STATISTICS EDUCATION WITHIN RESEARCH METHODS TEACHING

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Business Management Masters' students require courses in research methods to help them in their future careers and for the immediate task of carrying out research for their dissertation. The students often have limited statistical and numeracy skills and are wary of evidence based projects preferring desk based research or case studies. However those who do collect primary or secondary data gain considerably in depth of understanding of the subject matter and acquire confidence in collecting and extracting meaning from data. Statistics education is made more business oriented by using real-life data. Reviewing real research projects shows statistics in context. Exploring relevant open data encourages students to think creatively and instils confidence in carrying out practical data analysis thereby increasing their employability.

INTRODUCTION

Business management students tend to have extremely diverse backgrounds and this is reflected in their numeracy experience and capability. Nevertheless, all need to succeed in core compulsory modules on quantitative methods and have an understanding of the statistical and data analytical techniques referred to in scientific papers so that they can appraise them and decide whether or not to trust the findings. Many of the students will proceed to a dissertation in which they collect primary data or analyze secondary data. Even those who choose to do a review or opinion based dissertation can benefit by including analysis of available open data to support their findings.

The approaches students typically have to quantitative methods courses vary from an interest in deep learning to being achievement based (Bilgin, 2010). Even those who are focused purely on achieving a pass in the module generally have a desire to understand and are open to being persuaded to the value of statistics. This willingness to learn about statistics has been aided by the growth in visibility of data science and the importance of the digital economy with which all students are familiar.

To capitalize on the students' inherent openness to the value of statistics and data, we base our teaching on case studies from real business research and consultancy. This has many advantages including credibility and data that has all the rough edges and issues that students need to face and know how to deal with. It is satisfying for the teacher to be able to share research findings and it is a requirement of some research funding that findings are fed back into academia.

It is to be hoped that students learn some statistics and appreciate its value by the end of the module. To this end, we invite students to complete a pre-module questionnaire which helps to ascertain the level of the students before the first session. Their responses are compared with a post-module questionnaire to see if there are changes in confidence and understanding. These activities are incorporated into the teaching as examples of gathering data.

STUDY BACKGROUND

The study is based on a 10 credit research methods module with 21 contact hours of teaching carried out in semester 1 for Master's students of Advanced International Business Management. The module has been delivered for 5 years from 2013 to 2017. The aims of the module are to introduce students to quantitative research methods used in organizational analysis and management research and writing, and to explain commonly used statistical terms and methods, demonstrate how to interpret findings and provide students with the knowledge and skills to critically appraise research methodology. Topics to be covered include research objectives and contexts appropriate to the use of quantitative research methods; scientific method; sampling strategies and issues; development and validity of measures; survey of advanced statistical methods for discovering associations between variables; correlation and regression.

The statistics education is facilitated by using case studies and data from over 20 years of research and consultancy experience (Ahlemeyer-Stubbe and Coleman, 2014, 2018). Effective use of quantitative research methods is illustrated through guided reading of research papers drawn from several disciplines in management and social sciences.

METHODOLOGY

Data are provided from real projects in retail, utilities, shipping, assistive technology, retirement planning, social housing and automotive after sales. Some of these projects are two year knowledge transfer partnerships (KTPs) part funded by Innovate UK (67% funding for SMEs and 50% funding for larger organizations). In these KTPs a graduate research associate is employed by the University and supervised half a day a week by an academic whilst working full time at the partner company premises and following the company's work practices and culture. KTPs benefit from the overall guidance of skilled KTP managers working for the part funder.

Statistics education in specific areas is carried out in the following ways:

- Questionnaire design via pre and post module surveys
- Reproducibility via review of the Minneapolis Domestic Violence Experiment
- Hypothesis testing via practical in-class data collection and simulation
- Graphical and statistical exploratory data analysis by looking at survey questionnaire data
- Multivariate statistical analysis and machine learning methods using retail sales data
- Use of open data and its integration with company data via a monetization scenario
- Appraisal of research papers via a set paper with limitations and a contrasting paper of their choice

Reproducibility

In the 1980's US women's advocacy groups were calling on police to take domestic violence more seriously. In response the Minneapolis Domestic Violence experiment was undertaken to compare 3 ways of handling cases. The conclusions were that arrest was the most effective and new guidelines were put in place across several states (Sherman and Berk, 1986). However, when the experiment was later replicated the results were not conclusive. Altogether, the five replication studies produced mixed results, with three studies finding that offenders who were arrested experienced higher levels of reoffending. The other studies showed a modest but statistically significant reduction in re-offending for those arrested. In teams of three, the students are asked to present their views on why the results were not reproducible.

Simulation

To help students to understand what hypothesis testing is all about a simulation is carried out to demonstrate the Mann Whitney test. Students always like creating their own data (see, for example, www.censusatschool.com) but it is not obvious what data to collect (Turner, 2006). A variety of data has been collected during this course in the past including the width of the hand (to test against the standard "hand" measure used to indicate the size of a horse), the length of the middle joint of the forefinger (to test against the Imperial standard "inch" measure which is equal to 25.4mm) and the distance from tip of nose to hand in outstretched arm (to test against the Imperial standard "yard" measure equal to 0.91m). Height, however, is the easiest, least intrusive measurement and is usually non-controversial. Height vs sex gives a reliable difference and as a contrast height vs season of birth can be used; season can conceivably be related to season but usually shows no relationship. Group sizes by sex are known before data collection but season of birth is only known after data collection, which is an interesting observation.

The following hypotheses are stated and significance level is set to 0.05.

H0: heights do not differ by sex/season of birth

H1: heights differ by sex

H2: heights differ by season of birth

A simple simulation was used to demonstrate the concept of unusual results and statistical significance (see Appendix for details).

Exploratory data analysis

In the course of carrying out consultancy with business and industry a lot of data is collected. If this is suitably redacted it can be used for the students to work on. One such data set is retail sales in a clothes catalog company (Coleman and Smith, 2007). A survey was administered in Hong Kong and UK to determine retirement plans and factors that affect them (Monness et al, 2015). These two data sets in particular provide students with the opportunity to explore complicated relationships, often involving moderating and mediating variables.

The difference between counts and measured data proves to be challenging for all levels of students. Decision tree analysis provides a useful method of analysis as it involves t-tests when the target variable is continuous and chi-square when it is categorical. Decision trees give additional information to multiple regression because of the interactions that are revealed.
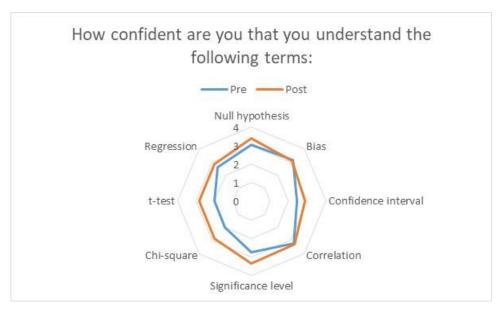
Open data

To encourage creative thinking a real-life case study focuses on a letting agency with clients who are landlords letting houses to students. The question is how to use the data that landlords and agency have to improve the business in terms of more assured lettings and satisfactory rents. The agency has 10 years' worth of data including location and characteristics of rental properties, rents, personal details of the students renting, their complaints, and records of their payment behavior. The current service level is limited to advertising properties, interviewing students, agreeing contracts, carrying out repairs and collecting rent. Students are asked to consider the insight that can be gained from the company data and the open data that can be integrated with the company data to give added value for the landlords. The final question is how to determine what insight the landlords would pay for.
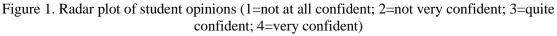
Appraisal of research papers

Students are asked to study a business research paper (Namukasa, 2015) and describe it in terms of its aims, hypotheses and methods; comment on the analysis including the statistical tests used and the results found; comment on the strengths and weaknesses of the research and give 2 suggestions how it could be improved. As a contrast, they are then asked to identify a business research paper that they have found interesting and note how it compares to the set paper.

RESULTS AND FINDINGS

The results from the pre and post module questionnaire conducted online using *Question pro* show a pleasing improvement in confidence with using statistical methods (see Figure 1).

Figure 1. Radar plot of student opinions (1=not at all confident; 2=not very confident; 3=quite confident; 4=very confident)

The Minneapolis Domestic Violence experiment lends itself to in depth analysis in a number of directions. The survey instruments and data are available from the authors of the report for independent statistical analysis. Students can consider issues of sampling, bias, training of data collectors, influence of changing populations, operational definitions, knock-on effects and implications from taking action on the basis of statistical analysis.

Class data was collected including height, sex and date of birth. There were 6 females and 8 males. The empirical distribution of Mann Whitney U values for groups of size 6 and 8 was based on 40 simulations providing values of U calculated for the smaller group (see Figure 2). The distribution was used to test the significance of U (= 6) derived from the heights in the class by sex and a second distribution was used to test heights by season of birth (summer or winter) with 7 people in each group. The Mann Whitney test showed a significant difference in height by sex but not by season of birth.
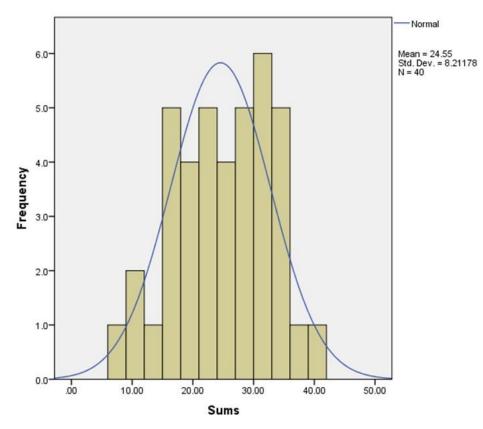

Figure 2. Simulated distribution of U values (rank sum in group of size 6 minus 21)

Allowing students a free reign to explore data leads to some interesting insights. For example, looking at the survey to determine retirement plans and factors affecting them it was noticed that the spread of responses was generally wider in the UK than in the other country where responses were collected (see Figure 3). This raised the possibility that UK people are more willing to express more extreme values.

A wide range of relevant open data was found for the housing task including police crime data (police.uk, 2018) and liability to flooding. Insight included ideas for attracting and retaining students such as putting in bicycle racks, advertising increased security in areas with higher crime rates, comparing rents achieved with property value (gov.uk, 2018). Open data provides many opportunities for business (Coleman, 2016).
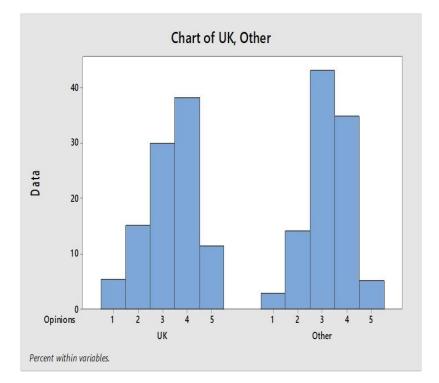
Figure 3. Wider spread of responses in the UK than in the other country.

Students found a wide variety of papers for comparison with the set paper, for example Rodger et al (2015) which reported an interesting designed experiment in Australian tourism. Designed experiments are not so common in the service sector (Antony et al, 2011) and so this was a useful find for future teaching.

DISCUSSION AND CONCLUSIONS

One pervading and persistent issue is whether it confuses students to work with multiple data sets instead of using one single case which they study throughout the module. Students have varying backgrounds, interests and future plans and so each will have their preferences for different case studies, hence it seems preferential to include a variety. There are considerable advantages in using simulated data but it lacks the power to convince the students of the real importance of data. It is also tempting to use standard data sets from textbooks, see for example Collis and Hussey (2013) or websites such as the UCI Machine Learning Depository and these have the advantage of being used by other groups and being well described.

Some industry employers are dismissive of statistical methods taught using fictitious examples and many innovative ways have been devised to teach subjects such as design of experiments in as meaningful a way as possible. Some students want more theoretical background but there is not enough time to deal with this in such a way as all the class will gain something from it. A compromise is a simulation to demonstrate the non-parametric Mann Whitney test which only requires familiarity with spreadsheets which is a necessity anyway for a business career.

Students complete standard evaluations of the module provided by administration for submission to UK quality control of universities. The students are generally happy with the course and find the case studies interesting and a good motivation for learning. Even if some students find the statistics methods difficult during the course, they find that the course helps when they encounter statistics in other modules and when they do their dissertation. The proof of the benefit of the practical focus of the teaching is illustrated by the choice of dissertation and the frequent use of data analysis and statistics which are often at a higher level than that taught in the course.

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APPENDIX

Estimate the Mann Whitney U score distribution from simulated data as follows:
- Set group sizes and generate uniform random numbers for members of each group
- Rank the numbers regardless of group membership
- Sum the ranks separately for each group
- Calculate U by subtracting (group size x(group size+1)/2) from the rank sum
- Repeat at least 40 times and note the mean and standard deviation

Carry out the Mann Whitney test as follows:
- State the null and alternative hypotheses and set the significance level
- Collect data and calculate Mann Whitney U score
- Determine the probability, p, of finding a score of this size or more extreme using the Normal approximation to the U score distribution.
- For a one-sided test, reject the null hypothesis if p is less than the significance level and for a two-sided test, reject the null hypothesis if 2xp is less than the significance level.