

Undergraduate Award – Previous Winners

- [2023](#) – Katie Jenkins
- [2022](#) - Manisha Gupta, Mathew Cohn, Fraser Maclean, Benjamin Malcolm, Josh McKay and Sharon Ross
- [2021](#) - Nikolaos Constantinou, Joel William Harris and Katie Robb
- [2020](#) - Oliver Cumberbatch
- [2019](#) - Elizabeth Williams, Nico De Oliveira,
- [2018](#) - Jacob Curran-Sebastian, Louisa James, Hristo Dobrev, Sam Ball, Emma Roberts
- [2017](#) - Anthony Luciani, Ffion James-Hargreaves
- [2016](#) - Archie Rees

Citation for The OR Society Undergraduate Award 2023

Katie Jenkins, University of South Wales

Following her graduation from USW in Mathematics, Katie plans to start a PGCE at the Open University to pass on her passion and knowledge of mathematics and its applications to inspire the next generation of mathematicians, statisticians, and data scientists.

SYSTEM DYNAMICS MODELS OF ECOLOGY

This project investigates system dynamics models of ecology under the theoretical assumption of James Lovelock's 1972 Gaia Hypothesis (2016), i.e., that the sum of life on Earth comprises a single mortal organism, which can live only while solar energy falling on the planet is below a certain level. Watson and Lovelock's (1983) Daisyworld, a hypothetical simplification of Gaia, is taken as a basic ecological model and reproduced using system dynamics. Daisyworld is then extended to include herbivores (prey) and carnivores (predators) to create a complete biosphere model, using and adapting the Lotka-Volterra predator-prey (Lotka, 1910) equations. The effect of internal changes to parameters on the behavior of the biosphere is examined. External influences such as plant plagues, ice ages, and global warming are also investigated. Though limited in its real-world applications, this research can demonstrate interactions between flora and fauna and the effects of global temperature, allowing parallels with and further understanding of Earth's contemporary issues with global warming. The research demonstrates the importance of flora, with adaptive albedo properties, to life on Earth and that even a small planetary temperature increase can cause a considerable decrease in a planet's lifespan.



Citations for The OR Society Undergraduate Award 2022

Manisha Gupta, University of Warwick

Following graduation from her degree in Mathematics, Operational Research, Economics and Statistics (MMORSE) Manisha will be joining the MSc Business Analytics programme at the University of Durham, followed by a CDT programme for implementing Operational Research and Statistical Techniques to solve business problems.

VISUALISING A BUSINESS DASHBOARD FOR BIRTELLI'S

A business dashboard is an interactive and powerful analytics tool performing various functions such as heat maps, statistical analysis, data mining and predictive analysis. This project implements Operational Research techniques to build a business dashboard for a pizza company called Birtelli's. Analysis focuses on using the company data set to study the customer behaviour and demographics. It also develops pricing models for the company by exploring different versions of the ϵ -greedy algorithm, the Iterative Least Squares algorithm and Thompson Sampling. Comparison of these models are made based on achieving optimisation over an arbitrary number of plays. This project also develops semantic analysis for customer reviews. Topic modelling is performed to quantify the relationship between the rating score and the qualitative text data by visualising text in a high dimensional space. These tools are implemented in R and recommendations are made for assembling the tools into a dashboard.



**Mathew Cohn, Fraser Maclean, Benjamin Malcolm,
Josh McKay, University of Strathclyde**

The overall best dissertation from students at the University of Strathclyde was a group project by four students. Since graduating some of the students have secured graduate positions in banking and business analysis. One student is working with a start-up business, whilst the other is taking some time to travel before applying for analysis / consulting roles.

**MODELLING THE FACTORS INFLUENCING AI-RELATED
BUSINESS DECISIONS**



The problem domain of the investigation presented in this group dissertation is the applicability and adoption of Artificial Intelligence (AI) within an enterprise context. In particular, the research aims to provide business practitioners with an understanding of how to increase the likelihood of AI project successes. Additionally, given the relative recent emergence of the AI field, this research intends to map more of the less known AI territory. The research question surfaced after conducting the whole research:

How do the factors influencing AI-related business decisions relate to one another?

A review of the literature related to AI adoption within a business context revealed that there is no one-size-fits-all method to successfully adopt AI, yet there are universal considerations that can help businesses make informed decisions around implementation. The intersection of the most pervasive AI challenges and common success characteristics highlight that a lack of commitment and attention to factors including data quality, AI strategy and organisational learning can lead to project failures. Moreover, the literature reviewed suggests that AI success stories frequently feature technology-embracing businesses that are enthusiastic about experimenting with AI in various contexts. However, many perceive the use of AI as experimental (and associate risk) and while certain aspects are, many of the core technologies have been around for several decades.

In an attempt to address the problems found in practice not covered by the literature, the research investigates the thoughts and opinions of expert practitioners from four sectors of interest concerning AI use. Semi-structured interviews with experts from sectors integral to modern societies were undertaken, namely the: (i) financial, (ii) legal, (iii) healthcare and (iv) manufacturing sectors.

Sharon Ross, University of South Wales

Following graduation from her BSc degree in Mathematics, due 2023, Sharon plans to work as a Business Analyst.

OPTIMISATION THROUGH LINEARISATION: APPLICATION OF THE KNAPSACK PROBLEM TO MAXIMISE PROFITABILITY OF BUNDLED ITEMS SALES

The "knapsack problem" refers to the commonplace problem of packing the most valuable or useful items in a limited space with constraints without overloading the knapsack. The concept dates to the early works of Tobias Dantzig (2007).

This project investigates the application of the knapsack problem with regards to product distributions for businesses to optimise profit. Initially, various applications of the knapsack problems are described, ranging from its use in financial investment decisions, energy management and discount shopping strategies, the latter of which motivates the main goal of this investigation.

The theory that underpins the solution method is then developed. In particular, it is noted that requiring integer solutions necessitates the use of optimization software to efficiently answer larger scale practical problems.

The theory is subsequently applied to a bundling marketing strategy to create combinations of products in such a way as to maximise profits while adhering to limitations placed on the bundle, such as its size, weight, or value.

A subset of products sold by an online retailer that specialises in importing, exporting and distributing are selected to create a virtual store. These items are drawn from a range of product lines including "health & beauty", "arts & crafts" and "back to school". Information on item characteristics, such as individual cost, dimensions and weight, are entered on spreadsheets. These spreadsheets are exported into the optimization package Xpress where software tools are implemented in such a way that allows a non-specialist to use the program. Specifically, bundles of products that maximise the sale profit when the overall bundle dimension / weight is taken into consideration are produced.

The overall solution package combines the requirements of commerce and industry, (namely that the tools are simple and efficient to use and manage) with the rigour of advanced mathematical techniques (that is, the correct answers are produced). Specially, the easy-to-use front-end system allows easy management and updating of inventory items while the complex back-end system calculates the optimal solutions given the specified constraints.

Citations for The OR Society Undergraduate Award 2021

Nikolaos Constantinou, University of Warwick

Following graduation from his degree in Mathematics, Operational Research, Economics and Statistics (MMORSE) Nikolas will be joining the CDT programme in Statistics at the University of Warwick with the aim of contributing in research on Mathematical Finance.

Option pricing and hedging with execution costs and market impact

Option pricing theory often relies on frictionless market assumptions, where illiquidity and volume of trading have no impact on prices, and so agents are price takers. The prime example is the Black-Scholes equation which admits an explicit solution for the price of a vanilla option, as well as for the optimal strategy, known as the Black-Scholes Delta. However, in practice, options cannot be perfectly hedged, among others, because of the presence of execution costs and market impact during the trading process. We therefore incorporate frictions of this sort, which are based on the so called Almgren-Chriss framework. On the other hand, the Almgren-Chriss framework deviates from the conventional log-normal stock price dynamics as it assumes Gaussian evolution instead, so that this gives rise to the second model in our study. Our problem, in both modelling approaches of the underlying, is concerned with pricing vanilla options with a given nominal, and stresses indeed the departure from the perfect market setting in terms of both option prices and hedging strategies, whose derivation relies on numerically solving relevant PDEs via a splitting technique.



Joel William Harris, University of South Wales

Following graduation from his BSc (Hons) Mathematics Joel's plans to pursue further education and research in OR and data science.

A data science approach to investigating waiting times in Welsh Health Boards

Within this project Joel set out to gather and use data to investigate waiting times across Welsh Health Boards. This involved what factors contribute to changes in waiting time, how it varies between health boards and whether there is a difference between South Wales and the Rest of Wales. He did this by collecting and processing admissions data from the Annual PEDW Data Tables (Wales [2020a]) and population data from Stats Wales (Wales [2020b]). He then conducted exploratory and statistical analysis, feature engineering and finally regression model fitting. From statistical analysis he found that Powys Teaching Health Board significantly different waiting times from all other Welsh Health Boards ($p \leq 0.05$), and there was a significant difference in waiting times between South Wales and the Rest of Wales ($p \leq 0.05$). Regression model fitting led us to create a random forest regression model that predicts mean waiting time for the majority of our unseen data to within 10 days, and told us that the percentage of population between age 0 and 14 is the most important factor in predicting this followed by the percentage of admissions that are female, the percentage of admissions that are emergencies and the mean age of patients.

NHS Wales. Pedw data online, 2020a.

URL: <https://nwis.nhs.wales/information-services/welsh-data-hub/pedw-data-online/>

Stats Wales. Stats wales data catalogue, 2020b.

URL: <https://statswales.gov.wales/Catalogue/Population-and-Migration/Population>

All code used to produce the results within this project can be viewed via github at:

https://github.com/joelharris1999/Final_year_project



Katie Robb, University of Strathclyde

Following graduation from her BA Business Analysis & Technology at the University of Strathclyde Katie plans to join a Technology Analyst rotational graduate scheme.

Clocking in From the Couch: An analysis of the impact of the Covid-19 induced shift to remote working on the mental wellbeing of the working population.

This project has been completed with the aim of understanding how the shift to homeworking because of the Covid-19 outbreak, has negatively impacted on the wellbeing of the working population. The researcher focused on technology-induced stress and its relationship with remote workers due to its relevance within society today. The literature review provides an insight into previous studies focused on teleworking and the role of videoconferencing technologies. This study is evaluative and exploratory, with semi-structured interviews chosen as the primary means of data collection. The collected data was analysed using a thematic approach, and the seven themes identified were then compared and contrasted with studies discussed within the literature review. Overall, findings suggest that remote workers suffer from overwork, weaker workplace relationships, and blurred boundaries between their work and personal life. Technostress has a direct relationship with age and has been exacerbated through excessive use of videoconferencing platforms during the pandemic. Findings suggest that remote working will become standard practice in the future, but there remains a need for a collaborative, flexible and optional office space. To improve the work-life balance of remote workers, a routine is encouraged, as well as identifying and exploring new avenues for employees to socially interact. However, this topic is of a recent nature, and therefore, additional research is recommended.



Citations for The OR Society Undergraduate Award 2020

Oliver Cumberbatch, University of Warwick

Calculating the Value and Exercise Thresholds for Compound Forward-Start Options with an Application to Conservation Area Payments at the University of Warwick

This project investigated the effectiveness of land conservation techniques landowners are subjected to third parties, and analysed the likelihood of the landowner exercising them. The project not only studied the idea of reversibility, but viewed the problem from the perspectives of the different parties involved. Option theory, random (stochastic) patterns and dynamic programming were all used in this project. The results of the study show that the decision a landowner makes changes drastically depending on the conservation technique. Adding reversibility as an option also increased its value. The findings from the perspective of the third-party show that the choices they make about the option they offer to the landowner also affect the payoff.



Citations for The OR Society Undergraduate Award 2019

Elizabeth Williams, University of South Wales

Following graduation from her [MMath Mathematics](#) course at the University of South Wales, Elizabeth has successfully gained funding to study for a PhD in the OR Group at the School of Mathematics, Cardiff University.

Operational Research techniques applied to Healthcare

The research conducted within this project investigates the use of Operational Research techniques and their application within healthcare services, focusing on two case studies; cancer waiting times within NHS England and Wales, and Accident and Emergency attendances within the Aneurin Bevan University Health Board.

Cancer diagnosis within the UK is increasing, with one in two people expected to be diagnosed with cancer within their lifetime. This statistic highlights the need for a quick diagnosis, to allow treatment to commence for a higher survival rate of patients. Survival rates of different types of cancer were firstly examined by stage of diagnosis in order to ascertain the need for short waiting times. Performance of NHS Trusts and the waiting times for different types of cancers were compared to targets set by the UK Government, to determine the exact location within the patient pathway where the targets are failing to be reached. A variety of data sets were acquired for this research from the following sources; Welsh Cancer Intelligence and Surveillance Unit, NHS England and NHS Wales.

The second case study focuses on patient pathways, examining Accident and Emergency attendances within the Aneurin Bevan University Health Board. The case study involved collaboration with the Aneurin Bevan Continuous Improvement team, with regular progress meetings and presentations required to be given on the results discovered from the data provided. Different patient pathways through Accident and Emergency were identified, and their associated trends of LOS and outcomes examined. The results produced, determine the patient categories which are more likely to be admitted, suffer mortality and have a longer length of stay as a result of attending an Accident and Emergency department.



Nico De Oliveira, University of Leicester

Following graduation from his BSc in Mathematics with Management, Nico will be pursuing a Masters in Finance and Investment at University of Loughborough, starting September 2019. Nico's long term aim is to start a career in the financial sector.

The analysis and future use of discounts for the Leicester Riders Basketball team.

This project involved working with the Leicester Riders basketball team to optimise the use of discount offers regarding game tickets, based on information on every ticket sold over the last season. The project identified optimal discount types and the games at each type should be applied, and also identifies the optimal times to offer discounts. For example, it identified those games at which it would be most beneficial to offer 'first timer' discounts; and for previous attenders it identified which types of discount would be most likely to generate increased sales. It also identified lists of customers eligible for given discounts, generates a timetable for future use of discounts and compares statistics for multiple different discount types. The results are implemented in Python code that can be used by the Leicester Riders ticketing and marketing teams in order to generate lists of eligible customers for given discounts in future. There are some aspects of the project that still need to be developed, and further analysis of the current season's data could lead to more accurate results, but the initial objectives of the project have been achieved.



Emma Roberts, University of Strathclyde

Following graduation from her BA (Hons) degree in Business Analysis and Technology, Emma will continue to work with SIMUL8 as a Product Developer.

Metrics and Insight: How SIMUL8 measure software success and embed user insight”

SIMUL8 is a software company which specialises in discrete event simulation for businesses, universities and individual users. The aim of this project is to improve the feedback process of SIMUL8 by developing processes to help them measure the impact of their releases and utilise customer feedback into their quarterly software releases. To achieve this aim, measures (metrics) of impact for every software feature released in their upcoming software releases have been researched and developed. Furthermore, a centralised feedback location was developed for SIMUL8 to store qualitative customer feedback they receive on their quarterly software releases, SIMUL8 features and market trends.

This project is divided into two mixed method phases: Quantitative Feedback and Qualitative Feedback. For the Quantitative Feedback phase, a Goal-Question-Metric (GQM) session was held to gather the metrics needing to be measured for the quarterly release. After this, the second stage gathered the data on these metrics defined by the GQM session and a questionnaire was sent out to users to gather additional metrics whilst also aiming to validate the metrics already gathered. For the second phase, Qualitative Feedback, the first stage involved group interviews regarding the idea of customer feedback and a central feedback location. Once this was completed, a Multi-Criteria Decision Analysis model was used to find the most optimal feedback location.

The project concludes by offering final recommendations which include: continuing to gather metrics which were defined in the GQM session, more specifically engagement metrics, continuously collect NPS score, develop prioritisation processes for technical feedback and use their current CRM software to store customer feedback.



Citations for The OR Society Undergraduate Award 2018

Jacob Curran-Sebastian, University of Manchester

After recently graduating from [MMath Mathematics](#) at the University of Manchester, Jacob is now preparing the work from his dissertation for publication. Besides this, he is applying for PhD positions with the intention to pursue a research career.

Lie algebraic methods for solving time-inhomogeneous Markov chains

Markov chains appear in a wide range of contexts in mathematical biology, and have been considered, for example in epidemiology (House, 2012, 2015; Keeling & Ross, 2008) and in the modelling of ion channels (Epstein, Calderhead, Girolami, & Sivilotti, 2016; Colquhoun & Hawkes, 1981). In some cases, these processes have been assumed to be independent of time, largely for convenience. However, such assumptions need not be made, and indeed it is possible to derive a solution of the time-inhomogeneous system in cases where it is possible to exploit Lie algebraic methods to obtain matrix exponential solutions. Once these solutions have been obtained, there exist a number of numerical methods for approximating the resulting matrix exponentials (Moler & Van Loan, 2003; Higham, 2008), which can offer significant computational advantages over the standard methods for numerical integration.



Louisa James, University of South Wales

Following graduation from her [BSc Mathematics](#) course at the University of South Wales, Louisa is now applying for data analysis roles in industry linked to OR in Healthcare.

The University Timetabling problem

One common problem facing the higher education industry is that of obtaining a timetable of core events that satisfies both the students and staff in the work place as well as sustaining the policies and protocols of the establishment. This report aims to tackle this problem using a range of heuristic based methods and seeks to improve on the previous model at each stage of the analysis. T

he original problem is reduced by characterising constraints as hard and soft, and prioritising where necessary to allow for the utilisation of optimisation software. A procedure to solve this reduced problem is coded into the software to generate an optimal timetable solution. Introducing new factors and constraints into the problem and exploiting the available course data provided by the University of South Wales allows the construction of a more realistic solution. Modifying the original data set to produce a group of central events, while considering additional constraints representative of real-world limitations enables the formation of a more accurate timetable.

Further improvements to the program using local search methods and evaluating the feasibility of the problem facilitates achievement of the optimum solution, scheduling all required sessions and accomplishing the original aim of the project. The report establishes additional aspects to be considered in the future to expand on the solutions, and eventually action the findings in practice.



Hristo Dobrev, University of Leicester

Following graduation, Hristo is planning to set up his own business. He believes that what he has learned in the operational research module of his [BSc Mathematics](#) course at the University of Leicester will be invaluable in providing him with a lot more ways to optimise any future business potential.

Risk Appetite

The aim of this project was to identify the optimal level of risk that Nottingham Credit Union should accept when making loans.

No loan is without risk, so if the credit union takes no risk it will make no loans and receive no loan interest. However, if it takes too much risk, the bad debt will outweigh the interest received on loans that do repay. It follows that between these two extremes there lies a level of risk that maximises net income (interest received less bad debt costs incurred).

There were two main parts to the project. The first was to find a way to identify the level of risk associated with making any particular loan. This was done analysing all the credit union's loans made over the previous three years to identify the factors that increased or reduced, by using logistic regression. The second part was to examine all loan applications received to identify the risk associated with each, using the regression model, and from this to calculate the expected net income at each level of risk. Logically, the credit union should make all loans on which the expected return is greater than zero so this gives the maximum level of acceptable risk and from this the average level of bad debt can be calculated.

The calculations need to be repeated for each level of interest rate charged by the credit union, as the interest rate affects the risk/reward balance for a loan.

All aspects of the project were successfully completed. The results indicated that the credit union's risk appetite was marginally too low, and that it should seek to improve its profitability by taking on marginally riskier loans than had previously been the case.



Sam Ball, University of Liverpool

After graduating from [MMath Mathematics](#) at the University of Liverpool, Sam plans to continue learning about OR through a PhD and carry this learning through to a career in consulting or management.

Integer Linear Programs

Integer Linear Programs (ILPs) are more complicated than Linear Programs over the rational numbers (LPs) since the Simplex algorithm (with quadratic average-case complexity) can no longer be applied, and the ILP problem is known to be NP-complete. In this project, we build on ideas from LPs to look at current methods of solution for ILPs. Whereas LPs have unique shadow prices, ILPs do not; they instead have dual price functions that only have to satisfy certain realistic constraints. It turns out that the structure of these dual price functions corresponds to the choice of solution algorithm. Our discussion of these results is largely based on the work of Wolsey [1]. We also discuss applications of this result, as well as recent developments and open problems in this area.

[1] L. A. Wolsey. Integer Programming Duality: Price Functions and Sensitivity Analysis. Mathematical Programming 20.1, 1980.

Citations for The OR Society Undergraduate Award 2017

Anthony Luciani, University of Leicester

After graduating from [BSc Mathematics](#), Anthony will be studying a Masters in Financial Mathematics and Computation at the University of Leicester and working on a long-term project regarding cryptocurrency trading with a friend.

Optimising a Mining Strategy For New Crofton Cooperative Colliery (NCCC)

New Crofton Cooperative Colliery is planning to sink a new coal mine near Wakefield in Yorkshire. The proposed method of working – room and pillar – is understood on a theoretical basis using a presentation written by Dr Hirschi, but NCCC would like to understand more about how it will work in practice and whether it is the most efficient method. The purpose of this project is to develop a simulation model in a suitable software package that can be used to demonstrate to NCCC its proposed method of operation and possible alternatives to it. The dissertation outlines the benefits of the proposed methods, and contains a simulation creator tool which allows people with no specialist simulation knowledge to measure the optimality of their own strategy against the methods of others.



Ffion James-Hargreaves, University of South Wales

Following Graduation from [BSc Mathematics](#) at the University of South Wales, Ffion has accepted a job at the Office for National Statistics based in Newport, South Wales as a Statistical Officer working in the National Accounts Coordination Division.

Investigating the impact of alcohol related attendances at A&E

This research investigates the impact of alcohol related attendances on the demand and capacity of the emergency services, specifically the Accident and Emergency departments within the Aneurin Bevan University Health Board.

Alcohol misuse is a major problem in modern society, resulting in both physical and mental harm, causing a large number of Accident and Emergency (A&E) attendances, which are therefore creating a significant burden on the department. The current operation of alcohol-related attendances, by most A&E departments, could be further improved. The remainder of this research examines the current literature published around areas of the subject, such that known methods can be implemented, i.e. statistical analysis and simulation.

Overall, there has been a decrease of 40.71% of attendances over the time frame of April 2010 to March 2016, yet men still encompass 61% of these. According to a Chi-Squared Goodness of Fit test, paired with the Kruskal-Wallis and the post-hoc Stepdown Bonferroni, there were no differences between the number of male and female attendances year on year, explaining that the ratio of males to females stays constant, although total alcohol-related attendances are decreasing in general. After performing further statistical analysis, it was seen that the Royal Gwent General Hospital and Nevill Hall General District Hospital handled the greatest number of attendances and were also found to have the largest number of patients arriving via Air Ambulance/Helicopter.

Then, when simulating an A&E department using the simulation software, Simul8, it was shown that having one doctor assigned to each specific triage category (1 through 5 and 6), was a viable solution to decreasing the impact of alcohol-related attendances on the A&E department. This was seen when 100% of patients left the system in less than the specified time frame, at four hours.

This should, in turn, strengthen the role of A&E departments and overall, may result in a decrease in the number of cases of alcohol-related incidences.



Citation for The OR Society Undergraduate Award 2016

Archie Rees, University of South Wales

When asked about his future plans, Archie said “after my degree in [BSc Mathematics](#) I wish to pursue a career in the analytics and statistics industry. In particular, my time doing the project reaffirmed my desire to have a career analysing sports statistics, as I thoroughly enjoyed focusing on the NFL, making decisions based on both the statistics and figures attained and the actual football and setup of the national football league.”

The best of the best: An investigation into the efficiency of NFL franchises

This project investigates the efficiencies of NFL franchises for the 2014 and 2015 Regular Seasons. After investigating the strengths and weaknesses of several benchmarking methods, an adapted CCR formulation of DEA is used. The approach is applied to the 2014 and 2015 seasons, and it is found that there is a range of efficiencies for the NFL franchises for both the 2014 and 2015 season, however on average the 2015 season (74.79%) has slightly higher efficiencies than 2014 (71.06%), although this difference is not significantly different. The Seattle Seahawks were the only franchise to be 100% efficient in both seasons.

The analysis is carried out using normalised data with regards to offensive and defensive salaries (as inputs) and winning percentage, passing touchdowns (taken as a differential of touchdowns scored and touchdowns conceded) and rushing touchdowns (also as a differential). The approach also allows for the identification of areas of inefficiency, which are analysed for the 2014 season.

The models and results are then contrasted with other work in the area, namely ‘Is Winning Everything?’ (Einolf, 2004). The main contrasts between the two papers is their attitude towards injuries and how they affect efficiency, and the formulation of DEA, as ‘Is Winning Everything’ uses the BCC formulation of DEA to include the concept of diminishing returns, where the CCR formulation used in this paper that assumes a constant rate of return from inputs.