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A Framework for Analysis of the Local Dependencies of a Regional Undergraduate Program

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Abstract

In regional Victoria, Australia there has been a steady decline in Information Technology graduates while large organisations within the region are experiencing a greater demand for these skill sets. What is unknown is the dependency organisations within the region have on the supply of these graduates. This paper examines potential quantitative (Rank Correlation and Markov chain) and qualitative (Importance-Performance Analysis) methods and proposes that to address this dependency the development of a framework encompassing all three methods could be used. The results will provide a more rigorous set of findings than using one method alone and could be used as an evidence base for organisational planning.

Keywords: Importance-Performance Analysis, Markov Chain, Correlation, University Graduates, Regional Organisations, Dependency Framework

Introduction

Since its application to commercial processing in the early 1950s (Shelly & Vermaat, 2010) Information Technology (IT) has infused itself in almost all industries and all aspects of organisations. As well as increasing efficiency, effectiveness and productivity within organisations, this adoption of IT has been a key driver for innovation (Australian Workforce and Productivity Agency, 2013; World Bank, 2006). It has also meant that organisations have become dependent on a supply of IT graduates to meet their skilled IT professional needs.

From mid-1960 (Cusack, 1973), organisations within the Bendigo region in Central Victoria have had a ready supply of IT graduates, but over time the number of enrolments and completions at La Trobe University, Bendigo has decreased. The graph in Figure 1 shows that since its peak in 1993 there has been a steady decline in IT graduates. Initially this downward trend was reflected nationally however the

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Department of Education, Employment and Workplace relations (DEEWR) (2013) has stated there has been improvement over the last few years (Australian Workforce and Productivity Agency, 2013). Conversely this has not been the case for La Trobe University in regional Victoria causing education planners and managers to review offering IT courses at Bendigo.

In contrast to decreasing numbers of IT graduates large organisations within the Bendigo region are experiencing a greater demand for IT professionals often resorting to consultants to fill knowledge and skill gaps. If the local university decides to cease offering IT degree courses, local organisations may find it even more difficult to employ and retain IT professionals. An investigation on the dependencies organisations have on the supply of IT graduates would be beneficial to these organisations and education providers.

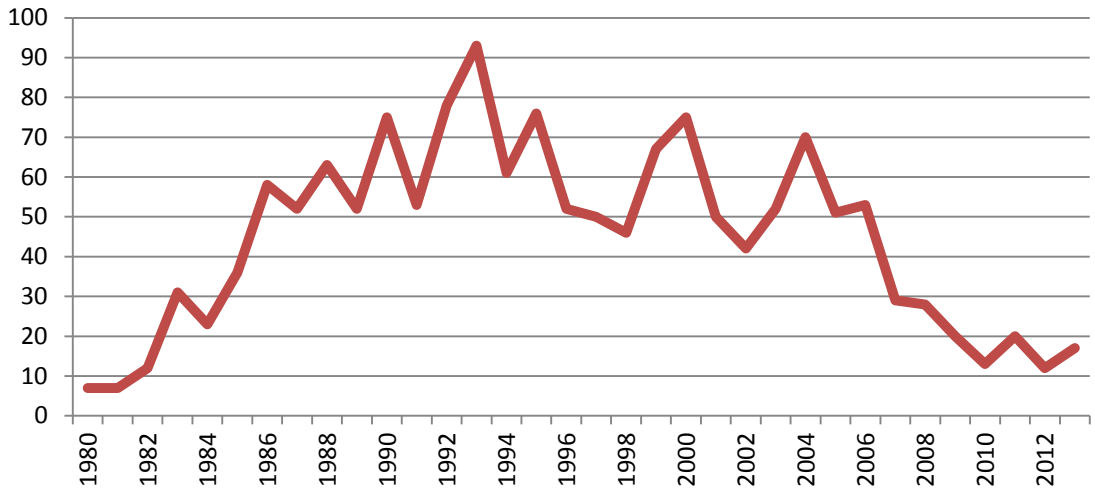

Figure 1: Information Technology Higher Education Graduates Bendigo 1980-2013 (Bendigo College of Advanced Education, 1980-1990; La Trobe University Australia, 1994-2013; La Trobe University College of Northern Victoria, 1991-1993)

The project described in this paper aims to investigate if a link exists between the availability of higher education IT graduates from La Trobe University's Bendigo campus and Bendigo based organisations that employ these graduates. The objectives of this project are:

To develop a model of the dependency of the organisation on IT graduates.

To identify the factors affecting the provision of professional or degree qualified employees within a regionally based organisation.

To develop a forecasting model to predict the organisational requirements for IT graduates.

The objectives will be addressed through the development of a new framework using both qualitative and quantitative analysis. Quantitative analysis will be performed using rank correlation and Markov chain and qualitative analysis using the Importance-Performance Analysis (IPA) method.

The next section of this paper provides a more in depth discussion of the background of the project. The third section presents the quantitative method, Markov chain, by providing an overview of the method and discuss related studies while the fourth section presents the

qualitative method, Importance-Performance Analysis. The two sections after this discuss the findings of the research and future research to be completed. The final section concludes the paper.

Background

Bendigo is a large regional city located in the centre of the state of Victoria, Australia with a present population of approximately 104,000 (City of Greater Bendigo, 2013). Bendigo has been providing tertiary education since 1873 when the Bendigo School of Mines and Industries was first established (Wallace, 1998). The current tertiary education providers in the region are La Trobe University and Bendigo TAFE.

In 1961 Business courses with various certificate and diploma qualifications were first offered and from 1964 Information Processing diplomas also became available (Cusack, 1973). Successive Bendigo based higher education institutions began offering degrees in both Business and IT from 1974, allowing businesses and organisations based or operating within the region to enjoy a ready supply of graduates. This includes one of the biggest organisations within the region, the Bendigo and Adelaide Bank.

The Bendigo and Adelaide Bank's history dates back to its birth on 9th of July 1858 as the Bendigo Land and Building Society (Mayne, 2008). It has now grown to become one of the biggest providers of employment within the Bendigo region, employing almost one thousand employees in Bendigo alone, approximately 240 of these being in IT roles (G. True, personal communication, February 28, 2013). Bendigo and Adelaide Bank is well known for its community focus, developing a Community Banking Model in 1998. The model assists communities where other banks had closed and caused significant economic problems which had an effect on other local business and their communities (Mayne, 2008).

Alongside its community focus, the Bank also has a focus on developments in information technology. Since 1995, the Bank together with La Trobe University's Bendigo campus has developed strategies to ensure the number of students graduating and staying within central Victoria remains sufficient for its needs and also nurturing an IT sector within the region. The first strategy implemented was the Industry Based Learning (IBL) scheme, a scholarship program allowing IT students to complete two 20-week work placements in the industry while completing their final year of study (La Trobe University, 2013a). The program has been running since 1995 and each year Bendigo and Adelaide Bank has offered on average, four scholarship placement opportunities (La Trobe University, 2013b).

More recently, Bendigo and Adelaide Bank and other local organisations have worked with La Trobe University to establish an IT Cadetship program. Cadets are employed directly from secondary school level of education to work in the industry and gain practical experience while completing their IT degree at La Trobe University, Bendigo (La Trobe University, 2013c). Beginning in 2012 with five positions, Bendigo and Adelaide Bank has continued to offer positions in 2013 and 2014.

In 2012 alongside the Cadetship program, the Bank also introduced a graduate program offering a minimum of two graduate positions in both Bendigo and Adelaide (S. Phillips, personal communication, August 9, 2013). This program is another strategy to recruit skilled Business and Accounting graduates to the Bendigo region.

By implementing the three strategies described above, Bendigo and Adelaide Bank has had a moderate level of success in an attempt to retain employable graduates and these skill sets within the Bendigo region. In order to assist the Bank in developing further strategies, modelling the dependency a large organisation has on IT graduates and their required supply to the region could

be carried out. For the Bank to achieve this objective, the ideal modelling framework would encompass both quantitative and qualitative methods of modelling.

Markov Chain

Overview

Markov chain is a methodology used for forecasting using a mathematical process to predict a future time using probabilities and past data (Kohut, 1986). Mathematically Markov chain is defined as:

"A sequence of random variables $X = X_0, X_1, X_2, \ldots$, *with the following properties. For* $t \in \{0, 1, 2, \ldots\}$, X_t *is defined on the sample space* Ω *and takes values in a finite set S. Thus,* $X_t: \Omega \rightarrow S$. *Also for* $t \in \{0, 1, 2, \ldots\}$, *and* $\{i, j, i_{t-1}, i_{t-2}, \ldots, i_0\} \subseteq S$

$$P\{X_{t+1} = j | X_t = i, X_{t-1} = i_{t-1}, \ldots, X_0 = i_0\} = P\{X_{t+1} = j | X_t = i\} \qquad (1)$$

and the transition probabilities

$$P\{X_{t+1} = j | X_t = i\} = p_{ij} \qquad (2)$$

are independent of t" (Chan, Lenard & Mills, 2012, p.41). All the transition probabilities can be represented as a Transition Probability Matrix (*TPM*), where $TPM(i.j) = P_{i,j}$.

Condition (1) is defined as the "Markov condition". This condition exists where the probability of the system shifting from state *i* to *j* at time *t* is not dependent on previous times (*t-1, t-2,...,0*) (Chan et al., 2012). Condition (2) exists when the conditional probability of the system shifting from state *i* to *j* at time (*t + 1)* is not dependent on *t;* therefore the transitional probability p_{ij} does not vary with *t*. Condition (2) is satisfied when the *TPM* remains constant (a time-independent Markov chain) but may not be satisfied where the *TPM* may change over time (a time-dependent Markov chain) (Chan, Lenard & Mills, 2013).

During the time period when condition (2) is satisfied equation (3) can be used;

$$\mathrm{TPM}^{(\mathrm{s})} = \mathrm{TPM}^{\mathrm{s}}. \qquad (3)$$

The set *S* contains various states that the system can change to. If the set *S* has *m* elements, then the 1-step *TPM* is a $m \times m$ matrix, where $TPM(i, j) = p_{i,j}$. The s-step *TPM,* denoted by $TPM^{(s)}$, is equal to the s^{th}power of the 1-step *TPM* when $s \geq 1$ (Chan et al., 2012).

For this research, we assume the Markov condition (1) is satisfied. Once data has been gathered it will be tested to determine if the transition probability is constant over a certain period of time. This will determine if the *TPM* can be used for short-term or long-term predictions. This model will be used for forecasting analysis and will be manipulated to determine what effects of changing probabilities will be.

The first step in the process is to determine the best time step *t* to use (Zanakis & Maret, 1980). This is indicated through the data and is important to choose the most appropriate. The second step is to identify all the states. For the project described in this paper, the time steps and states will be chosen according to the historical data available. During the analysis, additional states and time steps may also be investigated. Once these two steps have been completed, historical data is required for at least 2 consecutive time steps *t* and *t+1* to estimate the *TPM* which is then used to predict future probability values (Rowland & Sovereign, 1969).

Related Studies

Rowland and Sovereign (1969) used Markov chain to determine the flow of manpower throughout companies. As described above, they began by choosing yearly time intervals and the states that employees could be in. They then looked at historical data from two subsequent periods, took a sample of staff members and analysed movements. Absorbing states (states where an employee could move into, but not out of) were removed from the analysis and the estimated *TPM* was prepared, dividing the number of employees who moved states during the period by the number currently in each state. For future predictions, Rowland and Sovereign (1969) added the expected number of new employees during a period to what was currently employed. The probability of an employee moving states was then calculated by using matrix multiplication.

The process followed by Rowland and Sovereign (1969) highlighted some limitations. The *TPM* needed to be stable in order for it to be used for predictions. By taking data from only one period, rather than averaging over many periods meant that there was no way in determining if the *TPM* was reliable. Rowland and Sovereign also highlighted that they had minimal states for employees and to gain a more accurate measure additional classifications could have been considered. The major limitation however was the lack of testing. The accuracy of the *TPM* was not tested and could have resulted in inaccurate predictions.

Zanakis and Maret (1980) explored the Markov chain a little further by applying the method to Human Resource (HR) planning in a chemical organisation identifying the flow of staff through job positions.

Zanakis and Maret (1980) followed the same initial steps, highlighting their time periods (again yearly) and then their states. Historical data of employee transitions was obtained from the company for the last four years and the estimated *TPM* was calculated. They then used four x^2 tests to determine the stationarity of the *TPM*. The notations and equations identified by Zanakis and Maret (1980) and Anderson and Goodman (1957) are defined as follows.

At the beginning of period *t*, the total number of people in state *i* is given as

$$n_i(t) = \sum_{j=1}^{m} n_{ij}(t); \tag{4}$$

During period *t*, the ratio of employees who moved from state *i* to *j* is given as

$$\hat{p}_{ij}(t) = \frac{n_{ij}(t)}{n_i(t)}; \tag{5}$$

and at any single period *t*, the hypothesized constant (over *t*) transition probability from state *i* to *j* is given as

$$\hat{\mathrm{p}}_{\mathrm{ij}} = \frac{\sum_{\mathrm{t=1}}^{\mathrm{T}} \mathrm{n_{ij}(t)}}{\sum_{\mathrm{t=1}}^{\mathrm{T}} \sum_{\mathrm{j=1}}^{\mathrm{m}} \mathrm{n_{ij}(t)}}, \tag{6}$$

where

s: number of non-absorbing states,
r: number of absorbing states,
m: total number of absorbing and non-absorbing states,
T: number of time periods observes,
$n_{ij}(t)$: number of employees that moved from state *i* to *j* during period *t*.

The first test was to determine if the transition probability p_{ij} constant over time:

$$\sum_{t=1}^{T} \frac{n_i(t)[\hat{p}_{ij}(t) - \hat{p}_{ij}]^2}{\hat{p}_{ij}} < x_{\infty}^2[T-1]. \tag{7}$$

The second test was to determine if the transition to state *j* was stationary:

$$\sum_{i=1}^{s}\sum_{t=1}^{T}\frac{n_i(t)[\hat{p}_{ij}(t)-\hat{p}_{ij}]^2}{\hat{p}_{ij}} < x_{\infty}^2[s\{T-1)]. \quad (8)$$

The third test was to determine if the transitions from state *i* were stationary:

$$\sum_{j=1}^{m}\sum_{t=1}^{T}\frac{n_i(t)[\hat{p}_{ij}(t)-\hat{p}_{ij}]^2}{\hat{p}_{ij}} < x_{\infty}^2[(m-1)(T-1)]. \quad (9)$$

The fourth test was to determine if the entire *TPM* was constant over time:

$$\sum_{i=1}^{s}\sum_{j=1}^{m}\sum_{t=1}^{T}\frac{n_i(t)[\hat{p}_{ij}(t)-\hat{p}_{ij}]^2}{\hat{p}_{ij}} < x_{\infty}^2[s(m-1)(T-1)]. \quad (10)$$

The tests identified that some states were not stationary which were then ignored from the process however overall the *TPM* was stationary indicating as an employee moves up in seniority, the probability of them moving to a different state decreased (Zanakis & Maret, 1980). The tests also identified a limitation, that more historical data would need to give more accurate predictions for some states.

As predictions will never be fully accurate, Zanakis and Maret (1980) have highlighted some modifications to the method to improve outcomes. Combining non-absorbing states could result in a stationary *TPM* and to bring in additional states including length of service and age could result in more accurate results.

The research to be undertaken for this project will involve the development of a new framework encompassing both quantitative and qualitative analysis. The quantitative analysis will be addressed using Markov chain. The following section will address the methodology to be used for qualitative analysis, Importance-Performance Analysis.

Importance-Performance Analysis

Overview

Importance-Performance Analysis (IPA) is a method used most commonly in the service industry to evaluate a user's expectations versus experience (Ortinau, Bush, Bush, & Twible, 1989). IPA allows providers to review their services and determine if they are under-providing or over-providing areas of their services and re-allocate resources where necessary (O'Neill & Palmer, 2004).

The most common process followed is to produce a survey or questionnaire which is then distributed to potential customers and existing customers. The questionnaire reviews what customers feel is important and how well the provider performed. From the results, the importance mean and performance mean is calculated for each attribute (O'Neill & Palmer, 2004) and then the importance mean is subtracted from the performance mean. A positive value indicates the provider is meeting customer's expectations while a negative value indicates the opposite (Ford, Joseph, & Joseph, 1999). The results are plotted onto an IPA grid (see Figure 2) to give a graphical representation of areas and their performance.

Section A indicates the area where the provider is not performing to customers' expectations. To increase customer satisfaction, attention should be spent on those areas. Section B indicates the areas where the provider is performing on par with customers' expectations. Section C is where

the provider may not be performing well, but these are areas that the consumer doesn't think is important. Section D is where the provider is over-performing compared to what consumers find important. Resources should be re-allocated from this area to section A.

IPA is more commonly applied in the tourism industry, however there have been some cases where it has been used to measure students expectations of a higher education provider.

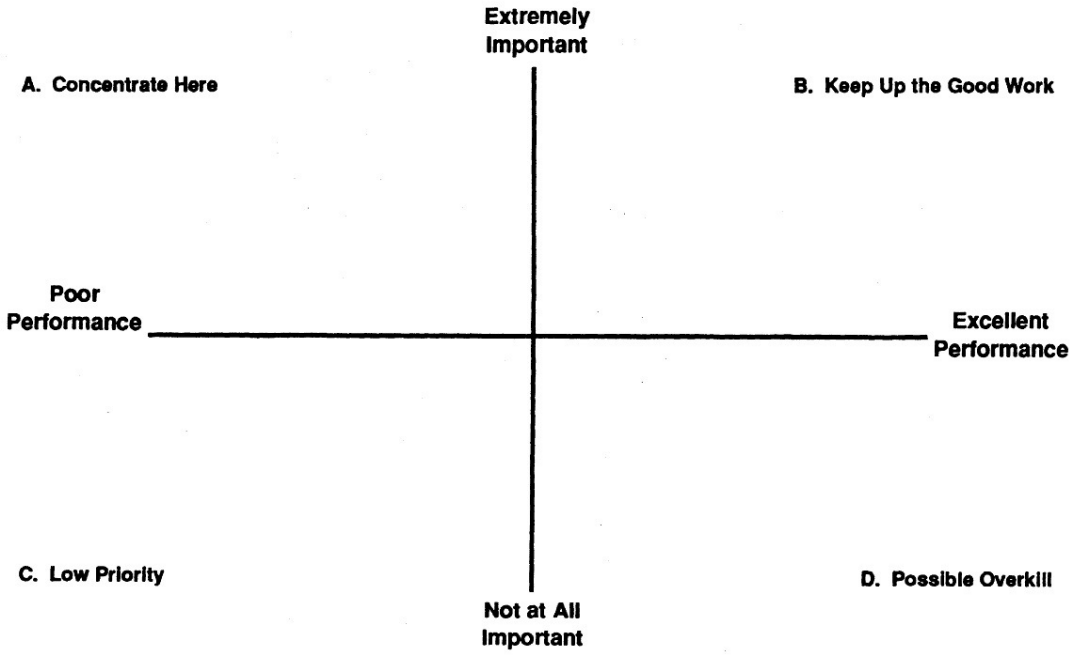

Figure 2: Traditional Importance-Performance grid (Oritnau et al., 1989, p.80)

Current Research

O'Neill and Palmer (2004) used the IPA methodology to measure students' expectations studying at a university in Western Australia and if the university met those expectations. Researchers developed a survey using the SERVQUAL (Service Quality Framework) model, a 22-part questionnaire as a template, modifying it to measure users' pre-consumptions and their post-consumption experiences. The scale items were then assessed and determined by three focus groups of current students at the university. The end result was broken into three categories; empathy, process and tangibles and was distributed to students to complete.

The reliability of the survey results was analysed by the coefficient alpha which returned high results. Importance mean and performance mean was then calculated, and subtracted from one another to determine the university's performance. Results found that students considered all services provided important, but the university lacked performance in empathy and process, the most important categories to the students.

O'Neill and Palmer (2004) identified some limitations with their research, the first being that it is unknown if these results are consistent. For this to be determined, the survey would need to be distributed over multiple years/semesters and then analysed. It would also highlight any attributes of a university that change over time.

Ford et al. (1999) used this method to analyse New Zealand and American business student's perceptions of universities. An initial survey was developed, however focus groups were formed in both countries making slight modification to the survey before distribution. Researchers distributed the survey to multiple universities across both countries to business students in their final year of study and responses were assessed separately for each country. A reliability analysis was ran over the results again and the importance and performance means were calculated. The results from New Zealand indicated that universities performed poorly against what students felt was important with the biggest problem areas being in academic facilities, cost of accommodation and the quality of instructors. The USA results were ranked in categories to highlight areas that needed the most focus, these being academic facilities, reputation of the degree, housing conditions and costs.

These results helped universities re-direct their resources into areas which the students felt were important to their experience attending the university. If a student feels the features of the university met their expectations this will increase their satisfaction at the university and increase enrolments and completions (Ortinau et al., 1989).

Findings

There has been considerable research completed on dependencies using quantitative methods and considerable research completed on dependencies using qualitative methods, however there is little research that combines both qualitative and quantitative methods. In order to meet the aims and objectives of this project and to create a more rigorous set of findings, a new framework has been developed incorporating rank correlation, Markov chain and IPA (as shown in Figure 3) where qualitative analysis will be used to analyse quantitative results. IPA results will be used to analyse and identify factors affecting the results from Markov chain then be used to manipulate the Markov chain results to find the ideal dependency.

The overall objective of the project is to identify the relationship that exists between the number of IT graduates from La Trobe University Bendigo each year and the number employed within the region. This will be addressed first using rank correlation to determine if a relationship exists between the two and how strong this relationship is. A model will also be developed using Markov chain to determine the dependency organisations within the region have on IT graduates. Factors affecting the provision of professional degree qualified employees within the region will also be identified using Importance-Performance Analysis. Finally a forecasting model will be developed to predict the organisational requirements for graduates. This will be done by using the results from both objective 1 and 2 and manipulating the Markov chain to determine the ideal dependency.

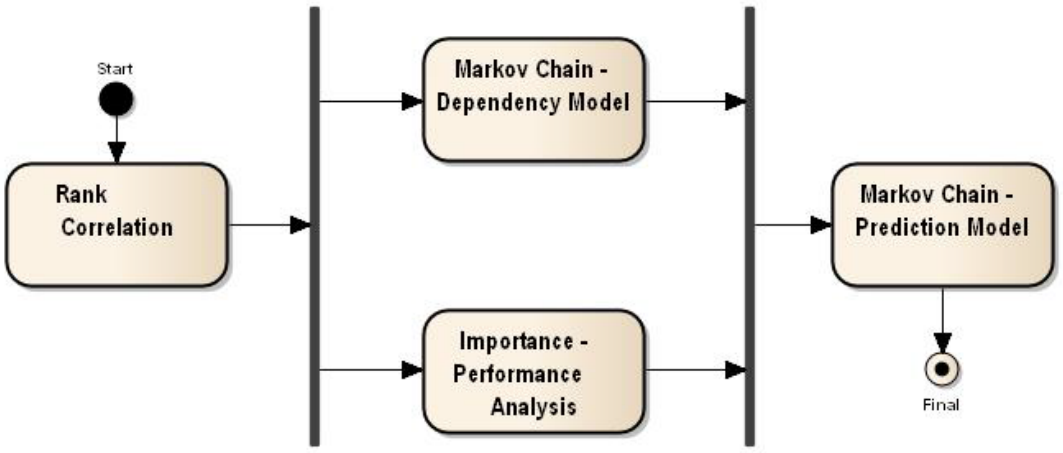

Figure 3: Proposed Dependency Framework.

Future Research

The dependency framework proposed in Figure 3 will be used to meet the objectives of this research project as highlighted in Table 1.

The framework may also identify trends in numbers of students enrolling, continuing and graduating and factors that affect their choice in universities and degrees. The framework could also be used to other similar regional areas throughout Australia. These results may assist business that are established in the region, looking to locate within the region and tertiary education planners to address the decrease in enrolments in these areas.

Table 1: Objectives and Methods of Analysis

Objective No.	Objective	Method
Overall	To establish the relationship between the number of enrolments, completions and locally employed graduates in Information Technology.	Rank correlation
1	To develop a model of the dependency of the organization on Information Technology graduates.	Markov chain – model will be tested to ensure its accuracy and stationarity and then used to determine objective number 3.
2	To identify the factors affecting the provision of professional or degree qualified employees within a regionally based organization.	Importance-Performance Analysis – developing a survey to gain all required information and analyse the results.
3	To develop a forecasting model to predict the organizational requirements for Information Technology graduates.	Markov chain – same model used in object number 2, but used to predict the future.

Conclusion

After reviewing the current literature, the ideal methodology to investigate the dependency of organisations within the Bendigo region would be the development of a new framework encompassing both qualitative and quantitative analysis. This will return a more rigorous result than using one form of analysis alone. Identifying existing correlations between the number of graduates and the number being employed within the region would be best achieved using rank correlation and Markov chain would assist in the prediction of future numbers of enrolments, completions and graduate employment within the region. To determine the skills required, numbers of required graduates and enrolments, IPA will be used. These results will identify the dependence organisations within the Bendigo region have on the supply of IT graduates from La Trobe University.

Conducting this research could potentially reveal much about the dependencies large regional organisations have on IT skill sets and assist with their future human resource planning.

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Biographies

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Ka Ching Chan received his BASc in Engineering Science and MASc in Mechanical Engineering from the University of Toronto, Canada, and his PhD in Manufacturing Engineering from the University of New South Wales, Australia. He was previously a Senior Lecturer at the University of New South Wales, and a Visiting Assistant Professor at the Hong Kong University of Science and Technology. Dr. Chan also had extensive industry experiences as founders and CTOs in growing technology companies from startups to public companies. Dr. Chan is currently a Lecturer in Information Technology at La Trobe University and a Visiting Fellow in Mechatronics at the University of New South

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