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Enhancing Future Capital Delivery: A Comparative analysis of Melbourne Water Corporation's Project Models

Melbourne Water

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1 List of abbreviations and terminologies

The analysis report will use numerous abbreviations and terminologies at various stages. This section will serve as a reference for what do these abbreviations mean alongwith their definitions.

1. **BNI** : Business Need Identifier
2. **PBC** : Preliminary Business Case
3. **BCA** : Business Case Approval
4. **Stage 1** : First stage of project completion
5. **Stage 2** : Second stage of project completion
6. **Stage 3** : Third stage of project completion

7. **FFC** : Final forecasted cost of project
8. **ID** : Unique identification for each individual project
9. **Owner group** : The division within Melbourne Water Corporation responsible for completing the particular project
10. **Delivery Program** : The subdivision within Melbourne Water Corporation responsible for completing the particular project
11. **PS** : Pricing submission period for Melbourne Water's business case to be submitted to Department of Treasury and Finance (DTF)
12. **CDM**: Capital Delivery Model

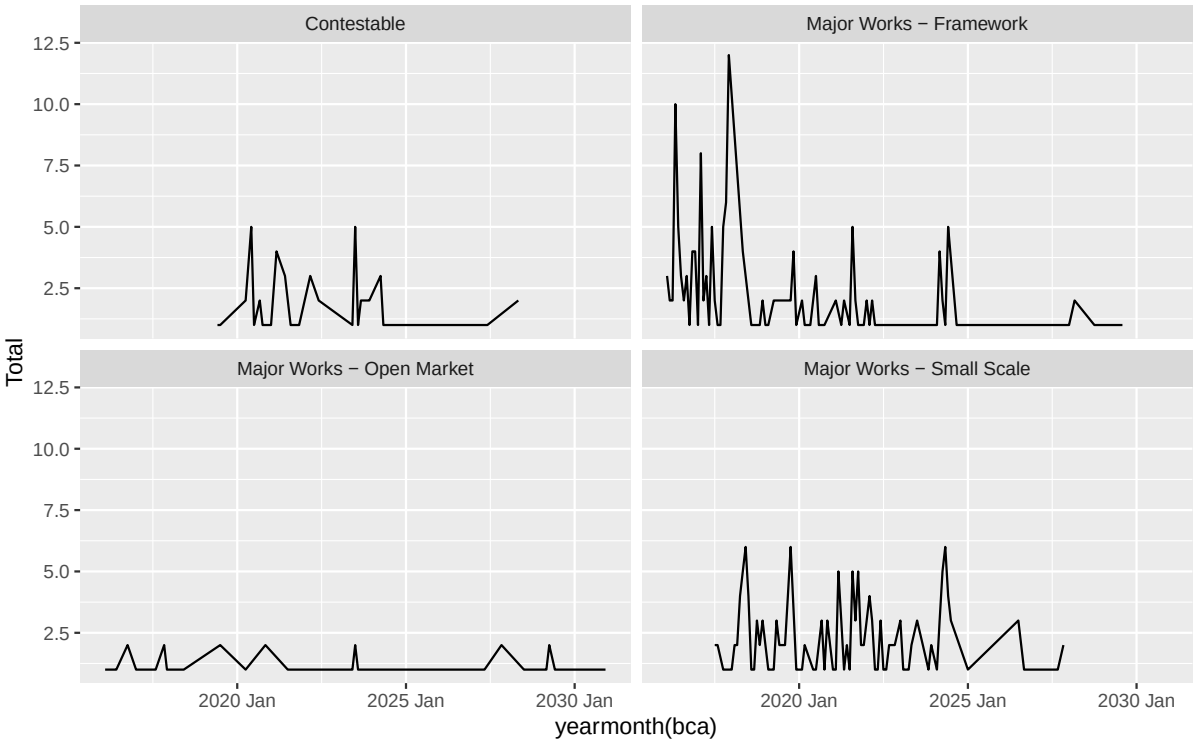
2 Executive Summary

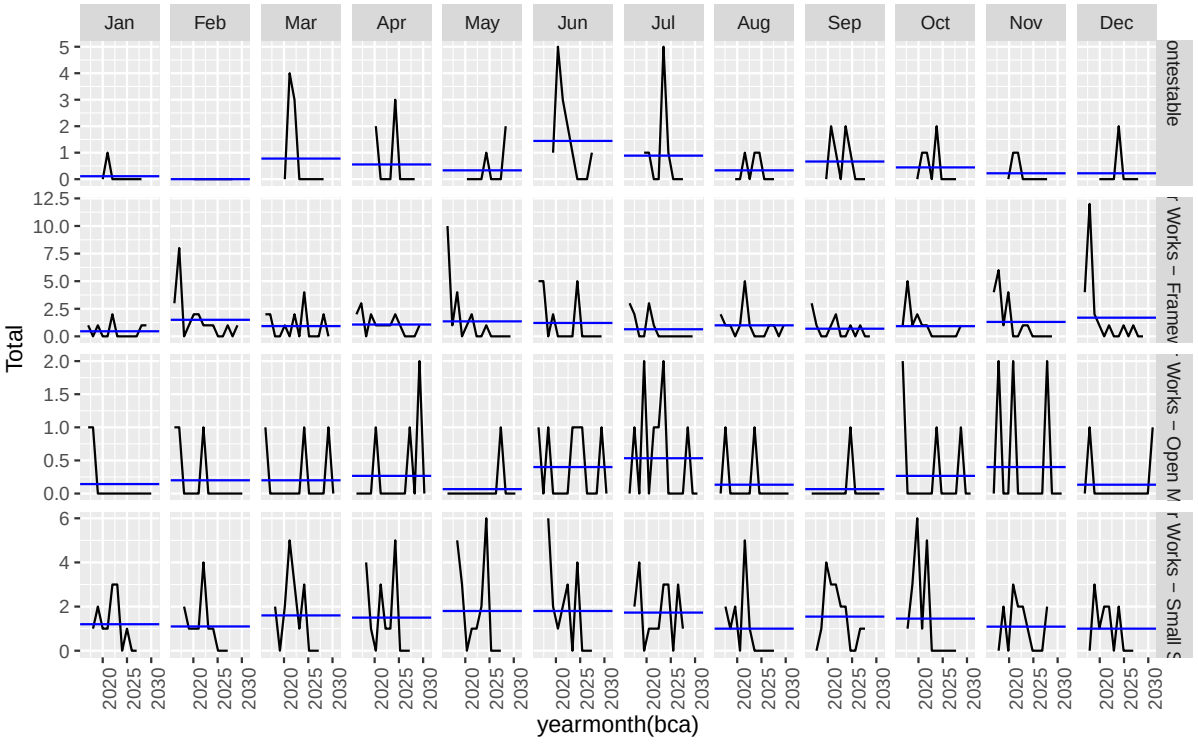
The purpose of this study is to outline the methodology and guidelines for conducting the Capital Delivery Model project data analysis. This analysis aims to develop a reproducible framework that compares the current delivery model with past models, providing valuable insights to enhance future delivery models planned for years between 2026 to 2031, and potentially use these learnings for future pricing submission periods.

By systematically examining past and present performance, the aim is to identify key trends, strengths, and areas for improvement, ensuring that future projects are executed more efficiently and effectively.

For the purpose of the current analysis, Melbourne Water Corporation's project data with business need identifier (BNI) dates between 2008 to 2024 were analysed. The major areas of study for the current analysis are delineated as follows:

1. Distribution of the projects in each delivery model based on the overall valuation of the projects as determined by the final forecast cost (FFC).
2. Distribution of the projects in numbers for each delivery model.
3. Distribution of project duration based on their overall valuations.
4. Project approval duration distribution across different stages of approvals.
5. Forecasted number of projects in the future delivery period from 2026 to 2031.

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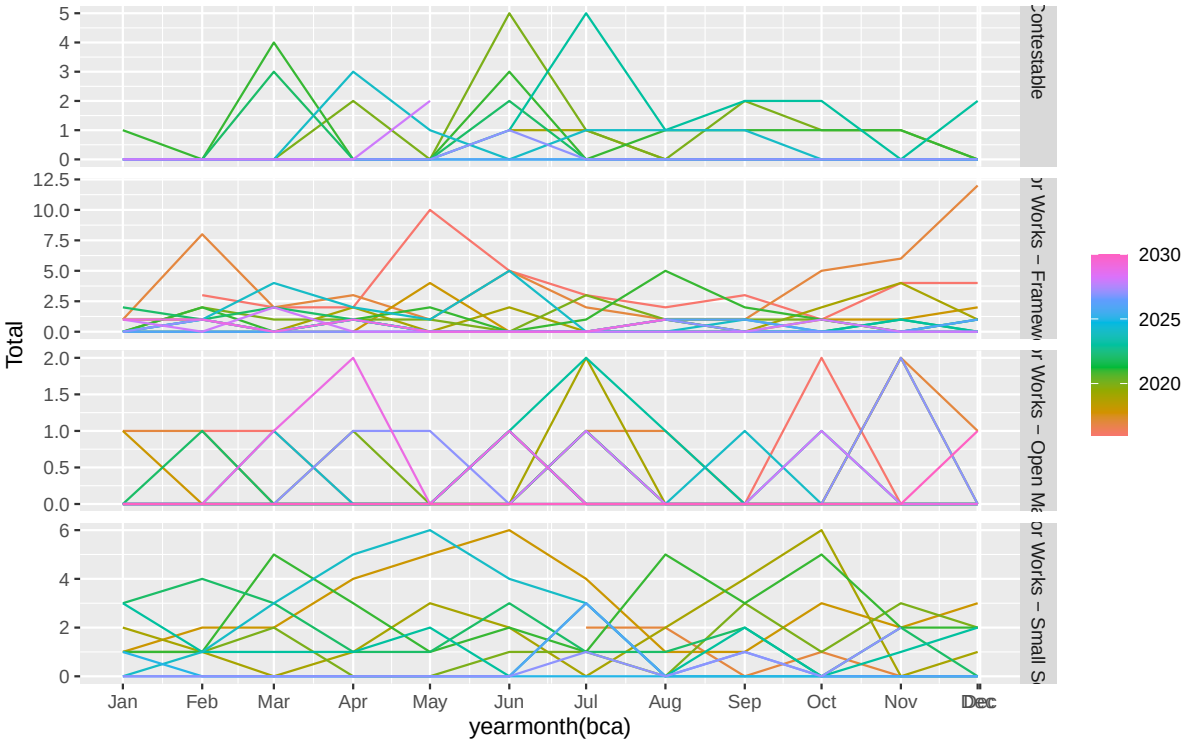
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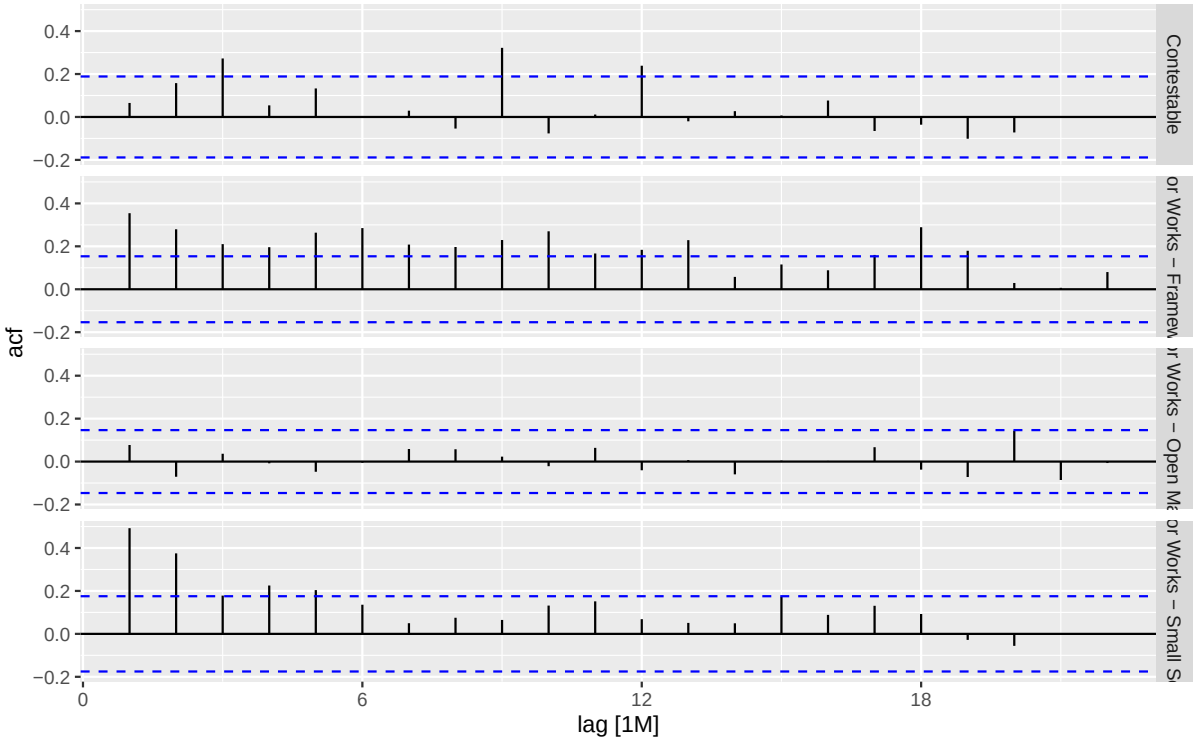
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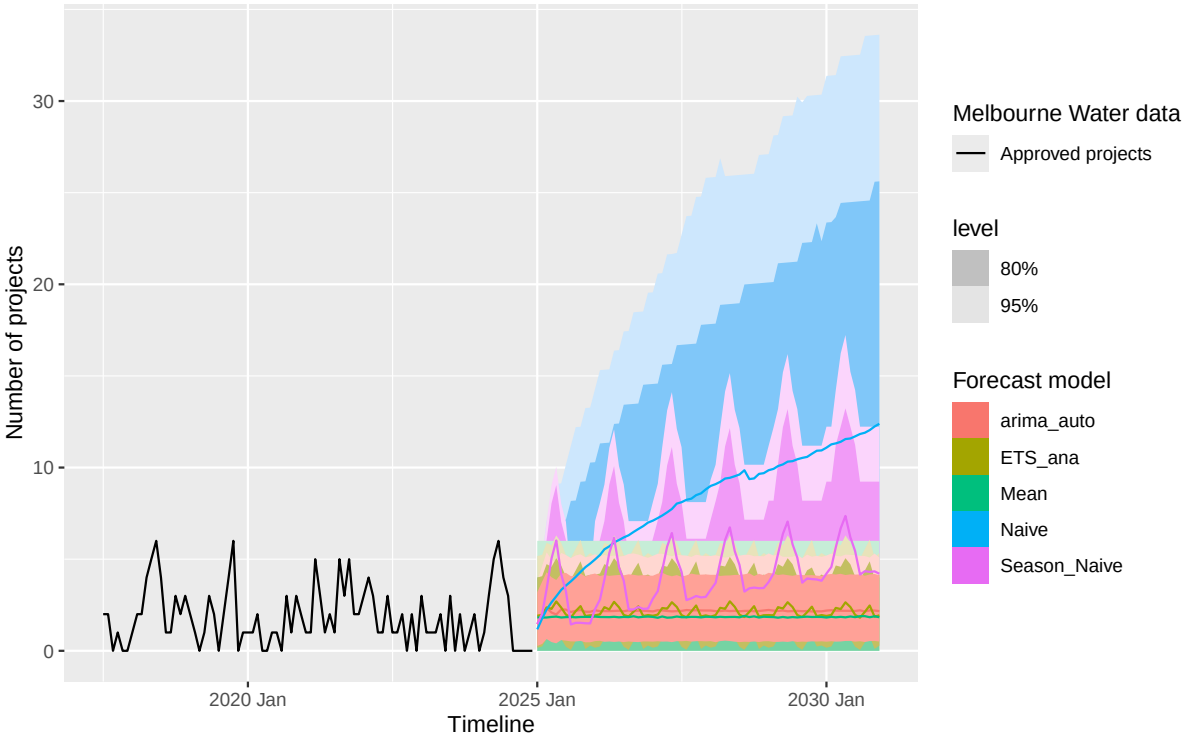
Number of projects
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2025 Jan
2030 Jan
Timeline
Melbourne Water data
Approved projects
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95%
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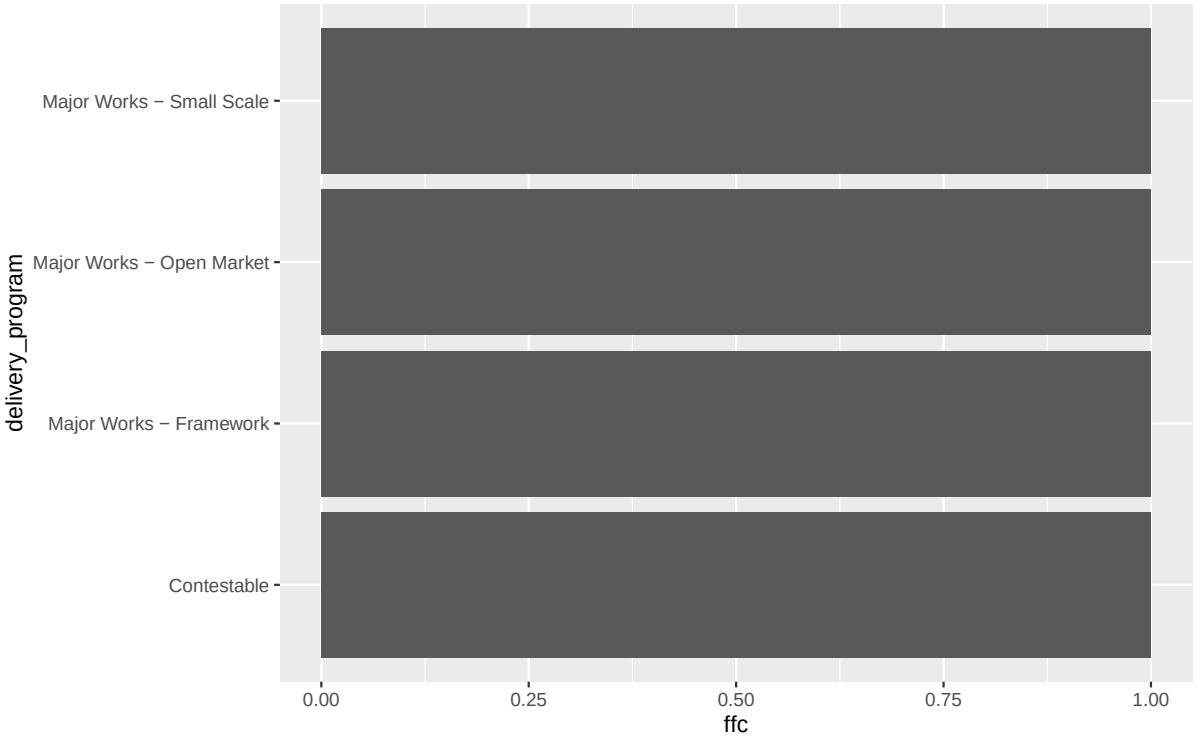
arima_auto
ETS_ana
Mean
Naive
Season_Naive



3 Data Source

The data for the current analysis has been sourced from the "Estimating & Scheduling" PowerBI dashboard in the Major Program Delivery workspace at Melbourne Water Corporation. This dashboard draws this data from the Microsoft Project Online software which logs individual project data based on the inputs of the assigned project managers. The data was exported as a CSV file on 19th July, 2024 and as such, contains the latest updated project valuations up to that date. Due to the sensitive nature of the data, there is no public access to this data.

Confidentiality statement

To comply with Melbourne Water Corporation's confidentiality requirements, the data has been de-identified and includes only the relevant fields necessary for obtaining insights for the intended evaluation purpose.

4 Introduction

The construction of large-scale infrastructure projects, commonly referred to as "CAPEX" projects, is highly resource-intensive and typically requires effective collaboration among multiple organizations for successful and timely completion. **no2013specification** suggests that in a collaborative work environment, teams are required to generate information using standardized procedures and agreed-

upon standards and methods. This ensures consistency in form and quality, allowing the information to be used and reused without the need for modification or interpretation. However, in practice, such high level collaboration is often challenging and needs well laid communication as well as contractual frameworks for effective

To initiate, monitor, and deliver these projects, a comprehensive framework is usually developed. This framework assesses the project's valuation and associated risks, and then engages the appropriate service providers to ensure timely project delivery. This framework which governs the delivery route of a project is termed as the Capital Delivery Model.

Each Capital Delivery Model presides over a period of 5 years, after the completion of which, a new Capital Delivery Model initiates. Before the creation of such a model,the host organisation (in this case, Melbourne Water Corporation) is required to submit a proposal of projects to be delivered over the next 5 years to the Department of Treasury and Finance, Government of Australia. Once the list of projects are approved or amended, a Capital Delivery Model is then designed, analysed, iterated and improved over a course of a year, after which, it is finally released to the market, where service providers may decide to get into a partnership with Melbourne Water for delivering the next set of infrastructures.

garcia2021measuring states that a key underlying challenge in today's model-driven approach to engineering is how progress and level of effort are being measured and reported. The goal of the current project is to quantify the key results of the past delivery models and obtain important insights which would allow for to design an improved capital delivery model for the upcoming pricing submission period between 2026-2031. In particular, the analysis would attempt to estimate the future number of projects and their expected valuations based on the distribution of projects in the current and past deliver models.

5 Motivation of the current study

The process of estimating the mix of the type of projects expected in the new capital delivery model after the 2026 price submission is based on the analysis of the current delivery model (CDM 2021) and the previous delivery model (CDM 2016). The forthcoming 2026 price submission is projected to surpass recent submissions in value, presenting significant challenges in project management. This includes the engagement of service providers for construction, efficient management of key crew resources, and rigorous monitoring to ensure timely infrastructure delivery. The current data analysis review of the projects in CDM 2016 and CDM 2021 will provide an adequate baseline of the expected proportion of the major capital delivery projects based on valuation and duration expected

in the future delivery model (CDM 2026), thereby providing insights and eventually aiding in the key decision making for creation of the frameworks.

The current analysis is performed by studying the following key parameters in the project data:

1. Total final forecast cost (FFC)
2. CDM period (2016, 2021 and 2026)
3. Project duration across each stage
4. Delivery Program

6 Objectives

The objectives and the scope of the analysis of the CDMs were defined through Melbourne Water fortnightly workshops and feedback as received from the project director and the steering group. These are delineated as follows:

1. The analysis must clearly indicate the performance level of project deliveries for both the current CDM-21 and the previous CDM-16. This should primarily focus on the duration of the projects and highlight any notable changes in this aspect.
2. Insights on the current and previous CDM must be able to provide a baseline for the estimated number of projects which can be expected in the future delivery model (CDM-26). These projections would allow for more informed decision making while building the contractual frameworks to engage service providers.
3. A detailed analysis of the historical project data should indicate the proportion of projects requiring approval by each governing body. This will provide an estimation of the duration of projects from the BNI stage to the BCA stage for the new delivery model, enabling better resource management.

7 Significance of the current study

Based on the numerous inputs from the project director and the steering group at Major Capital Delivery division in Melbourne Water, the the scope and significance for the current CDM data analysis project was finalised. These have been delineated as follows:

1. The analysis must provide an estimate of the project breakdown for CDM-26 after the latest price submission in 2026 by analysing the current delivery model (CDM-21) and the previous delivery model (CDM-16). This can be used as a basis for obtaining an informed prior information to design the new capital delivery model (CDM-26).

2. The analysis would supplement the decision making on effective selection of service providers for projects in the future delivery model based on the current distribution of the delivery programs across various FFCs and past CDMs.
3. The breakdown of the projects must allow a conservative estimate of the number of projects that would require approval at each level of authority, thereby indicating the approval duration for the project to be approved and initiated.
4. The analysis should aid in understanding how the proportions of projects in the future delivery model would differ from the benchmarks created by past models upon additional inputs.
5. Insights obtained from the total project duration and the average duration for the critical stages of each project may allow for effective project team planning.
6. The analysis must allow one to quickly detect outliers in the data and investigate these outliers further.

8 Methodology

This section is dedicated for the purpose of explaining the detailed methodology of the data analysis performed to obtain the actionable insights that will be delineated later in Section 9.

8.1 Selection of projects for analysis

While the dataset contains the details for projects undertaken by the various divisions of Melbourne Water Corporation, for the purpose of the current analysis, only those projects which are delivered or expected to be delivered by the Major Capital Delivery division are considered. In particular, these are those projects which are delivered through a contractual framework, called as the "Water and Sewerage Program", engineering maintenance projects to keep current assets running, or in certain instances, large projects which are tendered in the open market for service providers to bid.

In the current dataset, these projects are those which come under the delivery programs as tabulated in Table 1.

Table 1: *Major Capital Delivery programs*

Major Capital Delivery
Major Works-Small scale
Major Works-Framework
Contestable
Major Works-Open Market

As a result, while analysing the current data, projects with delivery programs matching the above list of programs are filtered.

8.2 Assigning project to each capital delivery model

While the data contains key dates such as the BNI, PBC, BCA and stages 1-3, however, it is essential to assign each project into its respective capital delivery model. Although this data is not readily captured at the source, however, through a deeper understanding of the critical project dates, a logic can be devised that assigns each project to a categorical variable indicating the version of CDM this model was a part of.

The hierarchy of a project approval flowchart is illustrated through Figure 1. This is a sequential process where the concept of a project is first identified and reported into the Project Online system on the BNI date. Once a project has been identified, a business case is prepared which undergoes an iterative process. The date of the first submitted business case is termed as the PBC. Once a project has been approved by the relevant Melbourne Water authority, the date is recorded as BCA. Stage 1 is the date on which the service provider claims that the project is now effectively "delivered". Special provisions within the contract as invoked by Melbourne Water with the service provider requires these two parties to collaborate together in order to repair any defects during the operation of the delivered infrastructure. This period typically ranges between 6 months to 1 year, post which, the project reaches its Stage 3 date and is now delivered in its entirety.

While selected projects may bypass some of the approval gates, however, this flowchart is generally true for all of Melbourne Water projects.

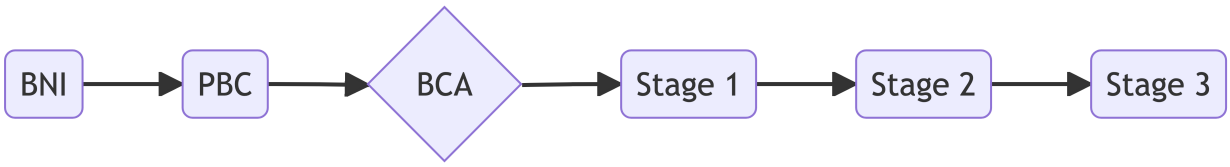


Figure 1: *Project approval gate flowchart*

For the purpose of assigning the delivery model to each of the projects, the BCA date is utilised as this is effectively the date when the project went live. On the other hand, the completion status of the project is determined based on whether the Stage 1 date is before or after the data export date. (19th July, 2024). Table 2 tabulates the criteria utilised for assigning each project to a relevant CDM.

Table 2: *Capital Delivery Model assignment criteria*

BCA Year	Capital Delivery Model
2016 <= BCA < 2021	C-16
2021 <= BCA < 2026	C-21

8.3 Project completion status

For the purpose of the current analysis, a project is considered to be "delivered" or "completed" if its Stage 1 date is prior to the date on which, the data was exported. The export date in this case is **19th July, 2024**. The completion criteria is further tabulated through Table 3.

Table 3: *Capital project completion criteria*

Condition	Status
Stage 1 date <= Data export date	Completed
Stage 1 date > Data export date	Ongoing

8.4 Project labour hours analysis

In the context of this analysis, labour hours refer to the total number of hours spent by both Melbourne Water personnel and the service provider's personnel on each project. Examining labour hours across various delivery programs may provide insights into current crew resource management.

The data for this analysis is sourced partly from Melbourne Water's internal enterprise resource planning (ERP) platform and partly from the service provider's quarterly data submissions. A single data frame is then created by performing an inner join based on the project ID number.

> Note
>
> Due to the sensitive nature of the data related to service provider submissions, a reproducible version of the dataset is not included in this analysis. However, visualisations and results will be detailed in later sections.

8.5 Classifying projects based on approval authority

Each capital project which is to be delivered within a CDM will require appropriate approvals from the relevant authority. The exact level of authorisation is generally based on the contract value of the project as well as the risk associated with each project. For the purpose of the current analysis, this decision is instead based on the FFC of the project. As a result, the total percentage of projects attributed to each authority is a conservative estimate of the actual expected projects. The FFC valuations that govern the authorisation level for a project is delineated in Table 4.

As the valuation of a project rises, it typically requires to go through multiple approval gates. This may extend the duration to obtain the BCA significantly, thereby causing delays in resource allocation, selection of the service provider for the project, and subsequent crew mobilisation. Through the analysis of the percentage of projects which fall under each approval authority, an informed decision can be made on the expected duration of approvals for a project.

Table 4: *Approval authority classification of projects based on FFC*

FFC of project ($)	Approval authority
0-2.5 mil	People leadership group
2.5-5 mil	Senior leadership group
5-8 mil	Executive leadership group
8-40 mil	Managing director
40-75 mil	Finance, audit and compliance
75-125 mil	Melbourne Water board
> 125 mil	Department of Treasury and Finance

8.6 Forecasting number of projects in the future CDM

The current analysis attempts to forecast the number of projects that are expected in CDM-26. For this purpose, the project data corresponding to the delivery models C-16 and C-21 are utilised to forecast the numbers in the future delivery model. As explained in Section 11, due to data migration and data integrity issues for the projects in the C-11 delivery model, this is not utilised as part of the current analysis.

Additionally, the forecasts were calculated for the "Major Works-Small Scale" delivery program. As explained in Section 9.1, this particular program tends to form the majority of the projects for any delivery model and also requires about as much labour hours as all other projects combined. Hence, a forecasted number of projects in each month and year of the new delivery program can allow for better crew resource management and will additionally aid in proactive procurement of raw materials rather than reactive procurement, allowing for more efficient delivery process.

The forecasts will be performed using both benchmark techniques as well as specialised techniques. These are listed in Table 5 and delineated further in Section 9.3.

Table 5: *Forecast techniques utilised for current analysis*

Forecast method
Mean
Naïve
Seasonal Naïve
ETS
ARIMA

8.7 Selecting an appropriate ETS forecast model

The selection of the ETS model would require us to study the timeseries data of the Major Works-Small Scale delivery program projects in detail and outline any important timeseries characteristics that might be beneficial to obtain the appropriate ETS model for forecasting the projects in the upcoming delivery model.

Figure 2 illustrates the additive decomposition of the time series data into its trend, seasonal, and remainder components. Analyzing the decomposed data enables us to select the most appropriate type of ETS model for forecasting the number of projects in the upcoming delivery period. The key characteristics of this time series are outlined below.

1. There appears to be a cyclic trend in the data which repeats itself in approximately 3 years as observed through the sinusoidal trend line. This indicates that there is no clear additive or multiplicative trend in the data which can be replicated through the ETS model. The ETS model is however well suited to work with cyclic data.

2. The seasonality of the current timeseries data indicates around 3 peaks when projects get approved in each year. Additionally, the seasonality appears to be fairly consistent throughout the years, indicating additive seasonality of the data.

3. The scale of the remainder appears to be large, meaning that the model is unable to capture some important characteristics in the timeseries, possibly due to the limited availability of the current data.

4. The remainder appears to have no distinct patterns in it and is centered around zero. This is an ideal outcome as it shows that information left over after accounting for the trend and seasonality in the data is unbiased and has a mean of zero over the entire timeseries.

5. Additionally, it can be observed through the autocorrelation function (ACF) plot in Figure 3 that the residuals are uncorrelated in nature, meaning no discernible patterns have leaked into

the residuals.

6. The distribution of the residuals has a **right skew**. While this may not affect the point forecasts directly, however, this is expected to **affect the prediction intervals which are assumed to be normally distributed in nature.**

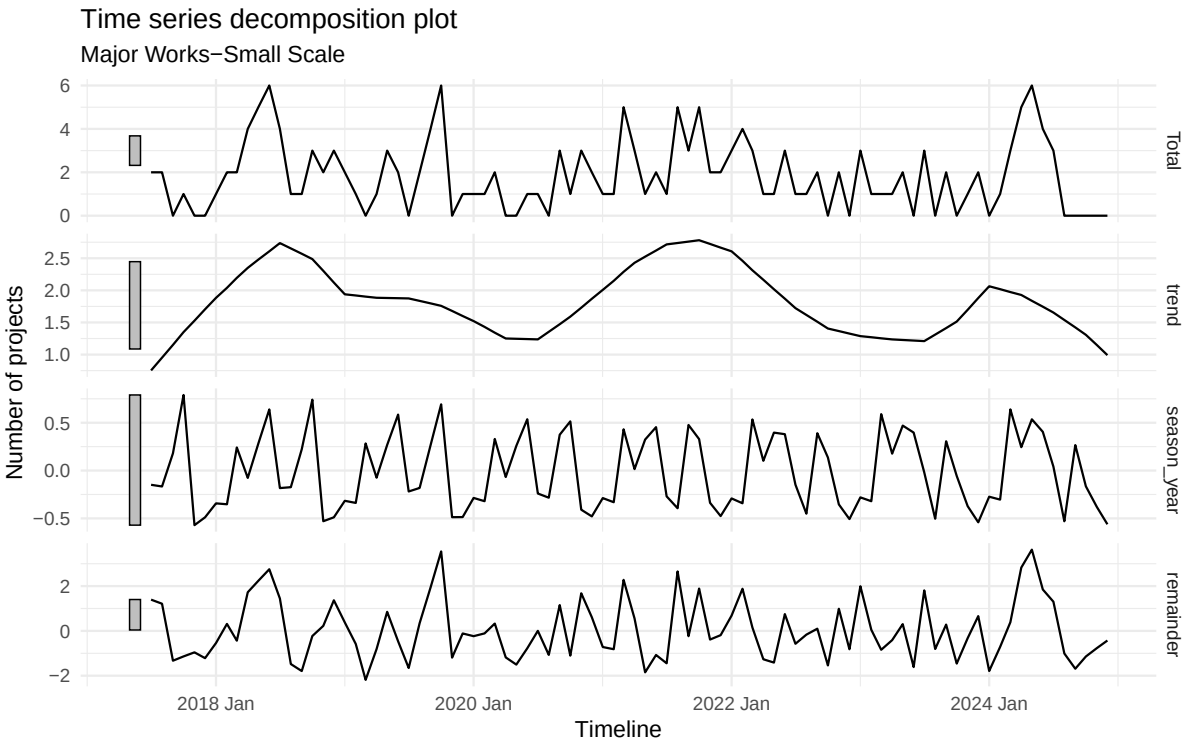


Figure 2: *Time series decomposition for Major Works-Small Scale projects*

Limitation

The current forecast models face limitations due to the unavailability of project data beyond the current and past CDM. As a result, the forecasts exhibit high uncertainty, characterized by large residuals and broad prediction intervals.

Nevertheless, with the accumulation of additional data in the future, the model is anticipated to produce more accurate point forecasts and narrower, more informative prediction intervals. The primary objective of this study is to establish a reproducible pipeline for generating these forecasts.

8.8 Tracking service provider's performance through KPIs and KRAs

The critical phase of a project initiates from the BCA to stage 3. As this is the period when the resources get allocated to projects, each day is expected to cost Melbourne Water. Hence, it is paramount to keep a track on the project completion and at the same time, ensure that the delivery of the project meets the quality requirements.

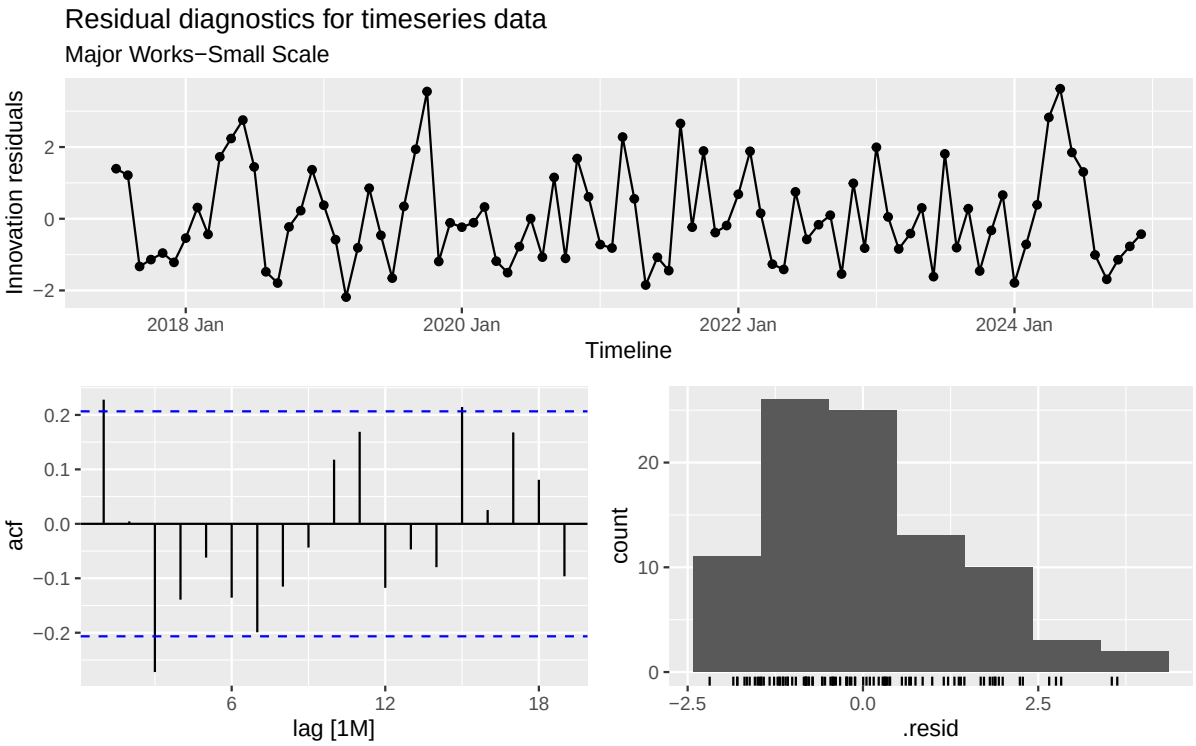


Figure 3: *Residual diagnostic plots*

kunkcu2022using have studied various construction management projects utilizing key performance indicators (KPIs) and found them to be highly effective tools for evaluating project performance. In the context of Melbourne Water's projects, the focus is to engage a service provider who is able to deliver the project within the constrained time period, communicates progress regularly, minimises cost and time variations,reports and mitigates unsafe work conditions, engages a diverse group of employees, and undertakes sustainable initiatives. These are called the key result areas (KRAs) and are drawn into a legal agreement while employing a service provider. A high KRA score often attracts a monetary incentive for the service provider, thereby making this an area of interest for both the key parties.

While the KRAs are subjective in nature and difficult to track, each of them are further quantified through the usage of KPIs. Based on the data provided by the service providers and through careful feature engineering, a framework to track and analyse project progress is delineated in Section 9. The role of the KPIs and KRAs are two-fold. First, these indicators allow the team at Melbourne Water to gauge the progress of the project, secondly, it allows Melbourne Water to engineer the right behaviour on the part of the service provider who is responsible for the construction of the project.

9 Results and Discussion

9.1 Distribution of projects by FFC bands for each delivery model

9.2 Labour utilisation analysis for each delivery program

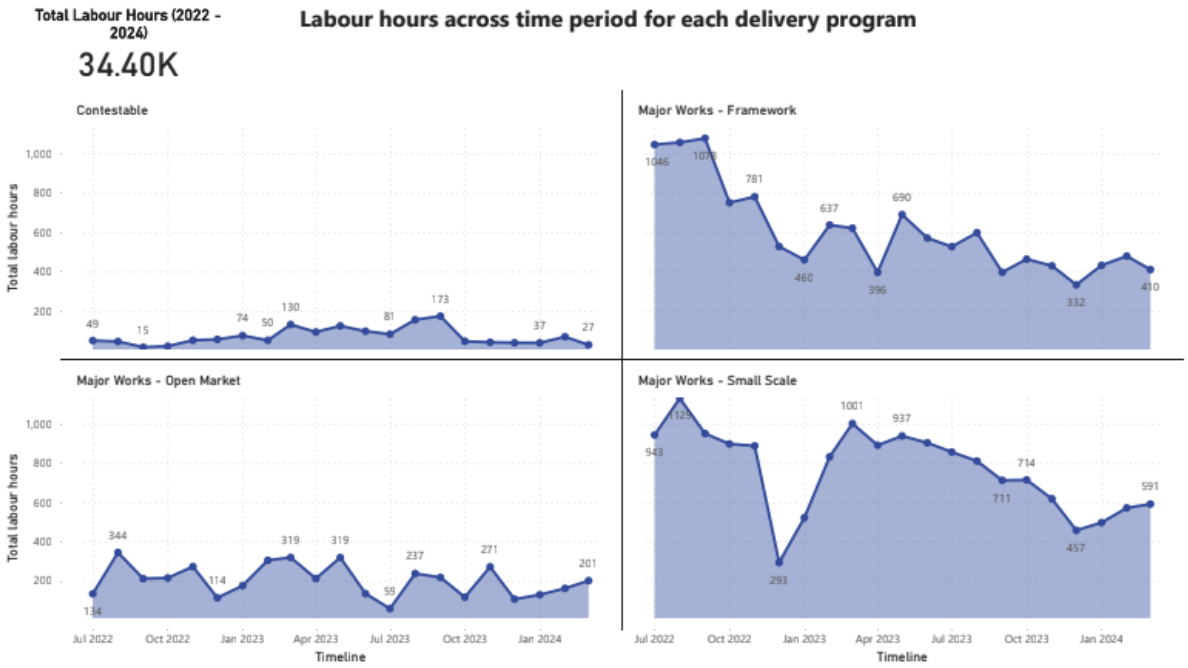


Figure 4: *Distribution of labour hours fo each delivery program*

Figure 4 depicts the distribution of the labour hours across each of the four delivery programs within MCD. The plot indicates that the current model is capable of delivering multiple small-scale and low risk contestable projects. The labour hours associated with Major Works-Framework and Major Works-Small Scale appear to be fairly similar, despite the fact that the **Small Scale projects account for about only 10% of the FFC in a delivery period**. The future CDM for PS-26 should consider **streamlining or bundling multiple small-scale projects together to generate higher efficiency in Project Management labour resource allocation.**

9.3 Forecasting number of projects in CDM-26

10 Conclusion

11 Limitations of the data

The limitations within the source of the data which may have affected the analysis are delineated as follows:

1. As the source file was exported from the Microsoft PowerBI organisational dashboard, certain fields such as the dates were not in their desirable format for the current analysis and were required to be converted into a machine-readable format.This was a critical step to perform the required exploratory data analysis and form the time-series data for forecasting purposes.

2. While the original dataset contains project data from 2008 to 2024, a recent software migration to the Microsoft Project Online platform has rendered the data for the period between 2008 and 2016 potentially unrepresentative. As a result, the current analysis utilizes data from 2016 to 2024. This period encompasses the two recent delivery model periods.

3. Multiple projects were observed to have empty PBC fields. This is likely due to the case where small scale projects tend to bypass one gate of approval to reduce approval duration. While this does not apply to all projects of similar nature, there is however no indicator in the data which allows for detection of such an event other than a missing date.

4. The dataset here is an observational data and in particular, a census data. Some of the limitations that are prevalent in such datasets are as follows :

    - Each row in the dataset is a project whose details are provided by an individual Project Manager. As a result, there may be non-uniformity in the data provided as each Project Manager may have their own interpretations of the data they may have provided.
    - The current dataset obtained is a subset of an observational data. These types of data are often plagued with lack of randomisation during the selection of data. This may lead to biases in the dataset such as selection and systematic bias.
    - The data maybe mis-classified or filled in non-uniform units by the various sources, leading to lack of accuracy of the overall dataset.

12 Key areas of improvement