A dissertation focussing on:

Work Based Project

Student Number

2204590

Prepared for:

Dr Deborah Hughes

Created by:

Toby George

Date accomplished:

27/02/24

Word Count: 5,352

Table of Contents

Study **Page Number**

1.0 Proposed Research Title..... 3

2.0 Abstract..... 3

3.0 Aims..... 3

4.0 Objectives..... 3

5.0 Initial understanding on the topic..... 4

6.0 How the proposed research will benefit the researcher..... 4

7.0 Literature Review..... 4

7.1 The role of a Quantity Surveyor in the 21st century..... 4

7.2 A journey through the evolution of Artificial Intelligence..... 5

7.3 Tested strategies that's implemented AI successfully into the role of the QS.... 6

7.4 When did AI regression modelling come into practice?..... 7

7.5 New age: Could BIM overrule the expertise of a Quantity Surveyor?..... 9

7.6 How can AI be further developed to enhance the role of a Quantity Surveyor?. 10

7.7 Redefining Quality Norms..... 10

8.0 Research Methodology(ies) and Justification..... 11

9.0 Primary Research Methods 11

10.0 Data Analysis..... 12

11.0 Access / Consent / Ethical Considerations..... 12

12.0 Testing the data..... 12

13.0 Timetable..... 13

14.0 Reference List..... 14

15.0 Appendices..... 16

15.1 Appendix 1..... 16

15.2 Appendix 2..... 17

15.3 Appendix 3..... 17

1.0 Proposed Research Title

'Quantum Shift: AI Challenges the Relevance of Traditional Quantity Surveying'

2.0 Abstract

The proposed research seeks to investigate whether artificial intelligence (AI) has the potential to support or replace traditional Quantity Surveying skills in the contemporary context of the construction industry.

3.0 Aims

The research proposition for this dissertation is to establish a greater understanding on, "the controversy surrounding the relevance of traditional Quantity Surveying skills arises from the fact that some experts argue that these skills are no longer necessary in today's construction industry due to AI possibilities." Therefore, the aim of this project is to prove that AI advancements are incapable of substituting the essential skills of a Quantity Surveyor. Instead, the fundamental aim is to showcase that AI is most effective as a tool for enhancing and amplifying the capabilities from the point of view of the QS. (Hubbard, 2023)

4.0 Objectives

These findings can be determined by the following objectives:

1. To extract from existing literature; the foundational concepts associated with traditional Quantity Surveying skills.
2. Research into tested AI strategies within the industry and identify if these methods were successful or unsuccessful through secondary data. Linking to traditional Quantity Surveying skills where possible.
3. Prove there is statistical distinctions between the accuracy of AI and the expertise of a QS across tested strategies. Proving that this statistical difference indicates AI's inability to replace the expertise of a QS. Supporting the assertion that AI is most effectively employed as a supplementary tool within professional context.
4. Careful examination of secondary research to identify if there's any limited or missing data requirements to support or disapprove the findings.
5. Expanding the research by developing a questionnaire which can fulfil the limited or missing data requirements. Then identifying a suitable group target which can expand on the initial data by providing essential viewpoints on the specified research question.

5.0 Initial understanding on the topic

The researcher invests and studies stocks alongside his full-time education and work hours. During this time, the researcher has observed a significant increase in funding across AI companies such as NVDIA and Symbotic inc. Ultimately, this sparked the curiosity of the researcher in AI possibilities; "with products like ChatGPT and GitHub Copilot, taking technology into realms once thought to be reserved for humans." Therefore, the incentive of AI driven possibilities questioned the researcher if his skills as a Quantity Surveyor would still be relevant in say 30 years time. (Chui, Roberts, Yee., 2022)

A concise exploration of the topic revealed that QS's are actively incorporating AI into practice. This integration involves using "AI to forecast construction costs, thereby improving the cost planning process for surveyors through regression modelling and automated data analysis." Furthermore, this dissertation requires extensive research to be able to achieve a strong critical comparison between the relevance of Quantity Surveyors skills and AI possibilities. (Domo, 2022)

However, initial research into the topic exposed a deficiency in sufficient secondary data concerning QS's views on integrating AI into the industry. As a result, there's a need to gather primary data. This primary data collection will involve the participation of Quantity Surveyors who have AI experience as well as those without any exposure to AI integration within projects.

6.0 How the proposed research will benefit the researcher

The researcher of this dissertation takes a particular interest in modern-day technology and aims to determine whether it will affect the significance of traditional Quantity Surveying skills.

With a focus on serving the best interest of the client, the researcher approaches the industry as a new construction professional with an open-minded stance towards embracing innovative technological perspectives. The aim is to contribute to the development and enhancement of the industry, with a focus on delivering and improving industry standards. Therefore, by being knowledgeable on this matter, the researcher can suggest and possibly adopt different technological approaches to industry standards. The impact of the research would prove highly beneficial for the researcher with practice in the industry.

Ultimately, this proposed research will confront and sync these two views in order to foresee if Quantity Surveyors skills will be challenged by technology or will it be the future for Quantity Surveyors moving forward.

7.0 Literature Review

7.1 The role of a Quantity Surveyor in the 21st century

A Quantity Surveyor (QS) is essentially a financially guardian for the client, tasked with estimating costs, preparing project timelines, calculating material quantities and identifying risks associated with a construction project. "Being a construction industry professional, a QS will be equipped with expert knowledge on construction costs and contracts, and can combine their engineering skills with that of management skills." A QS is introduced from the offset of a construction project and will be required to meet the legal standards, quality standards and to ensure compliance with all statutory buildings regulations. The QS will showcase their expertise in "stage 0 (strategic definition) where at this stage, the QS may be involved in feasibility studies and cost planning, which can help to determine the viability of the project." Once the work commences, the QS will prepare cost estimate and asses the costs based off the ongoing expenses associated with the project. Carefully evaluating any variations that could impact the project's costs and to produce regular reports to highlight profitability and possible improvements to the client's investment. (Saar, 2022) (Kaushal, 2023)

But what does a QS do on a day-to-day basis?
A QS will typically undertake:

- "work alongside clients to establish their requirements
- undertake feasibility studies to ensure a proposal will work
- estimate material quantities, costs, labour and time
- prepare tender and contract documents – this can include bills of quantities with the client and architect
- perform risk and value management, and cost control, during a project
- undertake cost analysis for repair and maintenance work
- negotiate contracts and work schedules
- assign work to subcontractors – overseeing their work throughout all RIBA stages
- value completed work and arranging payments
- ensure projects meet legal and quality standards

As you grow your career, it is likely a QS will:

- advise clients on the carbon emissions generated by their projects and buildings
- advise on property taxation
- assist clients in securing funding
- help clients to initiate construction projects
- offer life cycle costing advice. "

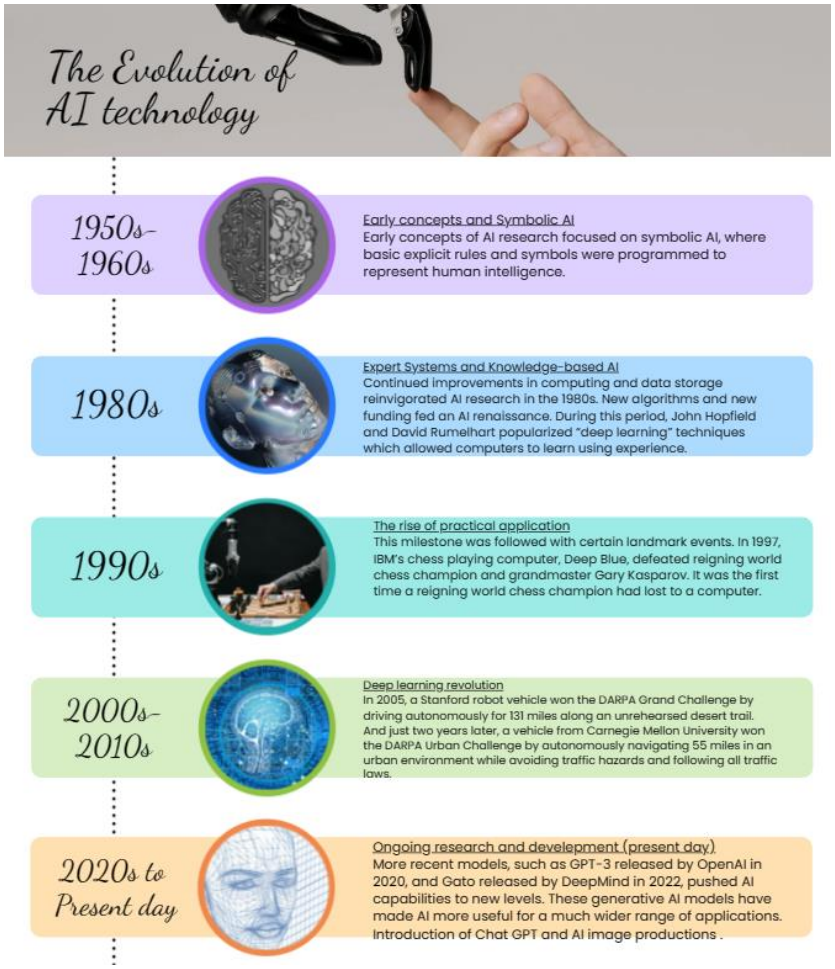
Source: (RICS, 2023)

7.2 A journey through the evolution of Artificial Intelligence

Artificial Intelligence (AI) refers to the science of creating machines that can operate and think like humans. These 'smart' computer systems can replicate human-like intelligence through natural language processing, problem solving and pattern recognition. The fundamental goal for AI technology is to be able to construct machines that's capable of being able to adapt and improve their performance over time for maximum productivity and efficiency. For example, "chatbots, such as ChatGPT and Google Bard, can handle routine and repetitive tasks easily and consistently, operate around the clock, and interact with many customers simultaneously." AI is indisputably an excellent tool for automating away tedious and repetitive tasks that's prone to human error. (Diaz, 2023)

Nevertheless, it's evident that the growing nature of AI advancements is becomingly increasingly advanced where instantaneous automation will begin to disrupt more skilled jobs on a larger scale.

The evolving nature of AI technology can be demonstrated in the image below:



Source: (Lawlor, 2023)

As many are aware, the looming concern for AI technology to replace current mainstream jobs is certainly a possible reality given the ongoing evolution of AI. For instance, many Qs's are questioning if their foreseeable future is a dying profession and whether their skills will remain relevant in the next 30 years. When reviewing the day-to-day basis of a QS, it's clear that estimating and cost planning play a pivot role in identifying a QS. However, as AI technology can process these large amounts of data in ways that a QS cannot; it can certainly raise an eyebrow or two.

From the 1950s to the present day, it's evident that advancements in AI technology have been driven by ongoing technological refinements. But has AI managed to evolve into the role of the QS?

7.3 Tested strategies that's implemented AI successfully into the role of the QS

AI tools possess the capability to successfully manage and oversee photo contests, translate books and text into thousands of different languages and unsurprisingly, they are presently employed to enhance the role of a Quantity Surveyor, aiming to deliver exceptional value to the client. Quantity Surveyor Cody Bui working at the Altus Group hosted a webinar with the Australian Insitute of Quantity Surveyors to navigate the path towards meaningful AI adoption through highlighting its challenges, opportunities and prospects with AI innovation.

As of the present moment, the findings stated that Quantity Surveyors are currently using AI to conduct regression modelling to anticipate construction costs. Through encompassing on diverse factors such as location, orientation, size/scale of the building, labour, quality of materials and other relevant factors. AI algorithms can comprehend the correlation between these elements and the actual cost. Subsequently, being able to construct a predictive model that can estimate costs for upcoming construction projects based off the inputted variables.

Whilst the capabilities of AI regression modelling are firmly established within the industry to predict or estimate the costs in each unique project. The effectiveness of AI algorithms is contingent upon the disciplined structure of the system. Consequently, machine learning is only capable of generating meaningful data when the data inputted into the system is organised and well-structured. Cody Bui stated that "the hardest part of the process is not to construct the formula – although this can be quite challenging. The hardest part is to collect the data to undertake the modelling." Therefore, incorporating AI regression modelling into application is undeniably more challenging than it may initially appear. But has this discouraged Quantity Surveyors from fully embracing AI cost regression modelling? (AltusGroup, 2024)

Although it's early days, the full potential of AI benefits is to be harnessed by the Quantity Surveyor. The time consuming and complex element of forming an algebraic formula has in the past discouraged many Quantity Surveyors to venture into this unknown realm. However, as cost models and their applications have developed and demonstrated a predominant ability to offer broader aspects of estimating. Quantity Surveyors are now capable of generating suitable cost information at an earlier stage in the design process. Consequently, QS can directly provide key information to the client by aiding and promoting more informed decision-making based off reliable regression modelling information. Thereby, rendering AI as an outstanding resource in the Quantity Surveyor's toolkit.

7.4 When did it AI regression modelling come into practice?

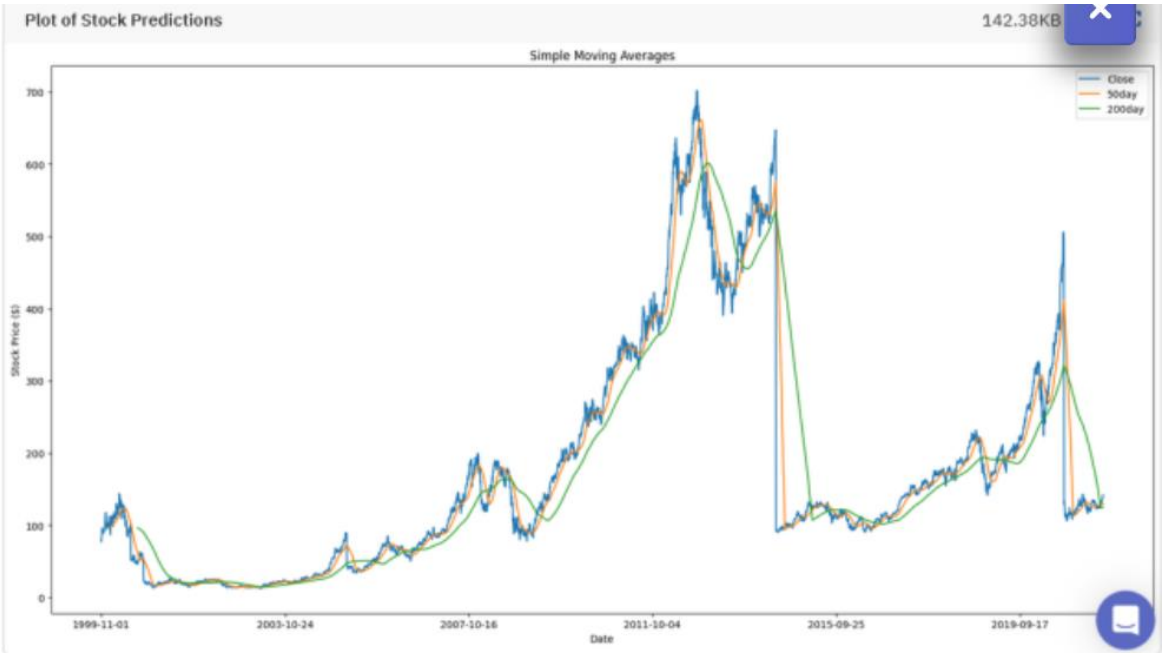
Fundamentally, this concept wasn't applicable prior to the 1980s; where the advent of cheap computers made cost modelling a reality. Without it, cost modelling for a QS would've been excessively tedious to contemplate, with results unattainable within a reasonable period of time. As AI technology evolved, it was anticipated that the surveyor(s) that wishes to consider cost modelling techniques would initially use a pre-written program for regression analysis. However, as the QS would become more proficient with applying the techniques to the project program, the QS could then amend or introduce subroutines catering their own independent needs to tackle their own personalised tasks. The ability to personalise and customise AI regression modelling for independent needs became the substantial cornerstone for AI development within the industry.

While Quantity Surveyors can employ AI regression modelling to forecast construction costs, it is ultimately the responsibility of the QS to rectify any discrepancies in the information. Once the most optimal model has been constructed, it's crucial to conduct thorough testing to assess the performance given the variables. For example, four tests can be adopted to justify the practical use of the model in project estimation, incorporating the following criteria:

I. "Comparison of the model's predictability against the actual values obtained from further project.
II. The coefficient variation (standard deviation divided by the mean and x100 for the percentage) should be as low as 10%. Where previous research has indicated some deterioration in value when models have been applied to new data.
III. Therefore, a maximum number of variables should be included in the model (12) to reduce the amount of data required initially; with the goal of facilitating future data utilisation. (Essentially advocating the model's effectiveness with consideration to various factors and variables)
IV. As with the standard deviation, it can be shown that 65% of all cases will fall within one standard error. For example, if the coefficient of variation was calculated at 10% then 65% of the cases should fall within a +/- 10% range. (Closely correlating the standard deviation)"

Source: (Ashworth, 1981)

An example of this test, applying Neptune AI simulation for AI regression modelling is as follows:



Source: (Li, 2021)

Although the AI stock predictions appear relatively correlated in the graph above. To be able to determine "the current model evaluation metrics for regression modelling, the RMSE (Root Mean Squared Error) and the MAPE (Mean Absolute Percentage Error) (%) will be useful measures for the QS's forecast accuracy." The two metric equations are as follows: (Li, 2021)

$$MAPE = \frac{1}{N} * \sum_{t=1}^{N} \left| \frac{At - Ft}{At} \right|$$

$$RMSE = \sqrt{\frac{1}{N} * \sum_{t=1}^{N} (At - Ft)^2}$$

, where N = the number of time points, At = the actual / true stock price, Ft = the predicted / forecast value.

Source: (Li, 2021)

RMSE quantifies the disparities between predicted and actual values, while MAPE (%) gauges the difference in relation to the true values. For instance, the MAPE value of 12% in the graph above represents, on average, that the predicted stock price differs by 12% from the actual stock price. While the data is closely aligned with the actual values, the data essentially reinforces the concept of AI serving as a tool. With the Quantity Surveyor holding the responsibility of overseeing the relevance and appropriateness in the data provided by AI. As Quantity Surveyors bear a significant responsibility in achieving highly accurate pricing, a crucial element for maintaining budget adherence and preventing cost overruns. The differential of 12% between the predicated and actual values in this example is far to disperse to be able to provide highly accurate pricing for concrete decision-making. Therefore, this proposition underscores that in certain contexts, the prominence of traditional QS skills overshadows the role of AI, often indicating that the intricate nature of the tasks may be more be effectively handled by the human expertise. As a result, the QS's adaptability, creativity and holistic understanding of project dynamics often surpasses the capabilities of AI.

While AI technology is still in its early stages, it's evident that AI cannot replace the expertise of a QS. Rather, it can be effectively utilised as a tool to streamline cost estimations and decision-making. By integrating AI with

the pertinent skills of a QS, it has the potential to improve the accuracy of projections in complex construction projects, leading to increased efficiency and effectiveness in delivering the best value for the client. However, through heightened AI development; it could have a ruinous effect on the role of an assistant QS. The QS could potentially leverage AI as assistance, and a result, will diminishing the need for the assistant QS. However, the writer of this dissertation holds the perspective that the role of an assistant Quantity Surveyor could be redefined to align with and complement AI, particularly by handling the technological aspects of the role. Nevertheless, this is a subject that should be re-visited as AI continues to evolve.

7.5 New age: Could BIM overrule the expertise of a Quantity Surveyor?

A frequently overlooked aspect of AI adoption is Building Information Modelling (BIM). Particularly in applications like Revit, where the Bill of Quantities (BoQ) feature is almost unexplored and untouched. This functionality holds the potential to redefine the role of a QS. Through the advancements of BIM technology, the BoQ feature can automate and extract the quantities directly from the digital model, ultimately reducing the manual input traditionally required from the expertise of a QS. While this streamlines the quantification process effortlessly, "a survey carried out by the UK by the Royal Institution of Chartered Surveyors (RICS) indicated only 10% of the quantity surveyors had been involved in BIM. With most research literature indicating BIM in architects' and designers' practices, less literature points to the integration of BIM in the Quantity Surveying practice." But why is this advanced AI tool simply being overlooked? (Muimi, 2020)

The adoption of BIM in the UK gained significant momentum around 2011 where in that year, the UK Government implemented a mandate requirement for the use of BIM in all publicly funded projects. Nevertheless, Revit provides a 'schedule/quantity' tool that can essentially generate a complete Bill of Quantities (BoQ) based off the designed model produced in a collaborative BIM central data environment (CDE). Although BIM promotes a collaborative environment amongst the project team and stakeholders, many Quantity Surveyors are sceptical about the implications associated with this AI tool. "For instance, when designing a house, walls constructed of brick with plaster on both sides should have each layer clearly defined. Missteps at this stage could lead to erroneous material estimations, consequently impacting cost projections." Hence, this process shifts the responsibility more on the design team rather than the QS but would ultimately impact the project team as a collective, especially in projects where AI tools are not coordinated correctly. (Desapex, 2023)

On the contrary, Revit's 'schedule/quantity' feature can individually categorised packages like windows, external walls and doors. Therefore, this feature can offer crucial support or clarification to QS's when preparing specific elements from NRM 1 for their take-offs and BoQ.

To add to this, extracting the quantities and inputting cost information directly from a live shared model can reduce errors stemming from isolated changes in project variations. By utilising BIM, any alterations made to the model will be promptly reflected in the quantity surveyor's material and cost schedules. Ultimately reducing the time amending the variations in the design and allowing the Quantity Surveyor to focus on higher value tasks and strategic decision-making, fabricating the significant of the QS role in the project.

7.6 How can AI be further developed to enhance the role of a Quantity Surveyor?

Revit's modern BoQ extraction capabilities with the significance of traditional quantity surveyor skills in modern construction gives rise to a notable paradox. Where in the past, QS was a manual and labour-intensive

process, susceptible to human errors. However, in the modern era, Revit not only offers remarkable automation; but it also offers a visual insight into providing invaluable information when communicating intricate designs to stakeholders. Consequently, "some quantity surveyors believe that if they accepted BIM practice most of their functions will be automated and it will lead to technological unemployment. However, this is just a misconception about BIM and associated technologies as no single technology can replace the human judgement required to offer professional QS services. Quantity take-off and Boq can be automated (which is an advantage to the QS), but contract management, technical and legal advice cannot be automated!" No matter how advanced AI's technology evolves, the human expertise remains crucial in interpreting complex project nuances, validating data accuracy and facilitating informed decision-making which eminently goes beyond the capabilities of AI automated tools. (Muimi, 2020)

Fundamentally, many QS's have been working under the assumption that BIM solely revolves around 3D modelling for architects. But once QS's embrace the full potential of BIM, the concept is set to transform, demonstrating active involvement with collecting, analysing and communicating cost databases through 5D BIM models. But how do we forecast the future for AI investments?

"With technology expert analyst Forrester predicting spending on AI to surge from $33 billion in 2021 to $64 billion in 2025. A doubling in just four years; it's certain that no corner of construction will remain untouched." This statement by Forrester suggests that through funding, BIM is likely to enhance a wider spectrum of QS functions which will include automated measurement and quantification, facilities management (7D), legal services, sustainability analysis (6D), investment advice and most importantly quality management. (O'Grady, 2022)

As there's a real need to move away from lowest cost-procurement, which can often disregard other significant risk considerations and contribute to the rise of suiciding bidding. Striking the balance between quality and cost procurement routes is essential for ensuring optimal value and successful project outcomes. This can be achieved through sophisticated AI systems that can continuously monitor market conditions and trends, labours costs, material prices and can consider various influencing factors to deliver precise and predictive cost estimates. This real time market intelligence enables the client's project team to make informed decisions regarding the most cost-effective yet quality driven procurement route. Therefore, AI tools can play a crucial role in redirecting Quantity Surveyors towards prioritising quality control and sustainability (6D).

7.7 Redefining Quality Norms

By implementing feasible piloting programs, AI information can be utilised in project meetings to bolster coherent decision-making and possibly form the primary foundations for well-informed project decisions. To add to this, AI tools can be harnessed by the QS to enhance budgeting and cost planning, thereby safeguarding the quality of the proposed project and preventing any compromises due to unforeseen financial constraints. In spite of the advantageous benefits, "the evolution of AI in the construction industry will continue to revolutionize how companies approach their work and position themselves as leaders in an increasingly competitive market. With AI integration, companies can become more agile, robust, and resilient, achieving greater profitability, increased ROI, and contributing to safer and smarter building." (Caddy, 2024)

Although AI tools could play a pivotal role in construction projects, the human expertise and experience remains a crucial aspect for interpreting results and ensuring the ethical considerations are considered behind the strategic decision making. This can be achieved by ensuring all construction bodies remain equitable in the process; whilst also delivering the client the upmost predominant excellence in providing the highest standard of technology integration and collaboration (BIM)from the QS and project team.

8.0 Research Methodology(ies) and Justification

Through preliminary research into the topic area, it become evident that there is a substantial body of research discussing how AI will impact and transform the responsibilities of a Quantity Surveyor. As AI is a current 'hot topic', the majority of data is up to date and relevant for this dissertation. Therefore, through adequate secondary data; research can be gathered but not limited to:

- "Educational institution
- Journals
- Libraries
- Online data
- Commercial sources " Source: (Bhat, 2018)

To capture a comprehensive range of data, it's imperative to incorporate primary data that's been collected from a diverse group of current QS's actively working within the industry. Gathering first-hand information from Quantity Surveyors who are directly involved in this topic area can contribute to valuable data and practical insights that may not have been as apparent in secondary research.

On the other hand, undertaking exploratory research through inductive reasoning will direct the researcher from a specific research question to a more pervasive understanding of the topic area. "Inductive reasoning will be utilised when analysing the results from the questionnaire to formulate an hypothesis that can undergo further testing." This approach aids in reaching conclusions that extend beyond the explicitly provided information, often leading to new insights and discoveries. (Neumann, 2022)

The researcher was initially going to undertake exploratory research through deductive reasoning. This would've been achieved by drawing an initial conclusion from a hypothesis that's believed to be true. However, deductive reasoning would've been too consuming given the deadline of the dissertation. Additionally, solely deductive reasoning can become biased for the fact that this method of reasoning can be aimed to prove a logical conclusion through logical reasoning. Researchers who depend on deductive reasoning can become unwilling to consider other points of view. Therefore, it's most advantageous for the researcher to be open minded to different viewpoints through inductive reasoning; where expansive results can direct the researcher into further areas of study.

9.0 Primary Research Methods

A combination of both quantitative and qualitative data will be gathered for this dissertation. The researcher felt it was most appropriate to include a mixture of both data types; "as quantitative data will help incorporate several analytical perspectives in the dissertation. Whereas qualitative data can assist in interpreting information by observing and understanding the data." If the data was solely Qualitative data, there would be a serious concern with completing the dissertation on time as this method of gathering data can be too time consuming given the deadline of the project. (FullStory, 2021)

Since AI is a relatively new development, there are currently no relevant case studies available to disprove the hypothesis between the relevance of Quantity Surveyors skills and AI possibilities. Additionally, given the time constraints, it wouldn't be feasible to interview a suitable number of QS's to gather their extensive opinions. Therefore, a more fitting method for efficiently collecting a sufficient amount of primary data within the designated timeframe, is through a questionnaire.

The author of the dissertation should approach the literature review without any predetermined notions on the topic area to prevent any bias or skewed research methodologies.

10.0 Data Analysis

Data analysis will be collected through Microsoft Excel's latest version.

The questionnaire will include a set of closed questions to improve the accuracy of the answers. This will be measured by grading the questionnaire. By doing this, the researcher will be able to ask indirect questions that are specifically associated with the topic area. These closed questions will limit the need to produce a second questionnaire if the questions are revised and carefully chosen. Subsequently, people submitting a questionnaire have the tendency to submit answers that the researcher wants to hear. To avoid this, the researcher will facilitate a mixture of:

- Both positive and negative statements to avoid encouraging a certain type of answer
- Being anonymous wherever possible
- Avoid skewing the questions to avoid a bias response
- Clarifying the language of the questions to avoid uncertainty and misconceptions
- Avoid using the title of the dissertation to avoid a preconceived opinion on the topic area

11.0 Access / Consent / Ethical Considerations

Once the questionnaire is conducted, the privacy of the collected data will be taken into account. "All data will be stored in a secure, password protected file, in accordance with the requirements of The Data Protection Act 2018." (GOV.UK, 2023)

It's estimated that the questionnaire will include between 10-15 questions where a prearranged date for distribution will be given ahead of time. Once the questionnaire has been finalised and compressed digitally, a letter will be sent out to the selected sample. This letter will confirm their anonymity in the questionnaire and ask for their consent to use their responses for research purposes. The questionnaire will then be sent by E-mail and will include a unique survey link for the proposed target group. Allowing for a 14-day request for return period.

12.0 Testing the data

The list of eligible candidates for the questionnaire will be inputted into Microsoft Excel. From this list, 20 Quantity Surveyors will be selected at random. This can be achieved by coding an active cell to '=RAND()' to produce a random list of suitable candidates. This sampling method is optimal to avoid any biased interferences through an automated spreadsheet system. This sampling method will also be used for potential interviews.

The data will then be coded and inputted into Microsoft Excel; this system will be graded 1-5 where 5 will represent 'strongly agree' and 1 will represent 'strongly disagree'. Upon the return of the completed questionnaires, the data will be inputted into Microsoft excel to comprehend and identify any patterns or trends in the data.

Upon completion, the results from Microsoft Excel should support or contradict the original hypothesis and direct the researcher into further areas of research. Any gaps or limitations from the results of the questionnaire will fuel the questions during the interview stage.

Following the data collection process, it will be necessary to code and input the information into a computer program, such as SPSS.

SPPS is a “statistical program for quantitative data analysis and is popular because of its simplicity, easy-to-follow command language. SPSS offers a fast-visual modelling environment that ranges from the smallest to the most complex models.” This statistical package will help carry out the statistical tests based on the resulting data from the questionnaire. The statistical tests to be carried out are: (William, 2023)

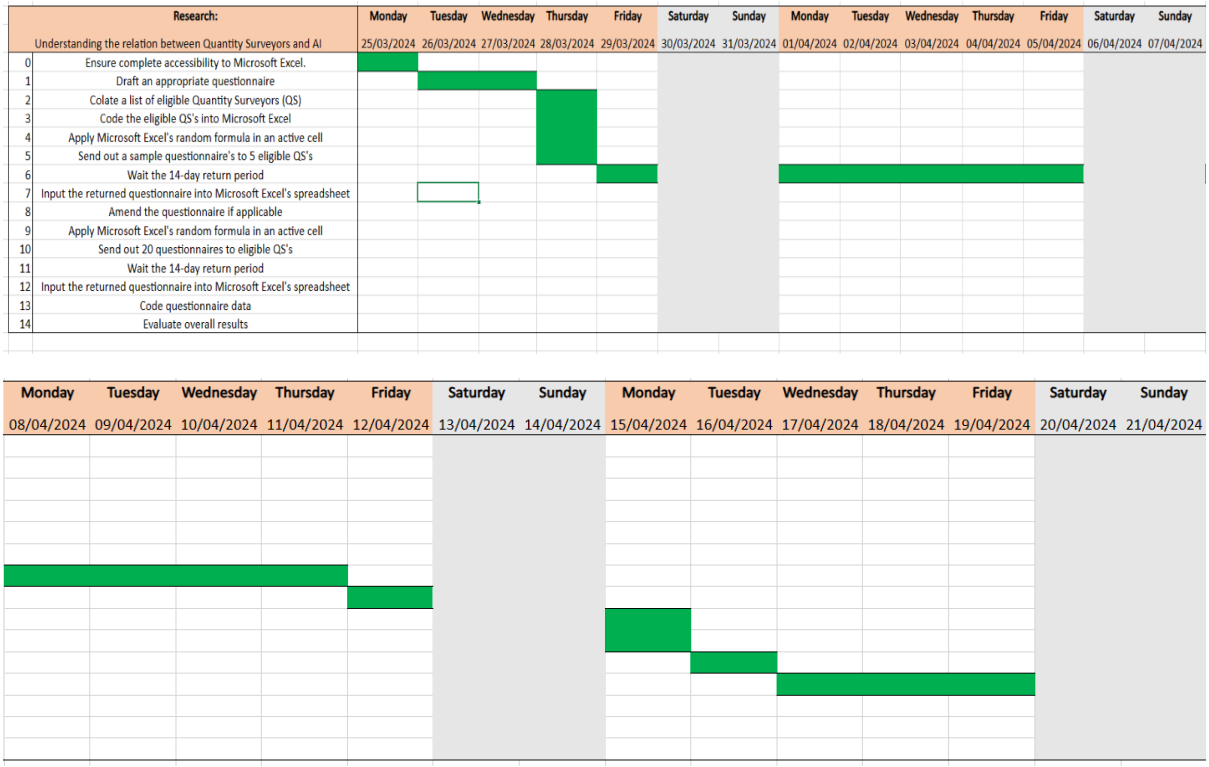
- **“Chi-square goodness of fit test-** A chi-square goodness of fit tests whether the observed proportions for a categorical variable differ from hypothesized proportions.
- **Wilcoxon-Mann-Whitney test-** The Wilcoxon-Mann-Whitney test will be used to determine the difference between the averages in ordinal data (assuming that the variable is at least ordinal).
- **Spearman’s rank correlation test**- This test will be used to correlate between two sets of ordinal data.”

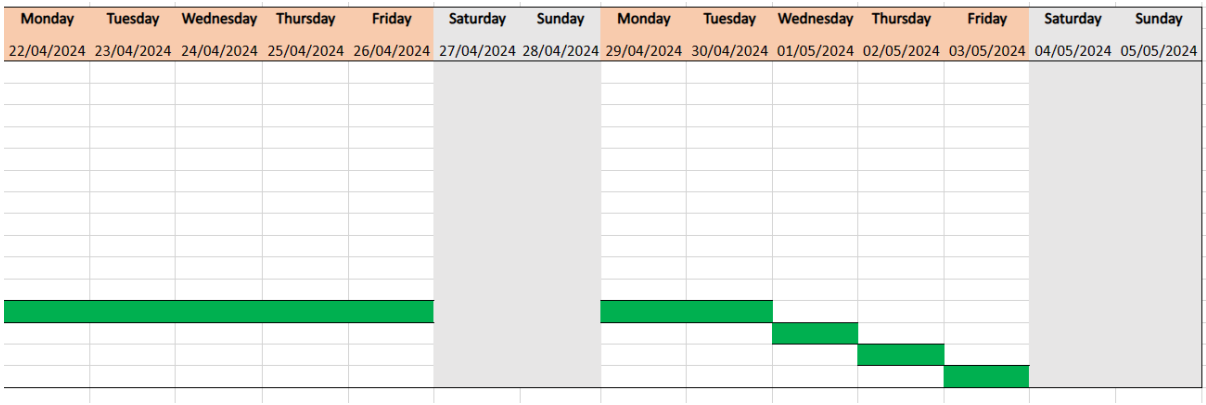
Source: (UCLA, 2021)

With the results derived from the testing methods in SPPS, it should be feasible to formulate conclusions in accordance with the initial hypothesis and to propose further areas of research.

13.0 Timetable

Please see the chart below for projected timelines and dates:





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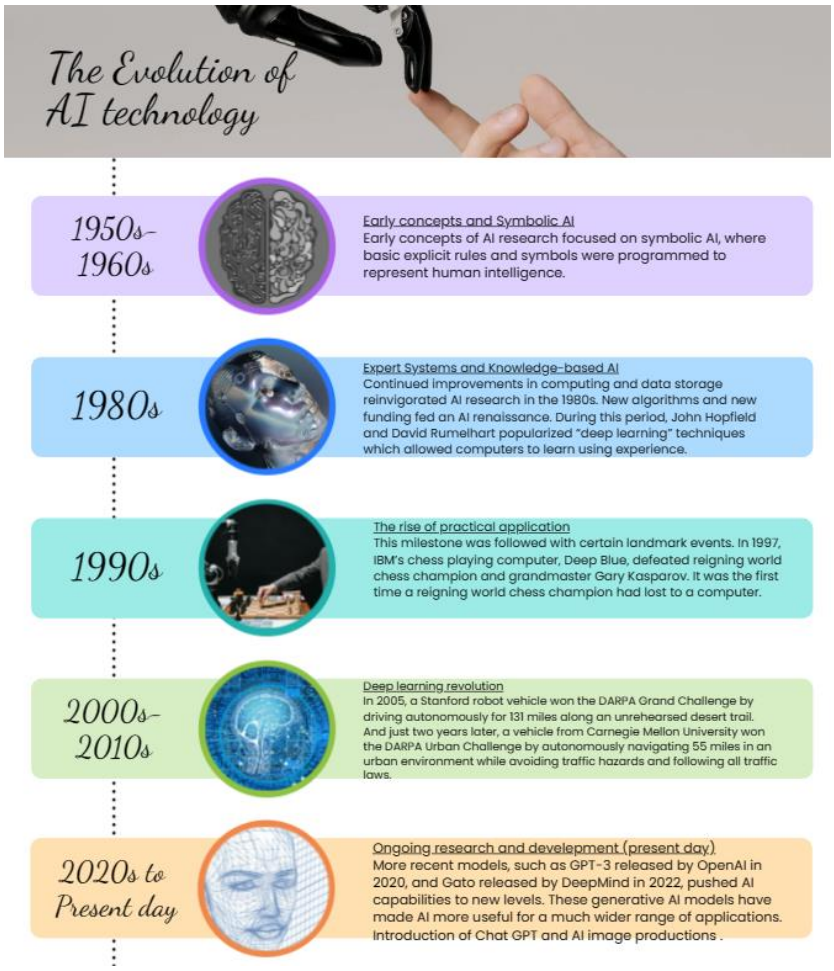
15.0 Appendices

15.1 Appendix 1

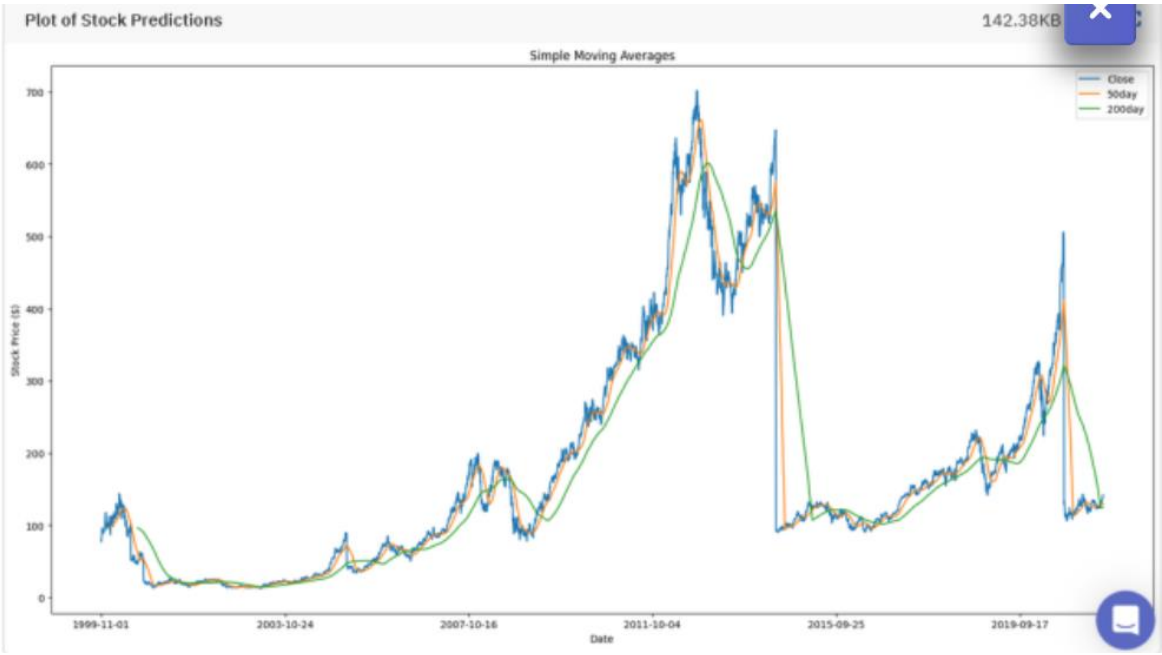
The image below illustrates the evolving nature of AI technology:



Source: (Lawlor, 2023)

15.2 Appendix 2

An example of a test, applying Neptune AI simulation for AI regression modelling is as follows:



Source: (Li, 2021)

15.3 Appendix 3

The two metric equations to determine the regression modelling:

$$MAPE = \frac{1}{N} * \sum_{t=1}^{N} \left| \frac{At - Ft}{At} \right|$$

$$RMSE = \sqrt{\frac{1}{N} * \sum_{t=1}^{N} (At - Ft)^2}$$

, where N = the number of time points, At = the actual / true stock price, Ft = the predicted / forecast value.

Source: (Li, 2021)