country Input-Output models

The first multi-country input-output table was constructed by Leontief (1977) as was discussed in the previous section. A number of other multi-country tables have been constructed more recently, but on a smaller scale. For example, Dietzenbacher (2001) constructed an interregional table for six European Community countries; Germany, France, Italy, the Netherlands, Belgium and Denmark. The objective of Dietzenbacher's study was to analyse output growth during the period 1975-1985. He found that output had grown to 2-3 times its 1975 level by 1985, and that only 30% of this growth was attributable to quantity effects (the rest was due to price effects). An earlier study was conducted by Lanza and Rampa (1988) in which a multi-regional input-output model was derived from the original Leontief and Isard models for France, the United Kingdom, Italy, and Germany and included the time periods 1970, 1975 and 1980. The study found that over the time periods studied, each of the four countries' economies tended to be increasingly integrated with foreign countries, resulting in the trade balance constraining each national demand policy (Lanza & Rampa, 1988). In addition to this it was found that a significant proportion of intermediate imports of one country did not depend on autonomous expenditure decisions, so the trade balance is affected by trading countries demand as well as domestic demand (Lanza & Rampa, 1988). Because of this Lanza and Rampa concluded that the economies would benefit from a common growth policy.

Another example is of Henderson (1970), who applied a multi-country input-output table for the European Economic Community countries to compare cost and tax incidences. He found that tariffs and taxes lead to major distortions in relative cost levels. He also found that France had cost advantages in agriculture and food processing sectors, while Germany protected its inefficient agriculture but not its efficient manufacturing industries.

More recently, He and Polenske (2001) used a multi-regional model to examine the conditions under which the H-O theorem[2] may be relevant to regions in that the Leontief paradox[3] doesn't hold at the regional level. They found mixed evidence at the regional level concerning whether or not the Leontief paradox holds. Dewhurst and Madden (2001) used a bi-regional model from their previous work (1998) to model the relationship between labour supply and labour demand. The resulting spatial decomposition allowed explicit observation of the intraregional and interregional components of the model.

3.6.1.5. Current Developments

There are currently a number of ready-made models available for input-output analysis which makes it easier for researchers to conduct impact and other types of analyses using these models. REMI is an eclectic multi-regional model for the United States that combines economic base, input-output, computable general equilibrium (CGE) and econometric methods (Treyz, Friedlaender, & Stevens, 1980). This model is a dynamic model and is thus used as a forecasting and simulation model by the Bureau of Labour Statistics for forecasting input coefficients to obtain regional technology forecasts (Oosterhaven & Polenske, 2009). There are also versions of REMI for the United Kingdom (ECOTEC

[2] Regions with an abundance of capital and a shortage of labour should export capital-intensive goods and import labour-intensive goods.

[3] The Leontief Paradox is where the country with the world's highest capital-per worker has a lower capital/labour ratio in exports than in imports (He & Polenske, 2001).

REMI) and the Netherlands (REMI-NEI). The model has been used by analysts to determine environmental pollution impacts, regional impacts of transport infrastructure and studies of large investment projects (Oosterhaven & Polenske, 2009). Another such ready-made model is the IMPLAN model developed in the 1970s which is a static input-output model, and in its current version is based on supply and use matrices and regional purchase coefficients for trade estimation (Oosterhaven & Polenske, 2009). These two models are most commonly used for impact analyses.

Looking forward, the latest MRIO accounts will represent actual data from the census as well as data from electronic files at the state and county levels, using algorithms that will make it relatively easy to construct accounts in the future (Oosterhaven & Polenske, 2009).

3.6.2. Regional Input-Output Studies

There have been many applications worldwide of regional input-output studies, including occupation and skill levels, environmental analysis, impacts on regions of educational institutes, regional economic structures, and the evaluation of specific events. This section will discuss just a few examples of these.

3.6.2.1. Environmental IO analysis

There has been much investigated in environmental input-output analysis in the past (see Miller and Blair, Chapter 7 for a more complete review of this), which was started by Leontief (1970b). When environmental pollution became a major issue in the 1970's, Leontief showed how this aspect of production could be fitted into the input-output framework (Carter, A. & Petri, 1989). It has been said that "Leontief's (1970b) application to environmental issues, was, surely, far from obvious, though once it had been carried out, it does seem an evident and natural way to go about the analysis of its subject" (ten Raa, 2005, p. 11). There has been much growth in the area of environmental input-output analysis with increasing use of multi-region models (Wiedmann, Wilting, Lenzen, Lutter, & Palm, 2011). The result of this is a remarkable improvement in methodological progress, quantity and quality of underlying data and policy-relevant applications (Wiedmann, et al., 2011).

Recently there has been some investigation about the Waikato region's ecological footprint, following increased attention to the environmental impacts of industry

(McDonald, 2000). McDonald and Patterson (2004) extended the input-output methodology of Bicknell et al. (1998) to investigate the ecological footprints and interdependencies of 16 regions in New Zealand, with a particular focus on the Auckland region. It was found that Auckland had the largest regional ecological footprint, but on a per capita basis this footprint was the second-lowest of all the regions included. The analysis was extended to demonstrate how Auckland was ecologically dependent on other regions, particularly the Waikato region (McDonald & Patterson, 2004). In a later study Market Economics (2006b) used an input-output framework which was based on Bicknell et al. (1998) and extended by McDonald (2000, 2001a, 2001b), McDonald and Patterson (2003, 2004), and Patterson and McDonald (2002) to calculate the Waikato Region's ecological footprint. It was found that on a per capita basis, the Waikato region's ecological footprint of 2.2 ha is significantly lower than the national average of 3.4 ha. This low ecological footprint is a result of the region having land productivities above the national average, meaning the land from which products are derived is more productive and therefore less of it is required, deflating the footprint measure (Market Economics Ltd, 2006b).

3.6.2.2. Economic Structure

Input-output studies which investigate the economic structure of a region can include those which explore the broad structure of the region, or those which investigate the importance of particular industries to the region. West (2001) and Hughes (2007) used input-output analysis to study the broad economic structure of regional economies. West (2001) used nine input-output tables for Australia over the period from 1974 to 1994 to consider the possibility of a temporal fundamental economic structure of core components which provides a platform on which the non-fundamental economic development at the periphery of the core can proceed. He found that there is strong evidence to suggest that the economic structure of the economy is holistically predictable over time. This is because non-fundamental activities define the patterns of structural change which are occurring, but these rest on the platform of fundamental core elements, without which they could not exist (West, 2001). Hughes (2007) used a regional input-output model for the Waikato economy to obtain the main drivers of the Waikato economy in the year ended December 2006. He found that the most important industry in the region was Dairy Farming and Processing, which accounted for 17% of employment and 24% of GRP in the region.

Dharmalingham, Hughes, Cochrane and O'Neil (2005) used a regional economic model of the South Waikato economy and other tools to provide an understanding of the impact that economic and demographic change could have on the South Waikato region. The main finding of their study was that relatively small initiatives in terms of annual sector output growth have the capability of making a noticeable improvement in growth measures for the South Waikato economy. They also found that the Dairy Farming industry had the highest direct Value-added per dollar of output as well as the Road Freight and Waste and Sewerage industries, such that expanding these sectors would generate significant follow-on activity in the South Waikato for output, employment and value-added (Dharmalingam, et al., 2005). Since there were strong linkages between many sectors, the authors concluded that there is scope for the region to develop a cluster of related industries that would encourage "best practice" methodologies and further development into related fields (Dharmalingam, et al., 2005).

Jordan and Polenske (1988), Butcher (1997) and Scrimegeour, Hughes and Marsh (2006) used input-output analyses to study the importance of particular industries to regional economies. Jordan and Polenske (1988) conducted an analysis of the impact of the decision on the delimitation of the US-Canadian maritime boundary in the Gulf of Maine on the fishing industry in the New England and Nova Scotia economies, and found that fishing activities are extremely stimulatory in terms of output, employment and income. Butcher (1997) investigated the employment impact of forestry expansion in the Mackenzie/Waitaki Basin by developing regional economic models for the MacKenzie-Waitaki Basin, the combined Waitaki and Mackenzie districts and the combined Otago and Canterbury regions. He found that since forestry (excluding processing) is likely to eventually generate 3.9 jobs in the Basin per 1,000 Ha in forestry and farming generates 0.4 jobs per 1,000 Stock Units (SU), then as long as forestry displaces less than 10 SU per Ha, employment will eventually be higher under forestry than under farming. Scrimegeour et al. (2006) used an input-output model of the Waikato region to assess whether establishment and successful management of an innovation park will significantly increase the rate of economic activity in life science and high technology industries in the Waikato region. They found that the impact of the park on the region would initially be limited but expand rapidly as the number of tenants increased. At full capacity of 3357 employees it could add 2.4-3.6% annually to the Waikato gross regional product and add around 2.5% to the Waikato workforce (Scrimgeour, Hughes, & Marsh, 2006).

3.6.2.3. Educational Institutes

In New Zealand, there have been studies undertaken to estimate the impact that educational institutes have on their local economies. Three of these studies include that of Poot (1993), Hughes (1994), and Hughes (2009). Hughes (1994) analysed the impact of the University of Waikato on the Waikato region using three 112-sector economic models of the New Zealand, Waikato Regional Council and Core Waikato economies. He found that the University of Waikato contributed 2.7% of regional GDP from its operations and supported 2194 persons employed in the Waikato region. However, this impact study only included effective full-time student operations and did not include research institutions that operate their regional facilities at the university (Hughes, 1994). Therefore the estimates obtained in this study can be argued to be conservative (Hughes, 1994).

In a later report, Hughes (2009) studied both the regional and New Zealand impacts of the University of Waikato for the 2008 calendar year, and used 112-sector economic models to calculate both direct and flow-on impacts. He found that the University accounted for 5% of economic activity in the core Waikato economy, 3% of the greater Waikato Regional Council economy and 0.3% of the NZ economy (Hughes, 2009). This study also found that expenditures by Hamilton-resident students are more important than university operations in terms of employment but that these expenditures generate less aggregate net income than University operations (Hughes, 2009).

Poot (1993), on the other hand, found that Victoria University had an overall final demand effect of 2.5% of GDP in the Wellington region and a total direct employment impact of 3546 jobs (i.e. 2.4% of Regional employment). This study also suggested that the University affects economic growth over time in that the price of education is lowered when a University is within reach. This is because local firms have better access to University graduates for employment and University staff are more accessible and have more local knowledge (Poot, 1993). The government also benefits from a local university because University staff make submissions to the government on numerous topics, and this has a lower cost if the staff are local (Poot, 1993).

An economic impact study has also been completed for the three tertiary institutions in Palmerston North (Infometrics, 2007). It was estimated that the tertiary education sector contributed $491m (including GST) to Palmerston North's value added (economic activity) in 2006. This is equal to a total contribution of 16.4% of total economic activity in Palmerston North in 2006 (Infometrics, 2007). Students in the region were estimated to have spent a total of $152 million in the same year, excluding imports and GST (Infometrics, 2007).

3.6.2.4. Evaluation of Events

Input-output analysis has frequently been employed to estimate the direct and indirect impact of specific events on a national or regional economy. This includes events such as natural disasters, sporting events and festivals. For example, Clarke (1998) used an economic model of the Wellington region to estimate the impacts of a major earthquake in Wellington. The impacts (not including injury and deaths) include a $6.8 billion capital loss, more than $400 million of direct income losses arising from the loss of capital, and $600 million of indirect losses in the first year following an earthquake (Clarke, 1998).

Daldy and Saunders (2010), and McDermott Fairgray Group and Ernst & Young (2000) are examples of impact studies done in New Zealand on sporting events. Daldy and Saunders (2010) used a regional economic model to analyse the direct and subsequent flow-on expenditure resulting from the weeklong National Masters Hockey Tournament held in Hamilton, New Zealand in March 2009. Total direct expenditure in the Waikato region from the 2009 tournament was approximately $2.5 million, and led subsequently to an extra $1.13 million of value-added to the regional economy mainly in the hospitality and accommodation sectors (Daldy & Saunders, 2010). McDermott Fairgray Group & Ernst & Young (2000) used regional economic models describing the Auckland and the national economy to estimate the impact of the impact of the America's Cup Regatta held in Auckland over the summer of 1999-2000 on the regional and national economies. It can be concluded that a total impact of $473m dollars added to regional GDP and $640m added to national GDP over the period during which preparations and the regatta took place means that much of the immediate advantage from the spending associated with the regatta accrued in the form of local economic stimulation underpinning the longer and more diffuse benefits from the event (McDermott Fairgray Group & Ernst & Young, 2000).

3.6.2.5. Input-Output vs. CGE Modelling

In recent years, there has been an increase in the number of studies which use a computable general equilibrium (CGE) model rather than an input-output model for both single region and multiple region analyses. This is because economists have needed the capacity to conduct quantitative general equilibrium analyses to make headway with the theoretical arguments in which, because of non-linearities in functional forms or the number and complexity of assumptions, it is difficult to isolate the effects of a change in an assumption (Donaghy, 2009). Limitations in data availability or computational know-how have meant that partial-equilibrium analyses were conducted instead (Donaghy, 2009). Some examples of spatial CGE studies emerged out of the multi-regional and interregional input-output tradition of Moses (1955) and Isard (1951), developed to study trade issues (Donaghy, 2009).

CGE models are able to overcome the limitations of input-output, but the determinants of results are not readily transparent and are therefore often criticized (Rose, Hanson, & Li, 2001). A multi-regional, multi-sectoral CGE model brings together different strands of theoretical reasoning, including input-output analysis, gravity modelling, the theory of intra-industry trade and the theory of general equilibrium under conditions of monopolistic competition (Brocker, 1995). This makes the CGE approach superior to the input-output approach for multi-region analyses because of the assumption that, within each sector, a large number of different brands of output are produced (Brocker, 1995).

Another general advantage of CGE is the explicit inclusion of constraints, however, results can be highly sensitive to the type of closure rule used (Rose, et al., 2001). Even with the imposition of closure rules, input-output models yield more positive total impacts of transfers than CGE models with the same rules (Rose, et al., 2001). This is because CGE models contain additional closure rules which inhibit expansionary effects (Rose, et al., 2001).

Differences in the treatment of labour in CGE and input-output models can create variations in the reactions of the labour force to economic shocks. While it is implicit in the input-output approach that labour can move freely across regions and is fully integrated with the national market, CGE assumes full flexibility of wages and prices, and fixed aggregate levels of factor employment at the regional level (Mazzola, 2001). Therefore a CGE model can better depict a situation of lower economic integration, where an input-output model would show movement of the labour force across regions (Mazzola, 2001).

In contrast with multi-regional input-output models, multi-regional CGE models tend to be characterised by endogenous price determination, price-responsive input substitution and constrained factor supplies (Donaghy, 2009). However, these models characterise interregional trade as a spatial network without regime shifts (Lofgren & Robinson, 1999). This weakness can be overcome by characterising regional economies with representative households, factors of production and commodity-producing activities, and ignore savings/investment, and government behaviour (Lofgren & Robinson, 1999). Input-output models also ignore supply-side effects, so if there are price as well as income effects there will be some diminishing of multiplier effects (Rose, et al., 2001).

Some studies where the authors have compared input-output to CGE models include Mazzola (2001) and Brocker (1995). Mazzola (2001) conducted a study which compared econometric versus input-output and CGE models, and found that input-output and CGE models can yield useful insights on the relative role of inter-industry flows and supply factors in determining the final outcome when combined with the right econometric approach. He also found that although input-output models can usefully address important issues connected with the regional distribution of the impact of fiscal policy, the overall assessment is likely to be overstated because of the fixed prices assumption (Mazzola, 2001). The purpose of Brocker's (1995) paper was to demonstrate how "input-output analysis, gravity modelling, the theory of the intra-industry trade and the theory of general equilibrium under conditions of monopolistic competition could be integrated in a common, logically consistent framework" (Brocker, 1995, p. 148). The solution of Brocker's model closely resembles models which have been applied on an ad hoc basic in regional economics before, but is well-founded in modern economic theory; in particular, trade flows obey a gravity law in equilibrium (Brocker, 1995).

Even though CGE models contain superior assumptions to the traditional input-output approach, the future will continue to feature interregional inter-industry models, as the sector-specific and location-specific nature of the employment, energy and emissions impacts of all kinds of exogenous shocks and policy measures requires such modelling (Oosterhaven & Polenske, 2009). However, increasingly these models will feature non-linear production and consumption functions, and integrate simultaneous price and quantity impacts in models with non-perfect competition (Oosterhaven & Polenske, 2009).

This is because of the much more detailed information that is required to build a CGE model, as well as the higher cost of such data collection and the complexity of CGE models due to the assumptions behind them. Information which is disaggregated enough by region is not always available, in which case an input-output model may be more appropriate because it requires less detailed information and larger-region input-output tables can be downsized to represent smaller regions. This is especially true for regional models in New Zealand as data that is disaggregated enough is not always available for small regions.

4. Method

In order to quantify the economic contribution of the University of Waikato to Hamilton city and the Waikato region, an input-output (IO) model of the Waikato region was constructed. This model is a comparative-static model, and includes information from the University and its students to provide a picture of how much students spend and how important this spending is to the local economy. To construct this model, data from students, the University and of the Waikato region was required. Student information was collected using an online survey. A link to the survey was distributed to students around the university to gain a representative sample, enabling a more complete picture of students' spending habits to be determined. Detailed information on both revenues and costs was obtained from the University of Waikato to gain a complete picture of its financial activities.

The New Zealand supply and use tables for 2007 were transformed into a national input-output table and downscaled to create a regional input-output table of the Waikato region[4]. Note that student information gained from surveys was not inputted into the I-O model, but used in conjunction with it to gain a complete picture of the University's impact on the Waikato region economy.

4.1. Building a National Input-Output Model

Before a national level input-output table could be constructed, the supply and use tables had to be balanced. This action is required because of rounding in the 2007 supply and use tables published by Statistics New Zealand. This rounding meant that the cells in the tables did not necessarily sum to the row and column totals. Therefore, the supply and use tables needed to be scaled so that they summed to the totals published by Statistics New Zealand in basic prices and purchasers' prices. The tables were first balanced in basic prices such that the row totals in the supply table were equal to the row totals in the use table, as well as ensuring that total supply in basic prices was equal to total use in basic prices. This was achieved by scaling up each cell in the table such that total supply (and total use) was equal to the published total (in the original tables from Statistics New

[4] The supply and use tables were for the financial year ended March 2007.

Zealand). The supply and use tables were then balanced in purchaser's prices to the published total. This was achieved in the supply table by scaling up margins and taxes, and in the use table by scaling up components of value-added.

To make the task of converting the supply and use tables into a national level input-output table easier, the commodities in both tables were aggregated so that the number of commodities was equal to the number of industries. The commodities were aggregated using the Australian and New Zealand Standard Industrial Classification 1996. Due to the degree of aggregation in the commodities "wholesale trade" and "retail trade", all of the wholesale and retail trade industries had to be aggregated into a single industry. Additionally, the industries "pulp paper and paperboard manufacturing" and "paper and paperboard containers manufacturing" were aggregated to form one industry, "paper, pulp paper, paper board and paper board containers manufacturing" since only one commodity, "pulp, paper, paperboard, books and stationery" is classified for both industries. The "real estate" and "investor in other property" industries are aggregated to a single industry, "real estate", since there was no commodity that could be classified into the "investor in other property" industry at the original level of aggregation of commodities. Finally, the industries "community care services" and "religious organisations and interest groups" were aggregated to a single industry, "community care services" because there was no commodity that could be classified into the "religious organisations and interest groups". Also, because of employment data availability that was used to regionalise the national input-output table, "life and health insurance" and "general insurance" were aggregated together to form one "insurance" industry and "pre-fabricated buildings" was moved into "other manufacturing".

Since the use table contains non-zero off-diagonal elements because sectors produce mixtures of outputs, assumptions were made such that the supply table became diagonal (Jackson & Murray, 2004; ten Raa, 1994). To achieve this, the industry technology method was then applied to the supply and use tables. This method assumes that the input structures of industries are proportional to their outputs and there are fixed commodity market shares of industries (Almon, 2000; ten Raa, et al., 1984; ten Raa & Rueda-Cantuche, 2003). These two assumptions meant that the inputs associated with each unit of secondary output could be separated and reclassified to the sector where it was produced as the characteristic product (Viet, 1994). The matrix form of the input-output coefficients under this method is given by;

$$A = U\widetilde{Ve}^{-1}V\widetilde{V'e}^{-1} \tag{40}$$

where U is the use matrix and $\widetilde{Ve}^{-1}$ is the inverse of the proportionate supply matrix. In practice, the industry technology assumptions require that secondary production is in the right sectors in the supply and use tables. In the supply table, this involves subtracting the supply of commodities from the wrong industry and adding it to the correct industry. In the use table, the proportion of the total supply that the commodity represents was subtracted from the incorrect industry and added to the correct industry. After these adjustments had been made the supply and use tables were balanced using the RAS method (see section 4.4.2.3.1 above) such that total supply of commodities was equal to total use of commodities.

The supply and use tables were then combined to produce an inter-industry transactions table. Before this step was undertaken financial charges was shifted to the end of the table where it was assumed that the regional technical coefficient was equal to the national coefficient. This is because the financial charges industry consists of fees and interest charged in the finance industry and makes a negative contribution to GDP. The inter-industry transactions table was constructed from a table which shows the proportions of goods supplied by each industry and imports (derived from the supply table) and was multiplied by the use table. From the resulting transactions table a matrix of technological coefficients for industries was constructed by dividing the cells in the inter-industry transactions table by the total for the column.

4.2. Regionalising the National Table

The method used to regionalise the national table largely followed those of Gary McDonald, who uses a Generation of Regional Input-output Tables (GRIT) method as set out in a study conducted by Statistics New Zealand (2003). GRIT is a non-survey based method developed in the 1980s which allows superior data to be used to derive regional input-output tables (Statistics New Zealand, 2003). Regional output for each industry was estimated by using the share of employment by industry, such that regional output was distributed to industries based on employment share. This assumes that industry productivity is constant across regions. The only data disaggregated enough for this purpose was regional employment headcount by industry which does not include owner-operators and part-time workers are counted as a whole worker, whereas full-time equivalent employment includes owner-operators and part-time workers are counted as a fraction of a full-time worker. Since small regions will have more owner-operators because of the larger number of small businesses, the location quotients calculated from this data are likely to be biased towards urban areas where there are more large firms and therefore more employees. Therefore, an assumption of this method is that the share of owner-operators and the share of full-time and part-time employees is the same for all geographical units, leading to no bias in the location quotients.

Regional consumption was estimated on the basis of mean personal income data from the 2006 census where the share of national total household income for the Waikato region was used to calculate regional household expenditure. The remaining final demand categories were estimated using the Waikato region's share of national output. The resulting regional table was then balanced using the RAS technique.

The updated table was put into technical coefficient form by assuming that industry technologies are the same at the national and regional levels, i.e. technical coefficients at the national and regional levels are the same. It was assumed that all primary inputs are available locally and that labour is supplied locally. Excess production was treated as regional imports such that if production in industry i doesn't occur in a region, any inputs from i into j are treated as regional imports. Therefore the technical coefficient was set to zero in the regional table and its value in the national table was added to the import coefficient. Regional self-sufficiency in each industry was then calculated using simple location quotients. These were calculated by taking the employment in industry i as a share of total regional employment and comparing it with the employment in industry i as a share of total national employment as follows;

$$LQ_i^r = \frac{e_i^r / e^r}{E_i^n / E^n} \qquad (41)$$

where e_i^r is the regional employment of industry i, e^r is the total regional employment, E_i^n is the national employment of industry i and E^n is the total national employment. This location quotient method of regionalising national tables is commonly used (Comer & Jackson, 1997; Flegg, et al., 1995; Jackson, 1998; Round, 1983), even though all studies note that the use of this method creates a positive bias on regional multipliers. The location quotient was applied to all cells in the table, and where the location quotient is greater than or equal to one the region is an exporter (or self-sufficient if the LQ=1) in the industry in question. This means that the regional technical coefficient was set to equal the minimum of national production coefficient plus the import coefficient or the location quotient multiplied by the national technical coefficient, such that the regional coefficient cannot be larger than national production. Where the location quotient is less than one, local production is assumed to be inadequate to supply local needs and the region imports some production from outside of the region. In this case the regional technical coefficient was calculated as

$$a_{ij} = LQ_i A_{ij}. \tag{42}$$

Applying this location quotient method gives a table of technical coefficients, but to calculate regional inter-industry flows further calculations were required. In the cases where the region is self-sufficient or an exporter in the region, regional inter-industry flows were computed as

$$x_{ij} = a_{ij} x_j = X_{ij} \frac{x_j}{X_j}. \tag{43}$$

and exports in industry i were computed as a residual

$$e_i = x_i - \sum_j^s x_{ij} - \sum_f^t y_{ij}. \tag{44}$$

However, where the region is an importer, no exports can be made so regional gross flows were calculated as

$$x_{ij} = a_{ij} x_j = X_{ij} LQ_i \frac{x_j}{X_j} \tag{45}$$

and imports of product i were computed as the amounts necessary to satisfy production requirements

$$m_{ij} = A_{ij}x_j - x_{ij} \tag{46}$$

and the difference between the national and regional technical coefficients was added to the import coefficient. This implied that part of the inputs from that industry was imported into the region.

A regional transactions matrix with all four quadrants of the table could then be produced by multiplying the technical coefficients by gross output for each industry. Quadrant one shows all inter-industry transactions, quadrant two contains household inputs and quadrant four contains household consumption. This table was unbalanced, so it was balanced using interregional imports and exports and further aggregated. Where negative exports occurred in an industry, imports for the corresponding industry were scaled up so as to eliminate the negative.

In order to conduct an impact analysis properly, the University of Waikato needs to be separated out of the Post school education industry. This is so that a multiplier for only the University can be obtained, so that it is possible to see its' interaction with the regional economy more clearly. The post school education industry was scaled back using its share of regional employment excluding the University of Waikato, and an industry for the University of Waikato was created in this same way. Therefore the input-output table has two tertiary education industries; the post school education industry which excludes the University of Waikato and a separate industry for the University of Waikato[5].

4.4. Impact Analysis

Information on both revenues and costs was obtained from the University of Waikato to gain a complete picture of its financial activities, and survey data about student spending was collected from both international and domestic students. Data collected from student surveys needed to be transformed into quantitative data and financial information obtained from the University needed to be altered accordingly. This information provided a basis for conducting impact analysis using linkages and multipliers for the Waikato Region.

[5] Note – This means that the technical coefficients for the University of Waikato and the post school education (excluding UoW) are the same.

4.4.1. University Financial Activities and Student Survey

Financial information about the University of Waikato was obtained from the Annual Report for the 2009 academic year (The University of Waikato, 2009c). The information available was only broken down by broad activity, so judgement was used in order to allocate revenues and spending to specific industries. Multipliers were then applied to the University's total revenue and the multiplier effects calculated by industry to get the direct and indirect effects by industry.

The student survey was created using Qualtrics software and contained specific questions about student spending in different industries in the last year. A copy of the student survey is given in Appendix 1. Qualtrics is an online survey application which was used for ease of uploading the student survey to the internet. Qualtrics also allows for easy storage of completed surveys since they are saved within the application. Before the survey was distributed to students ethical approval was obtained from the Ethics Committee at the University of Waikato. A link to the webpage was then emailed to all students who were enrolled in papers within the Management school inviting them to participate. The URL link to the survey was also written on white boards in classrooms all over the university and flyers with the URL were distributed around the University campus.

Students were asked about spending in a variety of industries over specific time periods up to one year[6]. Although these time periods differed they can be altered to get the average student spend over a year, which can then be used to analyse student spending in the Waikato region. However, it is important to note that unbounded recall is a problem when using survey data. This is because students' ability to correctly recall details of their spending over longer periods of time diminishes. This is especially true for items that are occasional purchases or that they do not purchase regularly. Therefore, where students are asked to recall spending over longer periods of time this data may be less reliable than spending over short periods of time.

An assumption was made that rent paid was an activity in the real estate industry and therefore that all landlords operate in this industry. This assumption is consistent with the treatment of rental property for the input-output model from

[6] These one year periods were for the 12 months ended September 2010.

Section 4.1, and was made because many landlords operate privately rather than through rental agencies, making their activities difficult to categorise.

Completed surveys were downloaded to an excel spreadsheet and the data was edited so that they were in a useable format. Where students answered questions about spending with “varies” or “unsure” it was recorded as $0 of spending in that industry. This is because there is no way to estimate their spending, so instead we assume that they do not spend anything in that industry so as to give a conservative estimate of student spending. In addition, where students entered a range (for example $50-$100), the midpoint was taken.

4.*4.1.1. Characteristics of Survey Respondents*

Survey respondents were asked general questions about their demographics, the results of which are shown in Figures 2-8. From this an overview of the group can be seen. Figure 2 shows that 63% of survey respondents were female. About 25% of survey respondents were under the age of 20, and just over 20% were over the age of 25 (adult learners), as shown in Figure 3. Around one third of respondents are in their first year of study, while less than 20% have been studying at the University of Waikato for four years or more (Figure 4). The majority of respondents are studying full time, with less than 10% studying part time (Figure 5). 91% of respondents are New Zealand citizens, and less than 10% are either permanent residents or overseas students (Figure 6). Most students who participated in the survey are enrolled as domestic students (Figure 7). Figure 8 shows the home region of survey respondents. 71% of respondents are from Hamilton City, while 15% are from outside of the Waikato region (this could be elsewhere in New Zealand or outside of New Zealand).

Figure 2: Gender of Survey Respondents

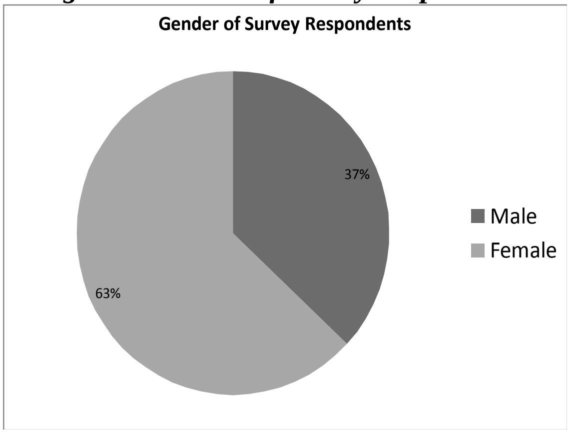


Figure 3: Age of Survey Respondents

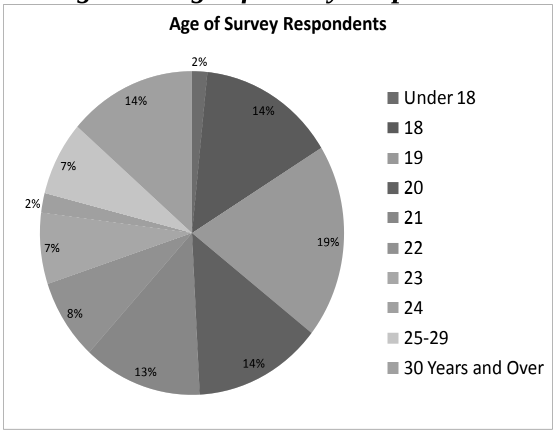


Figure 4: Survey Respondents' Year of Qualification

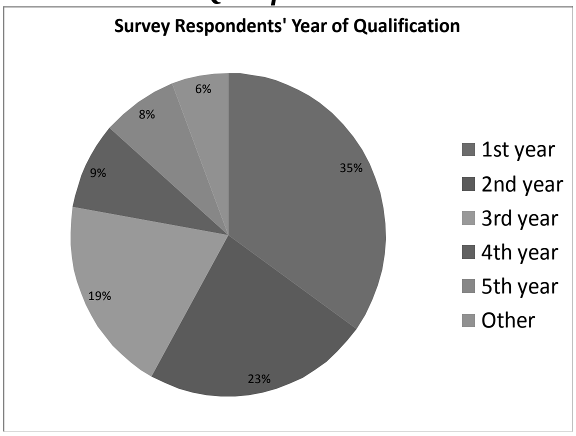


Figure 5: Full/Part-time Status of Survey Respondents

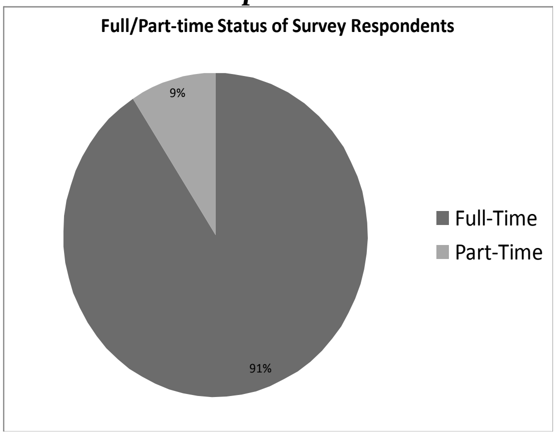


Figure 6: Residency Status of Survey Respondents

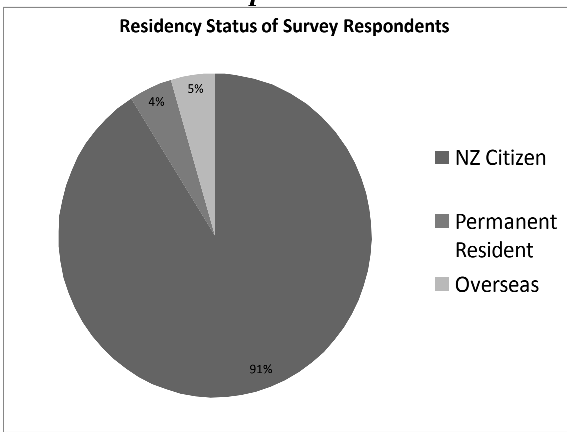


Figure 7: Enrolment Status of Survey Respondents

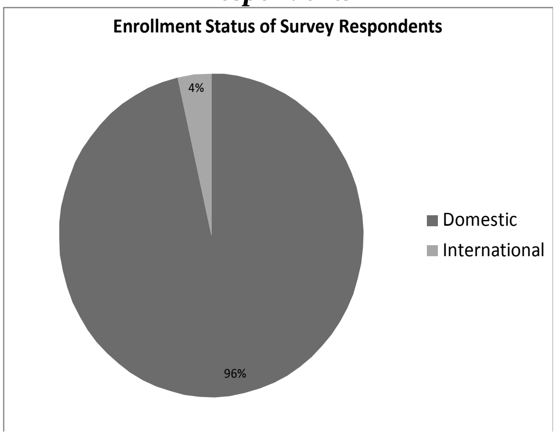
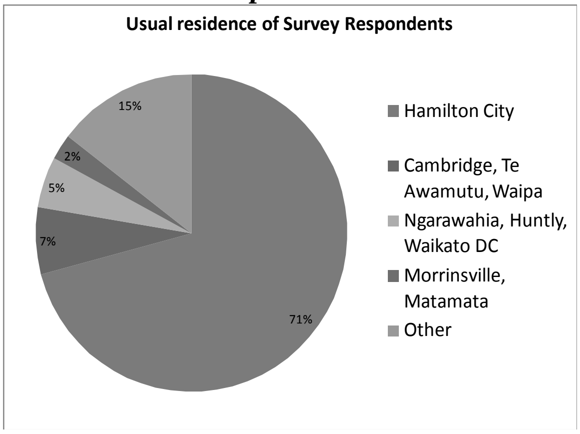


Figure 8: Usual Residence of Survey Respondents



This compares with the student characteristics in the 2009 Annual Report from the University of Waikato (The University of Waikato, 2009c). As illustrated in Table 3 below, in the 2009 year, 58% of enrolled students were female and 42% were male. Of all enrolled students, 38% were aged over 25 and 62% were under 25. The majority of students studying at the University were returning students, while 35% were new to the University (but not necessarily in their first year of study). Of these new students, 36% were school leavers and 21% were new to tertiary study. 83% of students have domestic citizenship, while 17% have international citizenship. Of the students with domestic citizenship, 74% came from the University's main catchment, 12% came from the University's inner and outer peripheries and 14% came from outside of the Waikato region (including elsewhere in New Zealand and outside of New Zealand).

Table 3 compares the demographics of students enrolled at the University of Waikato in 2009 to those of the survey respondents. Compared to enrolled students in the 2009 year, more survey respondents were female and more were under 25 (79% of survey respondents compared to 62% of enrolled students). Domestic students are slightly over-represented in the survey, with a higher proportion of New Zealand citizens responding to the survey. However, the home region of survey respondents is representative of the students who were enrolled in the University in 2009.

Table 3

	University of Waikato 2009	Survey Respondents
Gender:		
Male	42%	37%
Female	58%	63%
Age:		
Under 25	62%	79%
Over 25	38%	21%
Year of Qualification:		
New Students	35%	35%
Returning Students	65%	65%
Residency Status:		
Domestic	83%	91%
International	17%	9%
Usual Residence:		
Waikato Region	69%	85%
Outside Waikato	31%	15%

4.4.2 Forward and Backward Linkages

In this analysis, linkages are defined in terms of backward (demand-side) linkages and forward (supply-side) linkages. Backward linkages are the total of the direct and indirect purchasing of inputs per sector, and are calculated as the ordinary production multipliers of the Leontief inverse $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ less the direct effect. Forward linkages are the total of the direct and indirect processing of outputs per sector, and are calculated as the ordinary production multipliers of the Ghosh inverse $(\boldsymbol{I} - \boldsymbol{B})^{-1}$ less the direct effect.

A backward linkage is the interconnection of a particular sector to those sectors from which it purchases inputs i.e. it is demand-side of model (Miller & Blair, 1985). It is the amount that a sector depends on inputs, for example if sector j increases its output, this means there will be increased demands from sector j on the sectors whose products are used as inputs to production in product j (Miller & Blair, 1985). Backward linkages are interpreted in percentages, and if the backward linkage of sector i is larger than that of sector j, then a dollar's worth of expansion of sector i output would be more beneficial to the economy than an equal expansion in sector j's output, in terms of the productive activity throughout the economy that would be generated by it (Miller & Blair, 1985).

A forward linkage is the interconnection of a particular sector to those sectors to which it sells its outputs i.e. it is the causation in the supply-side of the model (Miller & Blair, 1985). For example, increased output in sector j also means additional amounts of product j that are available to be used as inputs to other sectors for their own production; that is, there will be increased supplies from sector j for the sectors which use good j in their production (Miller & Blair, 1985). Forward linkages are calculated using the Ghosh inverse, which is obtained from a supply-driven input-output model based on the assumption of fixed output coefficients and the calculation of the sectoral outputs from exogenously specified changes in primary factors (Dietzenbacher, 1997; Rose & Miernyk, 1989)[7]. The interpretation of forward linkages is the same as for backward linkages in that if the forward linkage of sector r is larger than that of sector s, a dollar's worth of expansion of the output of sector r is more essential to the economy than an equal expansion of the output of sector s, in terms of the overall productive activity that it would support (Miller & Blair, 1985).

4.4.3 Multiplier Analysis

The analysis followed that of Poot (1993) and Hughes (2009), and considered the impact on the Waikato Region if the University of Waikato were to close. In approaching the analysis this way, we were able to see the total contribution of the University to its local economies. From this information and that which was obtained from student surveys and the University's annual report, multiplier analysis was used to further assess the impact of the University on the local economy.

The additional spending[8] by students in each industry was summed and then averaged over the number of students who were in the region because of the University to get the average student spending in each industry. This included counting students who spent nothing in an industry, but would not have been in the Waikato region if not for the University. Student spending on living arrangements where they were living at home and paid board to their parents was

[7] These weren't calculated for this study, however the IRIOS software used in the analysis of the Waikato Input-Output table is capable of calculating this inverse for the purpose of obtaining forward interindustry linkages for the region.

[8] Additional spending is defined as spending by students who would not be in the Waikato region if it weren't for their study at the University of Waikato.

excluded because this expenditure is not part of calculations for GDP[9]. This total spending was then multiplied by the number of students enrolled for the 2010 year to get the direct additional spending by students due to the existence of the University. This spending is shown in Table 4 below. Multipliers from the single region input-output model were then used to calculate the total (direct plus indirect) spending by University students in the Waikato region.

Table 4

Annual Student Spending by Industry		
Retail Trade	$	129,804,800
Real estate	$	37,605,600
Restaurant and bars	$	20,971,900
Water and air transport	$	16,292,300
Sport and recreation	$	13,007,900
Communication services	$	10,972,800
Electricity, gas and water supply	$	9,259,000
Finance	$	9,065,200
Insurance	$	5,675,500
Personal and private household services & household employed staff	$	4,072,900
Road and rail transport	$	3,649,700
Motion picture, radio and TV services	$	2,514,300
Libraries, museum and the arts	$	1,645,100
Health and dental services	$	1,420,900
Accommodation	$	709,100
Veterinary services	$	536,300
Printing, publishing and recorded media	$	291,600
Vehicle and equipment hire	$	35,500
Total Student Spending	**$**	**267,203,300**

The financial activities of the University that were disclosed in the 2009 Annual Report are shown in Table 5 below. It can be seen that the University's largest source of income is government funding and grants, and its highest cost is salaries and wages. These revenues and costs were used to obtain multiplier effects for the University of Waikato.

[9] This is because students pay board directly to their parents rather than to an organisation. Therefore, circulation of this spending would be counted as consumer spending by the parents.

Table 5

University Income ($)		University Costs($)	
Total Government Funding and Grants	90,911,000	Salaries and Wages	115,973,000
Fees Income	63,280,000	Scholarships	10,190,000
Research Income	27,838,000	Operating leases	3,894,000
		Utilities	3,337,000
Student Accommodation and Other Services	7,176,000	Finance Costs	520,000
		Travel and accommodation	4,839,000
Income from supply of educational services	1,908,000	Repairs and maintenance	2,200,000
		Teaching and Research Materials	2,009,000
Interest Income	1,038,000	Hirage	1,249,000
		Restructuring costs	89,000
Carbon Dating Revenue	1,005,000		
		Depreciation and Amortisation	16,769,000
Other Income	11,210,000	Other costs	34,327,000
Total Income	**204,366,000**	**Total Costs**	**195,396,000**

Multipliers were calculated using IRIOS software. The completed single region and interregional input-output tables were inputted into the software where Leontief inverse matrices were calculated from technical coefficients. The technical coefficients for industry-industry were given by $\boldsymbol{A}$ in the equation

$$\boldsymbol{AX} + \boldsymbol{F} = \boldsymbol{X} \quad (47)$$

where X is the output matrix per industry and F is a matrix of final demand purchases. This equation was rearranged and solved to give the Leontief inverse:

$$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{F} \quad (48)$$

where $\boldsymbol{X}$ is the set of coefficients that show the increase in an input required to increase the final demand of an output by one unit. The result of the Leontief inverse equation gave necessary industry outputs for all industries in the table which satisfy any increase in final consumption. IRIOS generated both production and standard income multipliers from this Leontief Inverse equation. Appendix 7 and Appendix 8 show the production multipliers and standard household income multipliers by industry for the single region. For the interregional table, multipliers were calculated for each single region in the table as well as for the total Waikato economy. The larger the resulting multiplier effects (in both tables), the more valuable the industry is to the Waikato economy.

A production multiplier is defined for sector j as the total value of production in all sectors of the economy that is necessary in order to satisfy a dollar's worth of final demand for sector j's output (Miller & Blair, 1985) in a model where households are exogenous. That is, it is the ratio of the direct and indirect effect to the initial effect alone. Simple production multipliers use the $(\boldsymbol{I}-\boldsymbol{A})^{-1}$ matrix which only includes industries, and households are exogenous (Miller & Blair, 1985). The simple production multiplier for industry j is given by:

$$O_j = \sum_{i=1}^{n} \alpha_{ij} \tag{49}$$

where α_{ij} are elements of the technical coefficients matrix. These multipliers were calculated for both the single region input-output model and the interregional input-output model. A comparison of production multipliers shows where this spending has the greatest impact in terms of total dollar value of output generated throughout the economy (Miller & Blair, 1985).

A standard household income multiplier is the total effect on the output of the household sector, which is the total value of labour services needed, when there is a dollar's worth of new final demand for goods of sector j (Miller & Blair, 1985). Income multipliers include the direct and indirect income effect as a numerator and the initial labour income effect as the denominator (rather than the initial dollar's worth of output) (Miller & Blair, 1985). The simple household income multiplier for industry j is given by:

$$H_j = \sum_{i=1}^{n} (\alpha_{n+1,i} \times \alpha_{ij}) \tag{50}$$

Where $\alpha_{n+1,i}$ are the coefficients that make up the $(n+1)$th household row. The direct income effect will tend to be higher in labour-intensive industries because a substantial proportion of the costs in these industries consist of direct payments to labour, while capital-intensive sectors with strong links with other sectors may experience greater indirect effects (Oosterhaven & Polenske, 2009). Simple income multipliers were calculated from both the single-region input-output table and the interregional input-output table where the resulting models were open with respect to households (i.e. households are exogenous).

The employment multiplier shows the physical employment that is expected to be generated because of new output. It is the number of jobs created per dollar of new sectoral output, which arises because of an additional dollar's worth of final demand for the sector (Miller & Blair, 1985). Employment multipliers are calculated in the same way as income multipliers, but use physical labour input coefficients instead of household input coefficients (Miller & Blair, 1985). The simple household employment multiplier for industry j is given by:

$$E_j = \sum_{i=1}^{n}(w_{n+1,i} \times \alpha_{ij}) \quad (51)$$

where $w_{n+1,i}$ are physical labour input coefficients, given by:

$$w_{n+1,i} = \frac{e_i}{X_i} \quad (52)$$

Where e_i is the number of people employed in industry i and X_i is the gross output for industry i. Simple household employment multipliers were calculated from both the single-region input-output table and the interregional input-output table where the resulting models were open with respect to households (i.e. households are exogenous).

Once these multipliers have been calculated, total spending obtained from the student survey and the University's annual report was multiplied by these multipliers to get the direct plus the indirect spending. Student spending effects and University of Waikato effects were calculated separately by multiplying total spending by the employment, income and production multipliers for the University of Waikato. Using available information from the input-output table the direct and indirect effects were calculated. From this, the effects of the University on production, household income and employment were obtained.

5. Results

5.1. The Single-Region Structure of the Waikato Economy

In this section, the results of a descriptive analysis of the Waikato Region conducted in IRIOS will be presented. Using the Waikato Region input-output table, the sector structure and forward linkages were computed for the region. The sector structure of the region was computed in terms of production, exports, imports, consumption of fixed capital and operating surplus. Both forward and backward linkages were calculated to get an idea of the direct and indirect purchasing of inputs per sector as well as the direct and indirect processing of outputs per sector.

GDP for the Waikato region can be calculated directly from the input-output table. Since the table was not updated for 2009 prices, GDP is expressed in 2007 dollars. GDP for the Waikato region was $14.582 billion, while GDP for New Zealand was $156.826 billion. This is equal to 9.3% of national production, which is slightly higher than the 9.1% of total New Zealand GDP found by Hughes (2009) for the 2008 year.

5.1.1. Sector Structure of the Waikato Region

The sector structure of a region is calculated from the imports and primary costs and final consumption quadrants of the input-output table, as well as total gross production. It shows the distribution per region across all sectors as a percent of the total production. The sector structure can also be illustrated as each sector's contribution to exports, imports, consumption of fixed capital and operating surplus.

Table 6 shows the top 10 industries in the Waikato region by their contribution to total production. It can be seen that meat and dairy manufacturing is the largest industry, contributing 11% of total production for the region. Electricity, gas and water supply is a large producer in the Waikato because of the hydro-power plants along the Waikato River, as well as the Huntly power station. A full table of industries by contribution to total Waikato production is shown in Appendix 2.

Table 6

	% Contribution
Meat and dairy manufacturing	11.00
Ownership of owner-occupied dwellings	5.74
Electricity, gas and water supply	4.24
Other business services	4.05
Real estate	3.88
Construction trade services	3.48
Industrial machinery manufacturing	3.45
Wholesale Trade	3.36
Retail Trade	3.14
Non-building construction	2.78

Table 7 below shows the Top 10 industries in the Waikato by their contribution to total Waikato exports. It can be seen that meat and dairy manufacturing is the Waikato's biggest exporting industry, followed by mining and quarrying and wood product manufacturing. The largest industries in the Waikato are the production and manufacturing of primary products, and this is demonstrated in the structure of exports from the Waikato region. A full table of industries by contribution to total Waikato exports is shown in Appendix 3.

Table 7

	% Contribution
Meat and dairy manufacturing	33.40
Ownership of owner-occupied dwellings	6.43
Mining and quarrying	6.17
Wood product manufacturing	5.53
Dairy and cattle farming	5.15
Electricity, gas and water supply	3.72
Other business services	3.16
Forestry, Logging & forestry services	3.14
Residential construction	3.06
Pre-school, primary and secondary education	2.73

Table 8 shows the top 10 industries in the Waikato region by their contribution to total imports. It can be seen that wholesale trade is the Waikato's largest importing industry, while meat and dairy manufacturing is the second largest. This is most likely because meat and dairy manufacturing is also the Waikato's largest producing industry, indicating that the industry's imports are inputs for production rather than imports of final meat and dairy manufacturing goods. A full table of industries by contribution to total Waikato imports is shown in Appendix 4.

Table 8

	% Contribution
Wholesale Trade	7.83
Meat and dairy manufacturing	5.77
Finance	5.61
Water and air transport	4.02
Other business services	3.74
Livestock and cropping farming	3.18
Construction trade services	3.17
Road and rail transport	3.08
Industrial machinery manufacturing	3.00
Beverage, malt and tobacco manufacturing	2.81

Table 9 shows the top 10 industries by their contribution to total consumption of fixed capital in the Waikato region. Ownership of owner-occupied dwellings is the largest industry by consumption of fixed capital, followed by real estate. This is due to the large number of house and building purchases in these industries. Meat and dairy manufacturing is the third-largest due to the large contribution of exports and production by the industry (i.e. the industry needs to consume a lot of capital to maintain production levels). A full table of industries by contribution to total Waikato consumption of fixed capital is shown in Appendix 5.

Table 9

	% Contribution
Ownership of owner-occupied dwellings	17.83
Real estate	9.08
Meat and dairy manufacturing	8.37
Electricity, gas and water supply	4.19
Communication services	3.81
Vehicle and equipment hire	3.57
Road and rail transport	3.19
Basic metal manufacturing	2.49
Mining and quarrying	2.30
Retail Trade	2.14

Table 10 shows the top 10 industries by their contribution to the total Waikato operating surplus. It can be seen that the largest industry is ownership of owner-occupied dwellings, followed by real estate. Together these industries contribute almost 30% of the total operating surplus. The electricity, gas and water supply and meat and dairy manufacturing industries also contribute a large proportion of operating surplus, largely because of their size. A full table of industries by contribution to total Waikato operating surplus is shown in Appendix 6.

Table 10

	% Contribution
Ownership of owner-occupied dwellings	20.28
Real estate	9.68
Electricity, gas and water supply	6.90
Meat and dairy manufacturing	6.39
Finance	4.76
Other business services	4.76
Dairy and cattle farming	4.52
Industrial machinery manufacturing	4.12
Retail Trade	4.11
Construction trade services	3.94

5.1.2. Linkages in the Waikato Region

Table 11 below shows the backward linkages in the Waikato region for the 20 industries with the highest linkages, plus the backward linkage for the University of Waikato. A backwards linkage can be interpreted as the proportional increase in total demand for goods from supplying sectors that is gained from a $1 increase output in a particular industry. For example, a $1 increase in output from the meat and dairy manufacturing industry generates $1.14 of additional demand for goods from industries which supply to the meat and dairy manufacturing industry. It can be seen from Table 11 that some of the industries with the highest backward linkages are the industries with the largest contribution to production, such as meat and dairy manufacturing, construction, and electricity, gas and water supply (refer Table 4 above). The wood product manufacturing industry also has large backward linkages, along with other manufacturing industries such as structural sheet and fabricated metal product, paper, pulp paper, paper board and paper board containers, basic metal, other food, and non-metallic mineral products. A full table of backward linkages for all industries is given in Appendix 7.

Table 11

Backward Linkages in the Waikato Region (%)	
Residential construction	1.35
Non-residential building construction	1.29
Meat and dairy manufacturing	1.14
Non-building construction	1.16
Electricity, gas and water supply	1.11
Wood product manufacturing	1.09
Forestry, Logging & forestry services	0.99
Other farming	0.94
Structural sheet and fabricated metal product manufacturing	0.89
Paper, pulp paper, paper board and paper board containers manufacturing	0.84
Basic metal manufacturing	0.83
Other food manufacturing	0.81
Non-metallic mineral product manufacturing	0.79
Mining and quarrying	0.79
Sewerage, drainage and waste disposal services	0.78
Construction trade services	0.78
Local government administration	0.77
Horticulture and fruit growing	0.75
Fishing	0.75
Dairy and cattle farming	0.73
University of Waikato	**0.39**

Table 12 below shows the forward linkages in the Waikato region for the 20 industries with the highest linkages, plus the forward linkage for the University of Waikato. A forward linkage can be interpreted as the proportional increase in total supply of goods to supplying sectors that is gained from a $1 increase output in a particular industry. For example, a $1 increase in output in the road and rail transport industry generates $1.55 of additional supply of goods to other industries. It can be seen from Table 12 that the industries with the highest forward linkages are services to agriculture and hunting and trapping, non-metallic mineral product manufacturing, plastic product manufacturing and livestock and cropping farming. The industries with higher forward linkages tend to be in the services sector, whereas industries with higher backward linkages were mainly in the construction and manufacturing industries. A full table of forward linkages for all industries is given in Appendix 8.

Table 12

Forward Linkages in the Waikato Region (%)	
Services to agriculture and hunting and trapping	1.76
Non-metallic mineral product manufacturing	1.67
Plastic product manufacturing	1.60
Livestock and cropping farming	1.60
Road and rail transport	1.55
Basic metal manufacturing	1.54
Legal and accounting services	1.52
Other business services	1.46
Scientific research and technical services	1.45
Electricity, gas and water supply	1.40
Structural sheet and fabricated metal product manufacturing	1.37
Vehicle and equipment hire	1.30
Fertilizer, petroleum and other industrial chemical manufacturing	1.29
Other manufacturing nec	1.17
Industrial machinery manufacturing	1.12
Printing, publishing and recorded media	1.11
Communication services	1.08
Finance	1.08
Sewerage, drainage and waste disposal services	1.07
Forestry, Logging & forestry services	1.07
University of Waikato	**0.11**

The forward and backward linkages for the University of Waikato are substantially smaller than those of the dairy, electricity and forestry industries, which are the main producing industries in the Waikato.

5.1.3. Multipliers for the Waikato Region

Table 13 below shows computed production multipliers for the top 20 most valuable industries in the Waikato Region, plus the production multiplier for the University of Waikato. It can be seen that the industries which are most important to the Waikato Region are construction, meat and dairy, energy and forestry related industries. These industries represent where spending has the greatest impact in terms of total dollar value of output generated throughout the Waikato economy. For example, one dollar's worth of final demand in the electricity, gas and water supply industry will generate $3.11 worth of production over all sectors. A complete table of the production multipliers for the Waikato Region are given in Appendix 9.

Table 13

Production Multipliers for the Waikato Region	
Residential construction	3.35
Non-residential building construction	3.29
Meat and dairy manufacturing	3.14
Non-building construction	3.12
Electricity, gas and water supply	3.11
Wood product manufacturing	3.09
Forestry, Logging & forestry services	2.99
Other farming	2.94
Structural sheet and fabricated metal product manufacturing	2.89
Paper, pulp paper, paper board and paper board containers manufacturing	2.84
Basic metal manufacturing	2.83
Other food manufacturing	2.81
Non-metallic mineral product manufacturing	2.79
Mining and quarrying	2.79
Sewerage, drainage and waste disposal services	2.78
Construction trade services	2.78
Local government administration	2.77
Horticulture and fruit growing	2.75
Fishing	2.75
Dairy and cattle farming	2.73
University of Waikato	**2.39**

Table 14 below shows computed household income multipliers for the top 20 most valuable industries in the Waikato Region, which includes the University of Waikato. It can be seen that the industries which are most important to the Waikato Region in terms of income generated are education, health, government administration and technical service related industries. These industries represent where spending has the greatest impact in terms of labour services needed when there is a dollar's worth of new final demand for goods a particular industry. For example, one dollar's worth of final demand at the University of Waikato will generate $1.69 worth of new household income. A complete table of household income multipliers for the Waikato Region are given in Appendix 10.

Table 14

Household Income Multipliers for the Waikato Region	
Pre-school, primary and secondary education	1.74
Hospitals and nursing homes	1.70
Post school education	1.69
University of Waikato	**1.69**
Community care services	1.68
Central government administration and defence	1.58
Other education	1.58
Personal and private household services & household employed staff	1.51
Scientific research and technical services	1.48
Veterinary services	1.46
Local government administration	1.45
Restaurant and bars	1.43
Other business services	1.42
Motor vehicle and part manufacturing	1.42
Ship, boat and other transport equipment manufacturing	1.41
Retail Trade	1.40
Industrial machinery manufacturing	1.39
Non-building construction	1.39
Wood product manufacturing	1.38
Libraries, museum and the arts	1.38

Table 15 below shows computed employment multipliers for the top 20 most valuable industries in the Waikato Region, plus the employment multiplier for the University of Waikato. Because of the scale of figures used to calculate these multipliers, they are interpreted as the number of new jobs generated from an additional one million dollars in an industry. It can be seen that the industries which are most important to the Waikato Region in terms of employment are agriculture, forestry, fishing and mining related activities. These industries represent where output has the greatest impact in terms of physical employment generated throughout the Waikato economy. For example, one million dollars worth of new output in the dairy and cattle farming industry will generate 2.55 new jobs in the Waikato region. A complete table of the employment multipliers for the Waikato Region are given in Appendix 11.

Table 15

Employment Multipliers for the Waikato Region	
Residential construction	3.77
Non-residential building construction	3.56
Community care services	2.80
Meat and dairy manufacturing	2.67
Horticulture and fruit growing	2.67
Non-building construction	2.64
Other farming	2.61
Health and dental services	2.61
Local government administration	2.56
Dairy and cattle farming	2.55
Scientific research and technical services	2.40
Other food manufacturing	2.26
Other business services	2.19
Personal and private household services & household employed staff	2.13
Sport and recreation	2.13
Wood product manufacturing	2.11
Plastic product manufacturing	2.02
Forestry, Logging & forestry services	2.01
Services to finance and insurance	2.01
Construction trade services	1.98
University of Waikato	**1.20**

5.2. Single-Region Multiplier Effects for the Waikato Region

5.2.1. Economic Impacts of University Student Spending

The industries whose production is affected by student spending in the Waikato are shown in Table 16 below. It can be seen that in terms of increased production, the industry most affected by student spending in the Waikato is retail trade[10]. Retail trade encompasses a multitude of commodities that students spend money on, such as food, clothing, manchester, stationery and books etc. Real estate is also greatly impacted by student spending because it was assumed that any rental activity takes place in the real estate industry.

Overall, the multiplier effects are largest in industries where students spend on necessities, such as accommodation, food (in the retail trade industry) and electricity. This finding is consistent with Hughes (1994, 2009), who found that

[10] This is probably influenced by the level of aggregation in the input-output table, as the data used to create the table had a high aggregation level for the Wholesale and Retail Trade industries.

the industries which are most impacted by student spending are retail trade, electricity, gas supply, bars and restaurants, road passenger, other sport and recreation, and personal and community services. The University of Waikato is not one of the most impacted industries by student spending because it is included under the University's spending impacts.

Table 16

Production Multiplier Effects		
Retail Trade	$	328,367,700
Real estate	$	91,224,100
Restaurant and bars	$	53,456,900
Water and air transport	$	35,205,700
Sport and recreation	$	33,626,500
Communication services	$	26,692,300
Electricity, gas and water supply	$	28,751,900
Finance	$	20,140,500
Insurance	$	12,806,300
Personal and private household services & household employed staff	$	10,168,700
Road and rail transport	$	9,197,300
Motion picture, radio and TV services	$	6,199,600
Libraries, museum and the arts	$	4,096,400
Health and dental services	$	3,573,900
Accommodation	$	1,823,200
Veterinary services	$	1,274,400
Printing, publishing and recorded media	$	754,300
Vehicle and equipment hire	$	86,500
Total Student Spending	**$**	**667,446,200**

The industries which are most impacted by student spending in the Waikato in terms of household income are shown in Table 17 below. It can be seen that in terms of increased household income, the industry which is most impacted by student spending in the Waikato is retail trade. The restaurants and bars, real estate and sport and recreation industries are also highly impacted by student spending in terms of increased household income.

Table 17

Household Income Multiplier Effects		
Retail Trade	$	181,605,400
Real estate	$	42,723,800
Restaurant and bars	$	29,925,900
Water and air transport	$	18,053,400
Sport and recreation	$	17,184,000
Communication services	$	13,710,700
Electricity, gas and water supply	$	10,915,100
Finance	$	10,904,600
Insurance	$	6,525,400
Personal and private household services & household employed staff	$	6,154,700
Road and rail transport	$	4,925,100
Motion picture, radio and TV services	$	3,183,300
Libraries, museum and the arts	$	2,265,100
Health and dental services	$	1,954,700
Accommodation	$	972,600
Veterinary services	$	783,800
Printing, publishing and recorded media	$	381,000
Vehicle and equipment hire	$	42,000
Total Student Spending	**$**	**352,210,600**

The industries where students spend and the corresponding employment multiplier effects are shown in Table 18 below. It can be seen that student spending has by far the largest impact in the retail trade industry. Student spending of $129.8 million in the retail trade industry has resulted in 86.59 new jobs in the Waikato region. In total, student spending in the Waikato region has resulted in 215.41 jobs that would not have been created if the University did not exist.

Table 18

Employment Multiplier Effects	
Retail Trade	86.59
Real estate	35.40
Water and air transport	31.42
Restaurant and bars	13.14
Finance	12.35
Electricity, gas and water supply	9.75
Communication services	8.35
Sport and recreation	6.12
Insurance	4.26
Road and rail transport	2.31
Personal and private household services & household employed staff	1.91
Motion picture, radio and TV services	1.29
Libraries, museum and the arts	0.95
Health and dental services	0.54
Accommodation	0.44
Veterinary services	0.31
Printing, publishing and recorded media	0.25
Vehicle and equipment hire	0.03
Total Jobs	**215.41**

5.2.2. Economic Impacts of University of Waikato Operations

Due to the way in which expenditure is classified in the University of Waikato's 2009 Annual Report, multiplier effects were not able to be broken down by industry. Therefore, University spending impacts on industries in the Waikato region are estimates from existing knowledge of the University's operations. Table 19 below shows the calculated multiplier effects for the University of Waikato in terms of production, income and employment. It can be seen that the total impact on the Waikato region from the University's operations is $800.9 million. This consists of a production impact of the University's operations ($488.6 million) and a household income impact ($312.3 million). The University's operations[11] generate $240.4 million in revenue, which is then spent on purchasing inputs to provide services, which generates further output within the region for a total impact of $488.6 million. The University directly employs 1,438 FTEs, but the

[11] The University's operations include revenue obtained from course fees, government funding and grants, research, student accommodation (i.e. the halls of residence) and other income.

indirect effect of its operations in the region has resulted in an additional 171 FTE positions in other industries[12].

Table 19

	Production	Household Income	Employment
University of Waikato	$ 204,400,000	$ 116,000,000	1,438
Flow-on to Supplying Sectors	$ 284,200,000	$ 196,300,000	171
Total Impact on the Waikato Region	**$ 488,600,000**	**$ 312,300,000**	**1,609**
University of Waikato Multiplier	2.39	2.69	1.20

A description of how the direct activities of the University were allocated to industries is shown in Table 20 below. These direct activities undertaken by the University generate increased demand for output from other industries such as electricity, gas and water supply, real estate, finance, accommodation, transport, retail and wholesale trade, known as flow-on effects to supplying sectors. This is because these industries supply the University with inputs which enable it to provide educational services. For example, the electricity, gas and water supply industry supplies the University with water and electricity which allows students to attend class and spend time on the premises studying. In addition, the accommodation and transport industries supply University employees with accommodation and transport in other regions/countries if they need to travel to attend conferences or conduct research.

[12] The employment multiplier effect for the University of Waikato included the 1438 FTEs employed at the University, since if the University did not exist, neither would these jobs.

Table 20

Activity	Cost		Industry
Scholarships	$	10,200,000	University of Waikato Student Spending
Operating leases	$	3,900,000	Real Estate
Utilities	$	3,300,000	Electricity, Gas and Water Supply
Finance Costs	$	500,000	Finance
Travel and accommodation	$	4,800,000	Accommodation Road and Rail Transport Water and Air Transport
Repairs and maintenance	$	2,200,000	Non-Residential Construction Construction Trade Services
Teaching and Research Materials	$	2,000,000	Retail Trade
Hirage	$	1,200,000	Vehicle and Equipment Hire
Restructuring costs	$	100,000	
Depreciation and Amortisation	$	16,800,000	University
Other costs	$	34,800,000	Retail Trade Wholesale Trade Other Business services
Total Direct Activities	**$**	**79,800,000**	

Source: (The University of Waikato, 2009c)[13]

[13] Note that Columns one and two were retrieved from this source, whereas the final column is my own impression of where these expenditures go.

6. Discussion

6.1. The Waikato Economy

The GDP result for the Waikato region of $14.582 billion, or 9.3% of national GDP, is similar to the 9.1% contribution to total New Zealand GDP found by Hughes (2009) for the 2008 year. The meat and dairy manufacturing industry is the largest producing industry in the region, contributing 11% of total production for the region. Electricity, gas and water supply is also a larger producer in the Waikato (contributing 4.24%) due to the hydro-power plants along the Waikato River. This finding is supported by Market Economics Ltd (2006a), who found that industries which are most important to the Waikato region are dairy farming, electricity generation and distribution, mining and quarrying, forestry and logging, and education and research services. Phillips (2009) also found that the largest sectors in the Waikato economy in 2007 were dairy cattle farming, business services and real estate.

6.1.1. Linkages in the Waikato Region

This study has found that the industries with the largest backward linkages tended to be in industries with larger contributions to production (such as meat and dairy manufacturing, construction, and electricity, gas and water supply) and in the manufacturing industries (such as structural sheet and fabricated metal product, paper, pulp paper, paper board and paper board containers, basic metal). On the other hand, industries with the largest forward linkages were services to agriculture, hunting and trapping, non-metallic mineral product manufacturing and plastic product manufacturing. Overall, industries with higher forward linkages tended to be in the services sector. These results are similar to Dharmalingam et al. (2005), who found that the industries in the South Waikato region which are linked (both forward and backward) the most are meat and dairy processing, wholesale trade, retail trade, paper and products, structural and fabricated metal products, road freight, sawmills and basic metal manufacturing.

Hughes (2007) found that those industries with the highest backward linkages were meat processing, dairy processing and electricity, which is consistent with the backward linkages calculated in this study. Those industries with the highest forward linkages as estimated by Hughes (2007) were electricity, sheep, deer and beef farming, and retail and wholesale trade, which is similar to the forward linkage found in this study, but more closely aligned with Dharmalingham et al. (2005).

With regard to the strength of the forward and backward linkages for the University of Waikato, they are much weaker than those mentioned above. This indicates that the University of Waikato is not linked as strongly to other industries in the region compared to the main producing industries such as dairy, electricity generation, and forestry. However, it was noted by Round (1983) that linkages obtained from a non-survey or hybrid input-output table are unlikely to be adequately captured. This is because the technical coefficients matrices $(\boldsymbol{I}-\boldsymbol{A})^{-1}$ and $(\boldsymbol{I}-\boldsymbol{B})^{-1}$ on which backward and forward linkages are based are derived from the national coefficients matrices, which may not fully represent the regional industry structure.

6.1.2 Multipliers in the Waikato Region

The three categories of multipliers for the Waikato Region show where increased spending has the greatest impact in dollar value terms of output generated, new final demand or physical employment generated throughout the region. A high multiplier for a particular sector's impact indicates that it has significant linkages to other sectors and is an important sector for the economy (Hughes, 1994). Section 5.1.3 showed that the industries with the highest production multipliers were construction, meat and dairy, energy and forestry related industries, whereas the industries with the highest household income multipliers were education, health, government administration and technical service related industries. The industries whose increased spending had the largest impact in terms of physical employment (employment multipliers) were agriculture, forestry, fishing and mining related industries.

An industry with a lot of forward and backward linkages into labour-intensive industries will likely have a higher employment multiplier (Miller & Blair, 1985). So will an industry with a higher production multiplier. For example, the electricity, gas and water supply industry has a large number of forward and backward linkages in the region, as well as a high production multiplier. The meat and dairy manufacturing industry also has a high production multiplier associated with the large number of backward linkages it has in the region, as well as a high employment multiplier.

Table 21 below shows a comparison of the production, income and employment multipliers calculated in Hughes' (1994, 2009) and Poot's (1993) impact studies for the University of Waikato and Victoria University respectively. It can be seen that the production and income multipliers calculated in this study are higher than those previously calculated in the other studies, while the employment multiplier is lower than in previous studies.

The employment multiplier for the University of Waikato (2010) is lower than in previous studies because of the way they were interpreted. This is because Hughes (2009) defined the employment multiplier effect as the additional jobs created from a single job at the University where this paper has defined an employment multiplier as the additional number of jobs created from an extra $1 million of final demand at the University. Similarly, Poot (1993) defined the employment impact as being one job for every $52,000 of student and staff expenditure on regional goods and services. Therefore the impact on employment calculated in each of these studies will carry a different interpretation to the impact on employment calculated in this study.

Table 21

	Production Multiplier	Income Multiplier	Employment Multiplier
University of Waikato (1994)	2.18	1.58	2.09
University of Waikato (2009)	2.21	1.45	1.68
Victoria University[14] (1993)	2.70	1.50	1.50
University of Waikato (2010)	**2.39**	**1.68**	**1.45**

6.2. The Impact of the University of Waikato on the Waikato Region[15]

6.2.1. Student Spending Impacts on the Waikato Region

Students at the University of Waikato spend an estimated $267.2 million in the region on goods and services[16], as illustrated in Table 22. The industries where

[14] Based on multipliers calculated by G.V. Butcher (1985).
[15] All impacts reported in this section are of the type II variety as defined in IO theory, Miller and Blair (1985). This means that the induced consumption effect is added to the direct (or initiating) impact and the indirect (or round-by-round) sector impacts.

students spend the most are retail trade (which includes necessities such as food), real estate, restaurants and bars, water and air transport, sport and recreation, communication services and electricity and gas supply. The estimate obtained from the survey in this study gives a much higher estimate of spending than was calculated for 2008 by Hughes (2009), who estimated that students spend an estimated $166.6 million in the Core Waikato region. This is because Hughes' spending estimates were calculated as average total annual student spending based off a student expenditure survey, whereas this study has broken annual spending down by industry, giving a more accurate estimate of student spending in the Waikato Region. It is also much higher than Poot's (1993) estimate of $62 million spent by students in the Wellington region in 1991. These differences in student spending estimates result in much higher multiplier effects in the Waikato region than those calculated by Hughes (2009) or Poot (1993).

Table 22

	Production	Household Income	Employment
Direct expenditure by students	$ 267,200,000	$ 130,900,000*	-
Flow-on to Supplying Sectors	$ 400,200,000	$ 221,300,000	-
Total Impact on the Waikato Region	**$ 667,400,000**	**$ 352,200,000**	**215.41**
University of Waikato Multiplier	2.39	2.69	1.20

Note- Numbers may not add due to rounding.
*Based on an average annual student income of $10,071.

The overall production impact of student spending on the Waikato Region is $677.4 million. This is much larger than the estimated student spending impact of $377 million found by Hughes (2009) for the 2008 year. The multiplier effects (by industry) from student spending were the largest in industries where students spend on necessities such as accommodation, food (in the retail trade industry) and electricity. This finding is consistent with Hughes (1994, 2009), who found that the industries which are most impacted by student spending are retail trade, electricity, gas supply, bars and restaurants, road passenger, other sport and recreation, and personal and community services.

[16] This was estimated using survey data, discussed in Section 4.4.3.

The overall household income impact of student spending on the Waikato region is $352.2 million, based on direct spending by students of $130.9 million. This is also much larger than the estimated impact of $79.2 million found by Hughes (2009) for the 2008 year. The industry found to be most impacted by student spending in terms of increased household income in the Waikato is retail trade. This is most likely because the retail trade industry includes the sale of items which are necessities for students, such as food. The restaurants and bars, real estate and sport and recreation industries are also highly impacted by student spending in terms of increased household income.

The overall employment impact of student spending on the Waikato region is 215 jobs. Student spending has by far the largest impact in the retail trade industry. Student spending of $129.8 million in the retail trade industry has resulted in 86.59 new jobs in the Waikato region. This is a much lower impact than the estimated employment impact of 3058 jobs found by Hughes (2009) for the 2008 year. However, where Hughes defined the employment multiplier effect as the additional number of jobs created from a single job at the University, this paper defines an employment multiplier as the additional number of jobs created from an extra $1 million of final demand at the University. This makes it difficult to separate the reasons for differences in calculated multipliers. It is also much lower than the employment impact on the Wellington Region of 1962 jobs from Victoria University staff and student spending in 1991 (Poot, 1993). Poot (1993) calculated the employment impact as being one job for every $52,000 of student and staff expenditure on regional goods and services, thus this employment impact is also different to the employment impact calculated here.

6.2.2. University of Waikato Spending Impacts on the Waikato Region

Table 23 below shows a breakdown of the total impact of the University of Waikato's operations on the Waikato Region. It can be seen that the total impact on the Waikato region from the University's operations is $700.9 million. This is made up of a production impact ($488.6 million) and a household income impact ($312.3 million). The University's operations generate $204.4 million in revenue, which then creates increased demand for output from other industries such as electricity, gas and water supply, real estate, finance, accommodation, transport, retail and wholesale trade. These industries supply the University with inputs which enable it to provide educational services. This increased demand for output in other industries is called a flow-on effect, and contributes $284.2 million to the total production impact**.**

Table 23

	Production		Household Income		Employment
University of Waikato	$	204,400,000	$	116,000,000	1,438
Flow-on to Supplying Sectors	$	284,200,000	$	196,300,000	171
Total Impact on the Waikato Region	**$**	**488,600,000**	**$**	**312,300,000**	**1,609**
University of Waikato Multiplier		2.39		2.69	1.20

Hughes (1994) found that the University of Waikato's initial output in the Waikato Region of $88.9 million for the 1991 academic year generated a total impact on regional production of $193.8 million. This impact was largest in the wholesale and retail trade, building, real estate, machinery and electricity industries. The two sectors that gained the most from the University's operations were the wholesale and retail trade sectors, and the building sector (Hughes, 1994). In a later study, Hughes (2009) estimated that the direct impact of the University of Waikato was $170.4 million, which in turn generated an additional $206.2 million from flow-ons to other industries. The direct final demand impact of Victoria University for the 1991 academic year was $91 million, which is a much smaller impact than that estimated by Hughes (1994, 2009) for the University of Waikato. Both of these results differ to the above results where the most important industries dependent on the University of Waikato's operations in 2009 were electricity, gas and water supply, real estate, finance, accommodation, transport, retail and wholesale trade.

In terms of household income, the University contributes $312.3 million to the Waikato Region. This compares to $56.5 million in 1991 and $112.5 million in 2008 as estimated by Hughes (1994, 2009). The impact of the University of Waikato on the Waikato Region is therefore larger in 2009 than in previous years. This can be attributed to the higher household income multiplier calculated in this study compared to those calculated by Hughes. The multiplier calculated by Hughes (2009) is likely lower than the one calculated in this study because of the older data that was probably used to calculate the input-output table for the 2008 year[17]. Therefore, the underlying industry structure in the tables may differ.

The University directly employs 1,438 FTEs, but the indirect effect of its operations in the region has resulted in an additional 171 FTE positions in other industries, as shown in Table 23 above. This is much smaller than the 2,612 employment impact calculated by Hughes (2009). As discussed in Section 6.1.2, this is because Hughes' (2009) employment multiplier is defined differently to the employment multiplier used in this study. It is also much smaller than Hughes' (1994) estimate, where the total employment impact of the University was 2194 jobs – 1051 people directly employed and an indirect impact of 1143 jobs.

6.2.3. Total Impact of the University of Waikato on the Waikato Region

The impact of student spending and of University of Waikato spending can be combined to estimate the total impact that the University has on the Waikato regional economy. Table 24 below shows the combined impact of student spending and University on the Waikato Region, as discussed in the sections above. It can be seen that total impact of the University on the local economy is $1,166 million, or 3.4% of regional GDP. The existence of the University in the region contributes 1,824 jobs to the region through direct employment and demand for goods in other industries.

Table 24

Total Impact of the University of Waikato	
University Operations Impact	$489 m
Student Spending Impact	$677 m
Employment Impact	1824 Jobs
Total Impact	**$1,166 m**
% of regional GDP	3.4%

Table 25 below shows a comparison of the estimated impacts of Universities on their local economies from some previous studies of New Zealand Universities. It can be seen that this study (University of Waikato (2009) column) has the largest total impact on the local economy, largely because of the larger estimated impact from student spending. However, it also has the lowest impact on

[17] This study has used the Supply and Use tables for the year ended March 2007, released by Statistics New Zealand in 2010, whereas the latest tables available at the time of Hughes' study would have been the Supply and Use tables for the year ended March 2003.

employment, due to the way in which the calculation of each employment impact differs.

Table 25

	University of Waikato (1992)	University of Waikato (2008)	Victoria University[18] (1991)	University of Waikato (2009)
University Operations Impact	$193 m	$377 m	$91 m*	$489 m
Staff Spending Impact	-	-	$40 m*	-
Student Spending Impact	$137 m	$372 m	$62 m*	$677 m
Employment Impact	3448 Jobs	5600 Jobs	5400 Jobs	1824 Jobs
Total Impact	**$330 m**	**$749 m**	**$300 m**	**$1,166 m**
% of regional GDP	2.7%	3%	4%	3.4%

*These are direct impacts only, rather than total impacts

In terms of regional GDP, the University of Waikato accounted for 3.4% of GDP in the Waikato Region in 2009. This compares to 2.7% in 1991 and 3% in 2008, as found by Hughes (1994, 2009). Victoria University had a larger impact on its local economy, contributing 4% to the regional GDP of the Wellington Region in 1991, where the overall direct final demand presence of the University contributed 2.5% to regional GDP (Poot, 1993).

Student spending at the University in 2009 had a much larger impact on the regional economy than was estimated in the previous studies. Student spending contributed $677 million to the regional economy in 2009, compared to $137 million in 1991 and $372 in 2008 as estimated by Hughes (1994, 2009). This can be attributed to the higher amount of direct expenditure by students. Hughes (1994, 2009) estimated that students spent a total of $166.59 million in the Core Waikato Economy in 2008 and $64.1 million in 1991, compared to the estimated $267.2 million of direct spending by students in 2009.

University operations in 2009 also had a larger impact on the regional economy than estimated in previous studies. University of Waikato operations contributed $489 million to the Waikato Region in 2009, compared to $193 million in 1991 and $377 million in 2008, as estimated by Hughes (2009). This is due to the

[18] Based on multipliers calculated by G.V. Butcher (1985).

higher revenue for the University in 2010 of $204.4 million compared to $170.35 million of revenue in 2008 and $88.9 million in 1991, as estimated by Hughes (1994, 2009).

Overall, the University of Waikato had the largest impact from its own operations and student spending, as well as the largest contribution to regional GDP when compared to previous studies of the University of Waikato and Victoria University. The reason for this is that the estimates of student spending and University revenue in the 2009 year were larger than previous estimates used in the multiplier analysis of Hughes (1994, 2009) for the 1992 and 2008 years. As well as this larger starting point, the multipliers estimated from the Waikato Input-Output Model for 2010 were larger than those estimated from Hughes' earlier models. The combined effect is that the total impact calculated in this study is larger than that of previous studies.

6.2.4. Impact of the Hypothetical Closure of the University of Waikato on the Waikato Region

If the University of Waikato were to close, the region would lose both the revenue earned by the University as well as spending from University staff and students. As well as this, Hughes (2009) noted that if the University were to cease operations for any reason, the so-called flow-on losses to supplying sectors such as electricity would be extremely significant for the regional and national economies. The total loss is equal to 3.4% of regional GDP, or $1,166 million in production lost to the Waikato Region in the 2009 year[19]. It is important to note, however that the hypothetical closure of the University of Waikato in Hamilton, New Zealand's fourth largest city, may not be a reasonable counterfactual as other universities in the country would fill the gap left by Waikato University.

This compares to Poot (1993), who estimated that the closure of Victoria University in Wellington would decrease the Wellington Region's GDP by $300 million (4%) and reduce regional employment by 5,400 jobs (3.7% of total employment in the region). Hughes (2009), on the other hand, estimated that the combined impact of the University of Waikato operations and expenditure of its students in the 2008 year generated $749 million, or 3% of regional GDP. The

[19] Although the exact impact from University staff spending has not been quantified in this study.

University also accounted for 5,600 jobs, or 3.3% of total Waikato Region employment (Hughes, 2009).

However, there is also an impact of the closure of the University on regional economic growth over time, since the University is an institute which provides human capital. Poot (1993) found that the presence of Victoria University in the Wellington Region increases the total number of New Zealand graduates compared with if there were fewer universities to share the same national education budget. The same could be said for the closure of the University of Waikato. There would be fewer graduates coming from the Waikato Region, although some students would start or continue their study in Auckland instead.

In addition, there would be fewer foreign students travelling to New Zealand to study, which may reduce tourism in the Waikato Region as well reduce the opportunities for trade links between businesses in the region and students' home countries (see Poot, 1993).

There would also be a smaller pool of available skilled labour if the University of Waikato were to close. This means that firms may find it harder to recruit staff if there is not a local university to meet the needs of households and their members (Poot, 1993). In other words, households may choose to locate themselves where they have easier access to university education, such as in regions other than the Waikato.

Since graduates which remain in the region (where the University is located) help to build up a better informed and better skilled society, unemployment and its associated economic and social costs are reduced (Poot, 1993). However, if the University were to close, then the benefits of a better informed and highly skilled society are diminished and unemployment may rise.

The University of Waikato also contributes to the local community through its ability to hold public events and supports local innovation. The large sports grounds and Academy of Performing Arts enable the University to host events such as the annual Balloons over Waikato festival and other non-university events. These types of events are of benefit to local residents, as noted by Hughes (2009). The University assisted in the establishment of the Waikato Innovation Park, which was designed as an innovation for science research (Innovation

Waikato Ltd., 2011). The close proximity of the Park and the University allows for the fast transfer of knowledge and experience in that students and graduates are able to gain employment at the Innovation Park, as well as those at the Park being able to consult with University staff. The Waikato Region would therefore lose the ability to host events which benefit its residents if the University were to close, and the lower number of highly skilled workers would be a disadvantage for the Waikato Innovation Park and other businesses in the region.

7. Summary and Conclusions

7.1. The Economic Contribution of the University of Waikato to the Waikato Region

Table 26 below summarises the total impact of the University of Waikato's contribution to the Waikato Region. The University of Waikato contributes a total of $1,166 million to the Waikato region, or 3.4% of regional GDP. Students at the University account for $677 million of this, and University Operations contribute $489 million. As a result of the existence of the University in the Waikato region, 1824 jobs are created both directly from its operations and indirectly from supplying sectors and student spending.

Table 26

Total Impact of the University of Waikato	
University Operations Impact	$489 m
Student Spending Impact	$677 m
Employment Impact	1824 Jobs
Total Impact	**$1,166 m**
% of regional GDP	3.4%

If the University were to close, the Waikato Region's GDP would fall by 3.4% due to the loss of spending in the region by students and the University. It would also lose jobs due to a fall in demand for sectors which supply to the University.

In addition to these tangible impacts, there are also other impacts of the existence of a University to its local community. These include higher economic growth over time, increased tourism from foreign students and their families, a larger pool of skilled labour and a better-informed society. If the University of Waikato were to close the Waikato Region would lose all of these things. More specifically, there would be fewer graduates coming from the Waikato region and a smaller pool of skilled labour because households may choose to locate themselves where they have easier access to university education. There would also be reduced tourism in the Waikato Region because foreign students would not be able to come to the University to study.

The University contributes to the local community through its ability to hold public events and support local innovation. The Waikato may lose the ability to host events such as the Balloons over Waikato, which benefit residents, if the University were to close. The University is also valuable for the Waikato Innovation Park because it provides the transfer of knowledge and experience from both staff at the University and students who graduate and gain employment at the park. The loss of the University would be a disadvantage for the Innovation Park because there would be a lower number of highly skilled workers for the park to access.

7.2. Limitations and Improvements for Future Study

Although this study has provided some valuable insights, it is not without its limitations. First, the method used to construct the input-output table is flawed in that non-survey approaches to calculating regional technical coefficients can be inferior to survey approaches. The method used was the Simple Location Quotient (SLQ) method, which is known to overestimate multipliers. Despite these limitations, this method was used because of its simplicity. Additionally, the SLQ method was appropriate in this case because it requires regional employment by industry, information which is relatively easy to access. Other methods may be superior, but usually require more detailed information. However, a point for further improvement to this study is to either use survey information to get a more accurate description of regional production, or use a more sophisticated non-survey approach which uses more information to obtain more accurate technical coefficients, such as the cross-industry location quotient or iterative balance technique.

As well as this, construction of an interregional input-output table for the Waikato Region would enable us to see exactly where in the Waikato region the University's impact is greatest. In doing this it could be discovered how important the University of Waikato is to the Waikato region and to Hamilton city, and how the University's activities contribute to the economies of the Territorial Authorities within the Waikato Region. An interregional analysis of the Waikato University in the Waikato Region would give a more detailed understanding of the University's role within its local economy.

In order to improve the impact analysis of the University on the Waikato Region, University staff should be included in the expenditure survey to obtain a more complete impact of expenditure in the region. As well as this, more detailed information from the University of its expenditure by industry will provide a clearer picture of the University's operations and thus a more complete view of the University's impact on the Waikato Region.

Finally, the analysis of impacts for the Waikato Region could be improved simply by making comparisons to the impact of the University on the nation, or to isolate the Core Waikato or Hamilton city area and compare this to the wider Waikato Region impact. This would give a richer analysis of where the University of Waikato has the largest impact.

7.2. Concluding Remarks

This paper has used input-output analysis to show that the University of Waikato is important to the Waikato Region both in its contribution to regional GDP and in the benefits it provides to the community such as the use of the University grounds and higher-skilled labour force it brings. The University has a positive and significant impact on regional GDP and provides employment both directly through its delivery of services and indirectly through its operations and spending of staff and students. If the University were to close it would have a significant negative impact both on regional GDP and more intangible losses to its local community.

8. References

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9. Appendices

9.1 Appendix 1: 2010 University of Waikato Student Expenditure Survey

The main objectives of this study are to quantify the economic contribution of the University of Waikato to Hamilton city and to the Waikato region, and also to investigate how the activities of the University of Waikato contribute to the economies of the Territorial Authorities within the wider Waikato region. In doing this it can be discovered how important the University of Waikato is to the Waikato region and to its Territorial Authorities. In investigating how much students and staff are spending, multiplier effects can be determined and it can be seen exactly how valuable the University is to its local economy.

In order to fully understand this impact on the Waikato region, information is required about student spending in the Waikato. If you opt to participate in this survey you will be required to provide estimates of spending in a number of different categories over specified time periods. This will take approximately 20 minutes. The data collected from these surveys will then be used to calculate multipliers which will indicate how important the University is to the wider Waikato region. This information will be presented in a report format as my master's thesis.

The information obtained from the surveys will only be seen by myself and my supervisor, and students will not be identifiable. Information given by you in the survey will not be stored with your email address so that the information cannot be traced to individual students. However, data will be stored with your student ID number as this will enable us to easily identify data if you wish to withdraw from the survey. During and after data collection, survey forms will be kept on a secure server at the University of Waikato. All information that is collected will not be identifiable to individuals. Only my supervisor and I will have access to the secure data. Two years following completion of the research, this data will be deleted.

All questions which do not have an asterisk next to them are not compulsory, and the students may leave them blank and skip to the next question. Participation in the survey is not compulsory, so if you feel uncomfortable about disclosing information about your expenditure then you should not complete the survey. If you require more information about this survey and your involvement, or wish to withdraw any information you have provided in the survey you can email myself (ceold2@gmail.com) or my supervisor, Michael Cameron (mcam@waikato.ac.nz) by 1 November 2010. If you decide you wish to withdraw any information you provide in the survey, upon receiving an email from you any data you wish to withdraw will be immediately destroyed and will not be used in the analysis.

I understand that I am free to withdraw from the study at any time, or to decline to answer any particular questions in the study. I agree to provide information to the researchers under the conditions of confidentiality set out on the Information Sheet.

I have read the above information and agree to participate in this study under the conditions set out above. Also, by completing this survey I consent to my information being used.

(Students must agree to these terms before proceeding with the survey)

What is your student ID number? (This is only to verify that you are a University of Waikato student. Student ID numbers will not form part of the final dataset of be used in the analysis).

Personal Details

What is your gender?

- Male
- Female

What age are you?

- Under 18
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25-29
- 30 and over

What year of your qualification are you currently in?

- 1st year
- 2nd year
- 3rd year
- 4th year
- 5th year
- Other, please specify

Are you studying full time or part time?

- Full time
- Part time

What is your citizenship/status in New Zealand?

- NZ citizen
- Permanent Resident
- Overseas

What qualification are you studying? Please select all that apply.

- Bachelor of Arts
- Bachelor of Business Analysis
- Bachelor of Communication Studies
- Bachelor of Computer Graphic Design
- Bachelor of Computing and Mathematical Sciences
- Bachelor of Electronic Commerce
- Bachelor of Engineering
- Bachelor of Environmental Planning
- Bachelor of Laws
- Bachelor of Management Studies
- Bachelor of Maori and Pacific Development
- Bachelor of Media and Creative Technologies
- Bachelor of Music
- Bachelor of Science
- Bachelor of Science (Tech)
- Bachelor of Social Science
- Bachelor of Social Work
- Bachelor of Sport and Leisure Studies
- Bachelor of Teaching
- Bachelor of Tourism
- Masters Degree
- Postgraduate Diploma
- PhD Degree
- Masters of Philosophy
- Bachelors Degree with Honours
- Other, please specify:

Are you enrolled as a domestic or international student?

- Domestic Student
- International Student

Where do you normally live?

- Hamilton City
- Cambridge, Te Awamutu, or Waipa District
- Ngaruawahia, Huntly, or Waikato District Council Area
- Morrinsville, Matamata
- Somewhere else, pleasy specify:

If you weren't studying at the University of Waikato, what would you be doing?

- Studying somewhere else
- Working/looking for a job
- Doing something else, please specify

Where would you be doing this?

- In Hamilton
- Elsewhere in the Waikato; please specify
- Elsewhere in New Zealand; please specify
- Outside of New Zealand; please specify

Living Situation

What kind of accommodation do you live in?

- Flatting/renting
- Living at home
- Own house
- Student village, fully catered
- Student village, self catered
- Bryant Hall, fully catered
- Bryant Hall, self catered
- College Hall, fully catered
- College Hall, self catered
- Orchard Park
- Other, please specify:

If you are flatting, how much does your flat pay per week in rent?

If you are flatting, how many people usually live in your flat?

If you are living at home, how much board do you pay each week?

If you own your own home, how much are your mortgage payments each month?

Living Expenses

How much does your flat spend on phone and internet bills in a month?

How much does your flat spend on electricity in a month?

Does your flat have SKY?

If yes, how much is your flat's monthly SKY bill?

If your flat pays for lawn-mowing services, how much does your flat spend on this in a month?

If your flat pays for a cleaning service, how much does your flat spend on this in a month?

If your flat pays for firewood, coal etc for heating, how much does your flat spend on this in a month?

If your flat pays for gas bottles, how much does your flat spend on this in a month?

Do you do your grocery shopping as a flat or individually?

- As a flat
- Individually

How much does your flat spend on groceries in a week?

How much do you individually spend on groceries in a week?

Do you smoke?

- Yes
- No

If yes, how much do you spend on cigarettes in a week?

How much do you spend on cellphone credit (or bills) in a month?

How much do you spend on telephone calling cards in a month?

How much do you spend on house/flat/contents/tenants Insurance in a year?

Entertainment Expenses

How often do you dine out in a week?

How much do you spend on dining out in a week?

How much do you spend on alcohol from liquor outlets/supermarkets in a week?

How much do you spend in bars in a week?

How much do you spend on magazines in a month?

How much do you spend on these leisure activities in a month?

Movies:

Gaming:

Lotto and scratchies:

Gambling:

Do you spend money on any other leisure activities?

If yes, please state the activity(s) and how much you would spend on the activity(s) in a month:

Travel Expenses

How much do you spend on buses around Hamilton in a week ?

How much do you spend on taxis in a week?

Do you have a car, motorbike or scooter?

- Yes
- No

If yes, how much do you spend in a week on petrol?

How much would you spend on car maintenance every 6 months?

How much do you spend on car insurance in a year?

How much do you spend on air travel in a year?

How much do you spend on buses to travel outside of Hamilton in a year?

Education Expenses

How much would you spend on text books in a semester?

How much would you spend on stationery in a semester?

Medical and Fitness Expenses

How much do you spend on memberships for sports teams/sports clubs in a year?

How much do you spend on gym memberships in a year?

How much do you spend on sports equipment in a year?

How much do you spend on doctors visits in a year?

How much do you spend on dentist visits in a year?

Electronic expenses:

How much would you spend on appliances in a year?

How much would you spend on computer equipment in a year?

How much would you spend on household appliances in a year?

Clothing/Retail Expenses:

How much do you spend on clothes in a month?

How much do you spend on shoes in a month?

How much do you spend on accessories in a month?

How much do you spend on Manchester in a month? (i.e. linen, towels, bedding etc)

How much do you spend on homewares in a year? (i.e. crockery, cutlery, cooking utensils etc.)

Beauty Expenses:

How much would you spend on toiletries in a month? (i.e. toothpaste, shampoo, conditioner, bodywash/soap, razors etc.)

How much would you spend on cosmetics in a month?

How much would you spend at beauty/hair salons in a month?

Other

Do you have pets?

If yes, how much do you spend on pet food in a week?

How much do you spend on vets bills in a year? (including vaccinations etc.)

How much do you spend on overseas travel in a year?

How much do you spend on travel insurance in a year?

How much do you spend on life insurance in a year?

How much do you spend on health insurance in a year?

How much do you spend on bank fees in a year?

Draw for book, itunes or supermarket vouchers:

If you wish to enter the draw for $200 book, itunes or supermarket vouchers, please enter your email address below:

9.2 Appendix 2: Industry Contribution to Total Waikato Production

	% Contribution
Meat and dairy manufacturing	11.00
Ownership of owner-occupied dwellings	5.74
Electricity, gas and water supply	4.24
Other business services	4.05
Real estate	3.88
Construction trade services	3.48
Industrial machinery manufacturing	3.45
Wholesale Trade	3.36
Retail Trade	3.14
Non-building construction	2.78
Residential construction	2.76
Finance	2.48
Wood product manufacturing	2.44
Dairy and cattle farming	2.36
Road and rail transport	2.15
Mining and quarrying	2.07
Basic metal manufacturing	2.02
Communication services	1.80
Central government administration and defence	1.76
Forestry, Logging & forestry services	1.73
Restaurant and bars	1.68
Hospitals and nursing homes	1.61
Health and dental services	1.60
Pre-school, primary and secondary education	1.54
Scientific research and technical services	1.43
Non-residential building construction	1.42
Sport and recreation	1.40
Paper, pulp paper, paper board and paper board containers manufacturing	1.27
Livestock and cropping farming	1.25
Other food manufacturing	1.25
Fertilizer, petroleum and other industrial chemical manufacturing	1.09
Legal and accounting services	1.04
Personal and private household services & household employed staff	1.01
Services to agriculture and hunting and trapping	0.97
Electronic equipment and appliances manufacturing	0.83
Water and air transport	0.82
Other farming	0.77
Horticulture and fruit growing	0.76
Other manufacturing nec	0.70
Non-metallic mineral product manufacturing	0.69
Vehicle and equipment hire	0.68
Plastic product manufacturing	0.67
Insurance	0.63
Structural sheet and fabricated metal product manufacturing	0.61
Accommodation	0.60
Beverage, malt and tobacco manufacturing	0.56
Computer services	0.55
Community care services	0.54
Local government administration	0.52
Sewerage, drainage and waste disposal services	0.51
Post school education	0.44

Motor vehicle and part manufacturing	0.42
Other chemical product manufacturing	0.34
University of Waikato	0.34
Motion picture, radio and TV services	0.29
Furniture manufacturing	0.27
Clothing and footwear manufacturing	0.26
Fishing	0.25
Other education	0.25
Textiles product manufacturing	0.22
Libraries, museum and the arts	0.20
Services to finance and insurance	0.18
Printing, publishing and recorded media	0.17
Veterinary services	0.16
Ship, boat and other transport equipment manufacturing	0.14
Photographic and scientific equipment manufacturing	0.13
Superannuation fund operation	0.12
Services to transport	0.09
Oil and gas exploration and extraction	0.06
Rubber product manufacturing	0.01
Financial charges	0.00

9.3 Appendix 3: Industry Contribution to Total Waikato Exports

	% Contribution
Meat and dairy manufacturing	33.40
Ownership of owner-occupied dwellings	6.43
Mining and quarrying	6.17
Wood product manufacturing	5.53
Dairy and cattle farming	5.15
Electricity, gas and water supply	3.72
Other business services	3.16
Forestry, Logging & forestry services	3.14
Residential construction	3.06
Pre-school, primary and secondary education	2.73
Industrial machinery manufacturing	2.40
Other farming	2.32
Health and dental services	1.97
Hospitals and nursing homes	1.97
Basic metal manufacturing	1.95
Paper, pulp paper, paper board and paper board containers manufacturing	1.89
Restaurant and bars	1.74
Accommodation	1.56
Sport and recreation	1.42
Horticulture and fruit growing	1.35
Non-building construction	1.19
Road and rail transport	0.97
Vehicle and equipment hire	0.85
Post school education	0.72
Fishing	0.56
University of Waikato	0.55
Structural sheet and fabricated metal product manufacturing	0.52
Services to finance and insurance	0.50
Motor vehicle and part manufacturing	0.45
Retail Trade	0.44
Construction trade services	0.36
Communication services	0.33
Scientific research and technical services	0.32
Plastic product manufacturing	0.29
Legal and accounting services	0.29
Veterinary services	0.25
Other education	0.18
Textiles product manufacturing	0.10
Services to transport	0.09
Local government administration	0.00
Livestock and cropping farming	0.00
Services to agriculture and hunting and trapping	0.00
Oil and gas exploration and extraction	0.00
Other food manufacturing	0.00
Beverage, malt and tobacco manufacturing	0.00
Clothing and footwear manufacturing	0.00
Printing, publishing and recorded media	0.00
Fertilizer, petroleum and other industrial chemical manufacturing	0.00
Other chemical product manufacturing	0.00
Rubber product manufacturing	0.00
Non-metallic mineral product manufacturing	0.00

Ship, boat and other transport equipment manufacturing	0.00
Photographic and scientific equipment manufacturing	0.00
Electronic equipment and appliances manufacturing	0.00
Furniture manufacturing	0.00
Other manufacturing nec	0.00
Sewerage, drainage and waste disposal services	0.00
Non-residential building construction	0.00
Wholesale Trade	0.00
Water and air transport	0.00
Finance	0.00
Superannuation fund operation	0.00
Insurance	0.00
Real estate	0.00
Computer services	0.00
Central government administration and defence	0.00
Community care services	0.00
Motion picture, radio and TV services	0.00
Libraries, museum and the arts	0.00
Personal and private household services & household employed staff	0.00
Financial charges	0.00

9.4 Appendix 4: Industry Contribution to Total Waikato Imports

	% Contribution
Wholesale Trade	7.83
Meat and dairy manufacturing	5.77
Finance	5.61
Water and air transport	4.02
Other business services	3.74
Livestock and cropping farming	3.18
Construction trade services	3.17
Road and rail transport	3.08
Industrial machinery manufacturing	3.00
Beverage, malt and tobacco manufacturing	2.81
Electronic equipment and appliances manufacturing	2.67
Retail Trade	2.41
Electricity, gas and water supply	2.39
Insurance	2.33
Basic metal manufacturing	2.15
Services to agriculture and hunting and trapping	2.11
Real estate	2.05
Non-building construction	2.01
Other food manufacturing	1.89
Computer services	1.76
Restaurant and bars	1.76
Fertilizer, petroleum and other industrial chemical manufacturing	1.75
Communication services	1.72
Wood product manufacturing	1.66
Dairy and cattle farming	1.65
Mining and quarrying	1.54
Central government administration and defence	1.47
Paper, pulp paper, paper board and paper board containers manufacturing	1.31
Residential construction	1.25
Hospitals and nursing homes	1.12
Clothing and footwear manufacturing	1.08
Other chemical product manufacturing	1.03
Sport and recreation	0.98
Plastic product manufacturing	0.97
Other manufacturing nec	0.95
Non-residential building construction	0.94
Health and dental services	0.87
Forestry, Logging & forestry services	0.85
Furniture manufacturing	0.84
Scientific research and technical services	0.78
Personal and private household services & household employed staff	0.76
Superannuation fund operation	0.74
Motion picture, radio and TV services	0.66
Other farming	0.66
Horticulture and fruit growing	0.65
Non-metallic mineral product manufacturing	0.64
Pre-school, primary and secondary education	0.58
Vehicle and equipment hire	0.52
Accommodation	0.51
Motor vehicle and part manufacturing	0.50
Legal and accounting services	0.47

Structural sheet and fabricated metal product manufacturing	0.45
Textiles product manufacturing	0.40
Ownership of owner-occupied dwellings	0.39
Oil and gas exploration and extraction	0.37
Fishing	0.36
Libraries, museum and the arts	0.34
Sewerage, drainage and waste disposal services	0.31
Photographic and scientific equipment manufacturing	0.29
Printing, publishing and recorded media	0.24
Ship, boat and other transport equipment manufacturing	0.23
Post school education	0.21
Local government administration	0.19
Community care services	0.17
Services to finance and insurance	0.16
University of Waikato	0.16
Other education	0.16
Financial charges	0.14
Services to transport	0.10
Veterinary services	0.08
Rubber product manufacturing	0.06

9.5 Appendix 5: Industry Contribution to Total Waikato Consumption of Fixed Capital

	% Contribution
Ownership of owner-occupied dwellings	17.83
Real estate	9.08
Meat and dairy manufacturing	8.37
Electricity, gas and water supply	4.19
Communication services	3.81
Vehicle and equipment hire	3.57
Road and rail transport	3.19
Basic metal manufacturing	2.49
Mining and quarrying	2.30
Retail Trade	2.14
Industrial machinery manufacturing	2.08
Paper, pulp paper, paper board and paper board containers manufacturing	2.05
Other business services	1.98
Central government administration and defence	1.91
Wood product manufacturing	1.87
Construction trade services	1.76
Pre-school, primary and secondary education	1.59
Sport and recreation	1.53
Dairy and cattle farming	1.51
Local government administration	1.41
Finance	1.37
Fertilizer, petroleum and other industrial chemical manufacturing	1.34
Forestry, Logging & forestry services	1.32
Hospitals and nursing homes	1.27
Wholesale Trade	1.26
Restaurant and bars	1.25
Livestock and cropping farming	1.23
Non-building construction	1.16
Other farming	1.16
Scientific research and technical services	1.06
Services to agriculture and hunting and trapping	0.98
Horticulture and fruit growing	0.82
Personal and private household services & household employed staff	0.82
Health and dental services	0.70
Other food manufacturing	0.64
Electronic equipment and appliances manufacturing	0.60
Sewerage, drainage and waste disposal services	0.57
Accommodation	0.56
Residential construction	0.52
Post school education	0.49
Plastic product manufacturing	0.47
Non-metallic mineral product manufacturing	0.46
Legal and accounting services	0.45
Motor vehicle and part manufacturing	0.44
Motion picture, radio and TV services	0.43
University of Waikato	0.38
Fishing	0.37
Community care services	0.35
Other manufacturing nec	0.34
Structural sheet and fabricated metal product manufacturing	0.25

Computer services	0.25
Water and air transport	0.24
Other education	0.21
Insurance	0.20
Non-residential building construction	0.17
Libraries, museum and the arts	0.16
Printing, publishing and recorded media	0.14
Textiles product manufacturing	0.14
Beverage, malt and tobacco manufacturing	0.12
Services to transport	0.11
Other chemical product manufacturing	0.10
Furniture manufacturing	0.08
Veterinary services	0.08
Services to finance and insurance	0.08
Ship, boat and other transport equipment manufacturing	0.07
Clothing and footwear manufacturing	0.07
Photographic and scientific equipment manufacturing	0.04
Oil and gas exploration and extraction	0.00
Rubber product manufacturing	0.00
Superannuation fund operation	0.00

9.6 Appendix 6: Industry Contribution to Total Waikato Operating Surplus

	% Contribution
Ownership of owner-occupied dwellings	20.28
Real estate	9.68
Electricity, gas and water supply	6.90
Meat and dairy manufacturing	6.39
Other business services	4.76
Finance	4.76
Dairy and cattle farming	4.52
Industrial machinery manufacturing	4.12
Retail Trade	4.11
Construction trade services	3.94
Health and dental services	3.28
Communication services	3.08
Wholesale Trade	2.98
Legal and accounting services	2.89
Mining and quarrying	2.79
Forestry, Logging & forestry services	2.23
Sport and recreation	2.08
Residential construction	1.67
Fertilizer, petroleum and other industrial chemical manufacturing	1.40
Road and rail transport	1.37
Scientific research and technical services	1.37
Basic metal manufacturing	1.17
Restaurant and bars	1.11
Wood product manufacturing	1.08
Livestock and cropping farming	0.98
Non-building construction	0.96
Other manufacturing nec	0.95
Other food manufacturing	0.86
Non-metallic mineral product manufacturing	0.77
Personal and private household services & household employed staff	0.76
Sewerage, drainage and waste disposal services	0.68
Horticulture and fruit growing	0.67
Accommodation	0.65
Paper, pulp paper, paper board and paper board containers manufacturing	0.63
Vehicle and equipment hire	0.63
Insurance	0.56
Structural sheet and fabricated metal product manufacturing	0.55
Services to agriculture and hunting and trapping	0.51
Non-residential building construction	0.48
Plastic product manufacturing	0.41
Computer services	0.40
Other farming	0.33
Veterinary services	0.29
Other chemical product manufacturing	0.26
Motion picture, radio and TV services	0.24
Beverage, malt and tobacco manufacturing	0.22
Motor vehicle and part manufacturing	0.21
Electronic equipment and appliances manufacturing	0.18
Community care services	0.16
Furniture manufacturing	0.15

Libraries, museum and the arts	0.15
Photographic and scientific equipment manufacturing	0.15
Printing, publishing and recorded media	0.14
Services to finance and insurance	0.14
Fishing	0.14
Services to transport	0.13
Textiles product manufacturing	0.12
Hospitals and nursing homes	0.12
Water and air transport	0.11
Other education	0.11
Ship, boat and other transport equipment manufacturing	0.04
Clothing and footwear manufacturing	0.04
Oil and gas exploration and extraction	0.00
Rubber product manufacturing	0.00
Superannuation fund operation	0.00
Central government administration and defence	0.00
Local government administration	0.00
Pre-school, primary and secondary education	0.00
Post school education	0.00
University of Waikato	0.00

9.7 Appendix 7: Forward Linkages in the Waikato Region

Forward linkages in percentages (%)	
Services to agriculture and hunting and trapping	1.76
Non-metallic mineral product manufacturing	1.67
Plastic product manufacturing	1.60
Livestock and cropping farming	1.60
Road and rail transport	1.55
Basic metal manufacturing	1.54
Legal and accounting services	1.52
Other business services	1.46
Scientific research and technical services	1.45
Electricity, gas and water supply	1.40
Structural sheet and fabricated metal product manufacturing	1.37
Vehicle and equipment hire	1.30
Fertilizer, petroleum and other industrial chemical manufacturing	1.29
Other manufacturing nec	1.17
Industrial machinery manufacturing	1.12
Printing, publishing and recorded media	1.11
Communication services	1.08
Finance	1.08
Sewerage, drainage and waste disposal services	1.07
Forestry, Logging & forestry services	1.07
Paper, pulp paper, paper board and paper board containers manufacturing	1.04
Construction trade services	0.10
Other education	0.84
Dairy and cattle farming	0.83
Real estate	0.80
Wood product manufacturing	0.79
Services to transport	0.79
Fishing	0.78
Wholesale Trade	0.70
Services to finance and insurance	0.68
Other chemical product manufacturing	0.68
Mining and quarrying	0.68
Textiles product manufacturing	0.66
Non-building construction	0.61
Motion picture, radio and TV services	0.62
Horticulture and fruit growing	0.54
Insurance	0.53
Veterinary services	0.51
Personal and private household services & household employed staff	0.45
Other farming	0.45
Non-residential building construction	0.42
Computer services	0.42
Meat and dairy manufacturing	0.40
Photographic and scientific equipment manufacturing	0.30
Other food manufacturing	0.29
Libraries, museum and the arts	0.26
Motor vehicle and part manufacturing	0.26
Electronic equipment and appliances manufacturing	0.26
Water and air transport	0.20
Accommodation	0.19
Retail Trade	0.18
Health and dental services	0.18

Community care services	0.15
Furniture manufacturing	0.14
Residential construction	0.13
Post school education	0.11
University of Waikato	0.11
Ship, boat and other transport equipment manufacturing	0.10
Sport and recreation	0.07
Beverage, malt and tobacco manufacturing	0.07
Restaurant and bars	0.05
Clothing and footwear manufacturing	0.02
Central government administration and defence	0.02
Local government administration	0.01
Pre-school, primary and secondary education	0.01
Hospitals and nursing homes	0.00
Oil and gas exploration and extraction	0.00
Rubber product manufacturing	0.00
Superannuation fund operation	0.00
Ownership of owner-occupied dwellings	0.00

9.8 Appendix 8: Backward Linkages in the Waikato Region

Backward linkages in percentages (%)	
Residential construction	1.35
Non-residential building construction	1.29
Meat and dairy manufacturing	1.14
Non-building construction	1.12
Electricity, gas and water supply	1.11
Wood product manufacturing	1.09
Forestry, Logging & forestry services	0.99
Other farming	0.94
Structural sheet and fabricated metal product manufacturing	0.89
Paper, pulp paper, paper board and paper board containers manufacturing	0.84
Basic metal manufacturing	0.83
Other food manufacturing	0.81
Non-metallic mineral product manufacturing	0.79
Mining and quarrying	0.79
Sewerage, drainage and waste disposal services	0.78
Construction trade services	0.78
Local government administration	0.77
Horticulture and fruit growing	0.75
Fishing	0.75
Dairy and cattle farming	0.73
Plastic product manufacturing	0.69
Other manufacturing nec	0.65
Scientific research and technical services	0.63
Industrial machinery manufacturing	0.62
Fertilizer, petroleum and other industrial chemical manufacturing	0.62
Textiles product manufacturing	0.60
Motor vehicle and part manufacturing	0.59
Printing, publishing and recorded media	0.59
Sport and recreation	0.59
Ship, boat and other transport equipment manufacturing	0.57
Accommodation	0.57
Restaurant and bars	0.55
Other business services	0.54
Retail Trade	0.53
Livestock and cropping farming	0.53
Road and rail transport	0.52
Health and dental services	0.52
Personal and private household services & household employed staff	0.50
Services to agriculture and hunting and trapping	0.49
Libraries, museum and the arts	0.49
Services to finance and insurance	0.48
Furniture manufacturing	0.47
Wholesale Trade	0.47
Motion picture, radio and TV services	0.47
Community care services	0.46
Other education	0.46
Other chemical product manufacturing	0.46
Electronic equipment and appliances manufacturing	0.44
Central government administration and defence	0.44
Photographic and scientific equipment manufacturing	0.44
Vehicle and equipment hire	0.44
Communication services	0.43

Real estate	0.43
Services to transport	0.41
Post school education	0.39
University of Waikato	0.39
Veterinary services	0.38
Pre-school, primary and secondary education	0.31
Legal and accounting services	0.31
Hospitals and nursing homes	0.31
Clothing and footwear manufacturing	0.29
Insurance	0.26
Computer services	0.25
Ownership of owner-occupied dwellings	0.23
Finance	0.22
Beverage, malt and tobacco manufacturing	0.19
Water and air transport	0.16
Oil and gas exploration and extraction	0.00
Rubber product manufacturing	0.00
Superannuation fund operation	0.00

9.9 Appendix 9: Industry Production Multipliers in the Single Region Model

Production Multipliers by Industry	
Residential construction	3.35
Non-residential building construction	3.29
Meat and dairy manufacturing	3.14
Non-building construction	3.12
Electricity, gas and water supply	3.11
Wood product manufacturing	3.09
Forestry, Logging & forestry services	2.99
Other farming	2.94
Structural sheet and fabricated metal product manufacturing	2.89
Paper, pulp paper, paper board and paper board containers manufacturing	2.84
Basic metal manufacturing	2.83
Other food manufacturing	2.81
Non-metallic mineral product manufacturing	2.79
Mining and quarrying	2.79
Sewerage, drainage and waste disposal services	2.78
Construction trade services	2.78
Local government administration	2.77
Horticulture and fruit growing	2.75
Fishing	2.75
Dairy and cattle farming	2.73
Plastic product manufacturing	2.69
Other manufacturing nec	2.65
Scientific research and technical services	2.63
Industrial machinery manufacturing	2.62
Fertilizer, petroleum and other industrial chemical manufacturing	2.62
Textiles product manufacturing	2.60
Motor vehicle and part manufacturing	2.59
Printing, publishing and recorded media	2.59
Sport and recreation	2.59
Ship, boat and other transport equipment manufacturing	2.57
Accommodation	2.57
Restaurant and bars	2.55
Other business services	2.54
Retail Trade	2.53
Livestock and cropping farming	2.53
Road and rail transport	2.52
Health and dental services	2.52
Personal and private household services & household employed staff	2.50
Services to agriculture and hunting and trapping	2.49
Libraries, museum and the arts	2.49
Services to finance and insurance	2.48
Furniture manufacturing	2.47
Wholesale Trade	2.47
Motion picture, radio and TV services	2.47
Community care services	2.46
Other education	2.46
Other chemical product manufacturing	2.46
Electronic equipment and appliances manufacturing	2.44
Central government administration and defence	2.44
Photographic and scientific equipment manufacturing	2.44

Vehicle and equipment hire	2.44
Communication services	2.43
Real estate	2.43
Services to transport	2.41
Post school education	2.39
University of Waikato	2.39
Veterinary services	2.38
Pre-school, primary and secondary education	2.31
Legal and accounting services	2.31
Hospitals and nursing homes	2.31
Clothing and footwear manufacturing	2.29
Insurance	2.26
Computer services	2.25
Ownership of owner-occupied dwellings	2.23
Finance	2.22
Beverage, malt and tobacco manufacturing	2.19
Water and air transport	2.16
Oil and gas exploration and extraction	1.00
Rubber product manufacturing	1.00
Superannuation fund operation	1.00

9.10 Appendix 10: Industry Household Income Multipliers in the Single Region Model

Household Income Multipliers by Industry	
Pre-school, primary and secondary education	1.74
Hospitals and nursing homes	1.70
Post school education	1.69
University of Waikato	1.69
Community care services	1.68
Central government administration and defence	1.58
Other education	1.58
Personal and private household services & household employed staff	1.51
Scientific research and technical services	1.48
Veterinary services	1.46
Local government administration	1.45
Restaurant and bars	1.43
Other business services	1.42
Motor vehicle and part manufacturing	1.42
Ship, boat and other transport equipment manufacturing	1.41
Retail Trade	1.40
Industrial machinery manufacturing	1.39
Non-building construction	1.39
Wood product manufacturing	1.38
Libraries, museum and the arts	1.38
Health and dental services	1.38
Non-residential building construction	1.37
Structural sheet and fabricated metal product manufacturing	1.37
Accommodation	1.37
Services to finance and insurance	1.36
Legal and accounting services	1.36
Construction trade services	1.35
Road and rail transport	1.35
Services to transport	1.34
Plastic product manufacturing	1.34
Meat and dairy manufacturing	1.33
Residential construction	1.33
Basic metal manufacturing	1.33
Sewerage, drainage and waste disposal services	1.32
Sport and recreation	1.32
Paper, pulp paper, paper board and paper board containers manufacturing	1.32
Textiles product manufacturing	1.32
Non-metallic mineral product manufacturing	1.31
Printing, publishing and recorded media	1.31
Horticulture and fruit growing	1.30
Services to agriculture and hunting and trapping	1.29
Other food manufacturing	1.29
Forestry, Logging & forestry services	1.29
Other manufacturing nec	1.29
Mining and quarrying	1.28
Motion picture, radio and TV services	1.27
Other farming	1.26
Photographic and scientific equipment manufacturing	1.26
Wholesale Trade	1.26
Computer services	1.25

Communication services	1.25
Electronic equipment and appliances manufacturing	1.24
Fishing	1.22
Furniture manufacturing	1.22
Fertilizer, petroleum and other industrial chemical manufacturing	1.22
Finance	1.20
Other chemical product manufacturing	1.20
Dairy and cattle farming	1.19
Clothing and footwear manufacturing	1.19
Vehicle and equipment hire	1.18
Electricity, gas and water supply	1.18
Insurance	1.15
Livestock and cropping farming	1.14
Real estate	1.14
Water and air transport	1.11
Beverage, malt and tobacco manufacturing	1.07
Ownership of owner-occupied dwellings	1.04
Oil and gas exploration and extraction	1.00
Rubber product manufacturing	1.00
Superannuation fund operation	1.00

9.11 Appendix 11: Industry Employment Multipliers in the Single Region Model

Employment Multipliers by Industry	
Residential construction	3.77
Non-residential building construction	3.56
Community care services	2.80
Meat and dairy manufacturing	2.67
Horticulture and fruit growing	2.67
Non-building construction	2.64
Other farming	2.61
Health and dental services	2.61
Local government administration	2.56
Dairy and cattle farming	2.55
Scientific research and technical services	2.40
Other food manufacturing	2.26
Other business services	2.19
Personal and private household services & household employed staff	2.13
Sport and recreation	2.13
Wood product manufacturing	2.11
Plastic product manufacturing	2.02
Forestry, Logging & forestry services	2.01
Services to finance and insurance	2.01
Construction trade services	1.98
Motion picture, radio and TV services	1.95
Structural sheet and fabricated metal product manufacturing	1.95
Sewerage, drainage and waste disposal services	1.91
Textiles product manufacturing	1.89
Fishing	1.89
Other education	1.88
Livestock and cropping farming	1.84
Services to agriculture and hunting and trapping	1.81
Non-metallic mineral product manufacturing	1.76
Veterinary services	1.74
Libraries, museum and the arts	1.74
Motor vehicle and part manufacturing	1.71
Basic metal manufacturing	1.69
Fertilizer, petroleum and other industrial chemical manufacturing	1.68
Central government administration and defence	1.64
Accommodation	1.62
Restaurant and bars	1.60
Road and rail transport	1.58
Industrial machinery manufacturing	1.57
Mining and quarrying	1.50
Retail Trade	1.50
Other manufacturing nec	1.49
Wholesale Trade	1.45
Other chemical product manufacturing	1.43
Paper, pulp paper, paper board and paper board containers manufacturing	1.42
Photographic and scientific equipment manufacturing	1.38
Services to transport	1.37
Ship, boat and other transport equipment manufacturing	1.35
Hospitals and nursing homes	1.35

Insurance	1.33
Communication services	1.31
Vehicle and equipment hire	1.26
Pre-school, primary and secondary education	1.23
Post school education	1.20
University of Waikato	1.20
Furniture manufacturing	1.17
Legal and accounting services	1.16
Printing, publishing and recorded media	1.15
Electronic equipment and appliances manufacturing	1.15
Real estate	1.06
Electricity, gas and water supply	0.95
Clothing and footwear manufacturing	0.87
Ownership of owner-occupied dwellings	0.77
Computer services	0.73
Finance	0.73
Beverage, malt and tobacco manufacturing	0.68
Water and air transport	0.52
Oil and gas exploration and extraction	0.00
Rubber product manufacturing	0.00
Superannuation fund operation	0.00