**MSc in Data Analytics – Integrated continuous Assessment 2**

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**Abstract**

*This work seeks to provide research about the Irish construction sector between 1997 and 2016, using techniques such as data analysis, statistics, and machine learning. The key area is the labour cost represented mainly by construction employees’ wages, in relation to additional factors such as number of enterprises, construction types and production volume. Additionally, an analysis has been performed to compare the Irish labour cost with the other European countries, and an executive dashboard has been produced. Data from the Irish department of housing as well as Central Statistics Office were used in a selection of machine learning algorithms to produce these forecasts. Sentiment analysis has been performed in relation to the Ireland housing cost, the results of which are presented and discussed in Section 3 below. Finally, plans for possible future extensions to this work are outlined in the conclusion.*

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# Introduction

The construction sector plays a significant role in the Irish economy, contributing approximately 7% to the country's Gross Domestic Product (GDP) and employing over 140,000 people as of 2021 (Central Statistics Office, 2021).

Data analytics has become an increasingly important tool in the construction sector, allowing stakeholders to gather and analyze data to make informed decisions and improve processes. This research paper aims to explore the Irish construction sector using data analytics, examining its current state, identifying key challenges, and comparing it to other European countries.

Specifically, this research will focus on the labour cost and wages of construction sector employees over time, as well as the construction of residential buildings and the people’s sentiment on social media in regard to it. The insights gained from this research may be useful for policymakers, academics, and the general public in developing effective strategies to address the challenges facing the Irish construction sector.

This document is structured as follows. Section 2 describes the tools used during this research also providing information about methodologies approach. Section 3 provides details coming for the analysis of relevant datasets as well as data scraped from social media. Conclusions for this work are then summarised in Section 4.

# Materials and Methods

## 2.1 Methods and tools

For this work the phases defined by the Cross-Industry Standard Process for Data Mining, as known as CRISP-DM (Smart Vision Europe, 2017), were implemented in the following manner:

*Business & Data Understanding*: The starting point was analysing the brief, clarifying the objective of the work. The relevant data source has been identified and available datasets have been reviewed and selected. This work is detailed in sections 2.1 and 3.

*Data Preparation:* All the data underwent a through E.D.A. and cleaning to prepare it for analysis. Initial insights have been visualized. This work is detailed in section 3.

*Modelling & Evaluation:* The data were fit with a variety of machine learning modules depending on the desired outcome or result. Results were evaluated and new iterations have been performed as needed to make predictions. This work is detailed in section 3.

*Deployment:* This document and its supporting documents (data and code files) represent the deployment of the work, along with the creation of an executive dashboard.

Python notebooks have been primarily used to handle datasets. The open-source project called Jupyter (Jupyter.org) has been used to execute the supporting python code for this analysis.

Report’s notebooks, along with datasets and report can be found at <https://github.com/sbs23006/MsC_DA_CA2>

The report wordcount (including titles, references, and all sections) is xxx.

## Data

The following datasets were analysed for this research:

BAA12.20230506T200513.csv (data.cso.ie, 2023)

BBA02.json (data.gov.ie, n.d.)

BEA04.20230506T200502.csv (data.cso.ie, 2023)

estat\_lc\_lci\_lev\_en.csv (Europa.eu, 2021)

While the following one has been produced during the analysis:

data.csv

Data sourced from Eurostat has been used under their free re-use of data policy (ec.europa.eu, n.d).

Data sourced from CSO has been used under the CSO data policy for researchers ([www.cso.ie](http://www.cso.ie), n.d).

Data sourced from Ireland Department of Construction has been sourced under the Open Data Directive (data.gov.ie, n.d.).

# Results and Discussion

The goal of this section is to provide an overview of the conducted analysis along with the main highlights.

## 3.1 Ireland construction sector

The first step of this analysis has been to explore the datasets to get some initial insights into the Irish construction sector, along with the identification of a suitable dataset for further work in relation to machine learning models. The code for this work can be found in the accompanying Jupyter notebooks *Analysis.ipynb*(section 1) and *Ireland Analysis + Eu comparison.ipynb* (section 2).

Visualization tools like matplotlib and seaborn have been used to plot data about the type of building and construction in Ireland over the years (Figure 1), along with the average index of employment in building and construction industry (Figure 2).

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Figure 1 – Building and Construction types between 2000 and 2022

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Figure 2 - Average employment index in building and construction between 1975 and 2008

It’s noticeable from the two plots above the decreased values for building and construction from 2008, specifically for residential buildings. In the same year a drop in the index of employment is observed. This can be explained as a consequence of the 2008 great recession and the property bubble that saw a combination of increased speculative construction and rapidly rising prices (Malzubris, 2008).

When it comes about the labour data, analysing the values from the Enterprise dataset, a drop of 60.2% is observed between 2008 and 2013 in the number of employees, demonstrating the impact on the labour market add jupyter line.

Eurostat data (Europa.eu, 2021) provided comprehensive data related to the labour cost structure where the values showed a peak in non-wages related costs in 2022. Figure 3 shows a representation of those values, with the dot size being related to the value; both the percentage of non-wage cost and costs other than salaries have their highest value in 2022. *Plotly Express* has been used to create this interactive dashboard, a high-level data visualization package that allow the creation of interactive plots (plotly.com).

The discussed labour cost trends can also be quickly spotted in Figure 4.

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Figure 3 - Representation of Irish labour cost structure

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Figure 4

A full report has been created using Dash, an open-source Python framework used for building analytical web applications (dash.plotly.com). As Jupyter has been used to run the Python code for this project, *jupyter-dash* module has been installed and used for this project (dash.plotly.com). The first step has been the actual definition and creation of the single figures, and then combine them in the app layout along with callback definitions. Full code for this can be found in the file *Analysis.ipynb* (section 1.2). The Figure 5 below shows a quick look of the dashboard, a user guide is available in the Appendix.

A screenshot of a computer

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Figure 5 - Ireland construction report

### 3.1.2 Inferential Statistic

As discussed before, this study will mainly focus on labour data and constructions type. Inferential Statistic has been used to gain insights on both populations and find confidence intervals.

The dataset provides data between 2008 and 2019, so this can be considered our sample. When calculating the average of this sample, there’s always some uncertainty as it might not represent perfectly the entire population. Confidence intervals are a way to measure that uncertainty, as they present the estimate average not as a single number but as a range (Bruce, Bruce and Gedeck, 2020).

To produce the confidence intervals for the plots of simulated IQ data above, *t*, *sem*, and *mean* functions available in the *scipy.stats* package have been used. Another option is to use the *tconfint\_mean* function from the *statsmodels* package. Both methods give nearly identical results.

The table below summarizes the findings about both populations for the years between 2008 and 2019.

|  |  |  |
| --- | --- | --- |
| **Population** | **Calculated Mean** | **Interval (95% confidence)** |
| Wages and Salaries | 4043069.16 | (3049317.15, 5036821.18) |
| Employees | 86280.66 | (68739.28, 103822.05) |

Table 1

Hypothesis testing techniques have been applied to get additional insights into the wages of employees in the construction industry. T-test has been used to validate the null hypothesis of Irish wages being equal to 50000, that has been rejected.

The construction type population has been also analyzed for inferential statistics, a sample of 10 items has been taken for each construction type. Unfortunately, Anova condition have not been met (distribution is normal and looks like there’s some dependency between population).

Code for those calculations can be found in the file *Analysis.ipybn* (section 3).

### 3.1.3 Comparison within EU

*Choropleth* module from *Plotly Express* has been used to visualise Ireland values compared to other European countries, and statistical tests have been performed to compare it to specific countries.

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Description automatically generatedOverall, Ireland hourly wages in construction have constantly been higher than the values in the Euro Area, with the difference being bigger from 2004 (Figure 6).

Figure 6

Figure 6 below shows that in 2022 Ireland is one of the countries with higher wages and salaries, and it’s noticeable that the value decrease in southern Europe.

A map of europe with different colors

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Figure 7 - Wages and salaries comparison in 2022

From a statistical perspective, Irish values seem to have similar distribution as Sweden, Germany and Finaland (Figure 7), so inferential statistic tests have been performed to compare those countries.

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Figure 8 - Wages and salaries distribution across European countries

Two different approaches have been used to analyze and compare the data: parametric and non-parametric tests.

Parametric tests assume that data follow a normal distribution. Samples have been collected for wages and salaries of Ireland, Germany, Finland and Sweden, and Shapiro-Wilk test have been performed to check data normality. T-test confirmed that Sweden and Ireland’s means are similar (confirmed also by Mann-Whitney), while ANOVA test failed to accept the null hypothesis for Ireland, Sweden, and Germany. *violinplot* was used to visualize the distribution of those three countries, confirming the ANOVA test’s outcome (Figure 9).

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Figure 9 - Ireland vs Germany vs Finland

Wilcoxon test was used to compare years this time, across all countries, resulting in a difference between construction wages between those two years and indicating changes in the economics of the construction sector labour.

## 3.2 Sentiment Analysis

Ireland economy has drastically recovered since the 2008 crash but, as observed in Figure 1, the construction volume of residential building has not changed leading to a demand higher than supply. This topic is constantly being discussed in the dedicated Reddit channel ‘*r/ HousingIreland*’ (reddit.com).

Python provides a powerful tool that allows quick interaction with Reddit APIs (praw.readthedocs.io). Reddit credentials are secret values, therefore their values are not hard-coded in the notebook but stored in a text file that won’t be uploaded on Github using the .*gitignore* file (git-scm.com).

The first step of the analysis has been data gathering, a dataframe has then been built with the extracted reddit posts about housing in Ireland. Valencer Aware Dictionary and sentiment reasoner (VADER) provides a score given text determining if there is a positive, neutral or negative sentiment. A lambda function *analyze\_sentiment* has been created to apply VADER classification to our dataset and add its value in a new variable called ‘sentiment’. The distribution of sentiment after classification is as follows:

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Figure 10

It’s noticeable that there are more negative posts than positives, even if not too many, while 41.8% of the posts are classified as neutral. In addition to sentiment classification, Latent Dirichlet Allocation has been used to identify the top topics, along with a graphical representation using WordCloud.

|  |  |
| --- | --- |
| **#** | **Topic** |
| **1** | irish market investment funds homes |
| **2** | crisis funds time ireland new |
| **3** | rent dublin ireland house new |
| **4** | house ireland protest prices government |
| **5** | homes new crisis government rent |

Table 2 - Top 5 topics extracted using LDA

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Figure 11 – WordCloud

It’s evident that according to what users are debating on Reddit there is a housing crisis in Ireland, spanning across rent and house prices and with Dublin appearing in trending topics. Those insights were useful to scope the research further and analyze the polarity distribution for those two trending topics. Figure 12 below shows the visualizations where it is observed that the discussions about rent are more in comparison to purchase, with a normal distribution; on the other side, both Dublin and Ireland values seem lightly left skewed to the left, indicating most negative posts, with Dublin having more values on the negative side.

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Figure 12 – polarity distributions

Text has been then processed to develop classification models to classify sentiment. Additional details can be found in the next section.

## 3.3 Models

# Conclusion

The sector has undergone significant changes since the economic downturn in 2008, which led to a decrease in demand for construction services and a subsequent reduction in construction activity (Forde et al., 2020). However, recent years have seen a resurgence in the construction sector, with strong growth predicted in the coming years (Construction Industry Federation, 2021).

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