Project Delay Analyses:

From DDC-Managed to Citywide Perspectives

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Introduction

Background

Public construction projects in New York City, managed by the Department of Design and Construction (DDC), operate under strict rules like Wicks Law and safety standards. Despite this, delays are common due to budget issues, supply chain disruptions, and design changes.

Focus

Based on DDC Project findings, this study analyzes detailed data from the Capital Projects Dashboard to identify the main factors causing delays in public construction projects. The goal is not to predict delays but to understand which factors have the biggest impact on timelines.

Research Objective

The City Capital Projects analysis are divided into three levels:

1. Citywide: Overall trends and key delay factors.
2. Borough: Variations in delays across NYC boroughs.
3. Sponsor Agency: Delays specific to different agencies.

Dataset Overview

DDC Dataset

Source	Purpose	Key Features	Records	Years Covered
DDC Spring/Summer Research	Identify key causes of delays in DDC projects	- Dealy Categories: weather, funding, etc. - Impact: Delay Days	- 500+ project delay entries - 4402 records	Mainly focus on 2019-2022

City Capital Projects

Source	Purpose	Key Features	Records	Years Covered
NYC Open Data	Analyze delays and trends across citywide/ agency/ borough levels	- Variance: forecast vs. actual completion - Data by borough, agency, project	- 8000+ project entries - 343 records with delays after cleaning	Mainly focus on 2023-2024

DDC Dataset Description

Key Variable	Description	Example
Project ID	Unique identifier for each project.	DDCProject1
Division	Department or division responsible for the project.	Public Buildings, Infrastructure
Borough	Borough where the project is located (7 total).	Brooklyn
Parent Project Type	High-level categorization of the project type.	EXTERIOR RENOVATION
Project Type	Specific type or nature of the project undertaken.	Plazas, Highway
Delays/Gains	Indicates if the project experienced delays or gains.	Delay, Gain
Delay Category	Main category of delay reasons (9 total).	Construction Conditions, Stakeholder Management
Delay Subcategory	Subcategory providing detailed delay reasons (44 total).	Health and Safety, Funding, 1.99 Other, 7.99 Other
Delay Impacted Phase	Project phase impacted by the delay (5 total).	Construction, Design, Closeout
Delay Description	Detailed description of the reason for the delay.	The rear wall of the building (East Side) collapse...
Overall Schedule Impact	Total schedule impact due to delays, measured in Calendar Contract Days (CCDs).	225
Delay Start Date	Date when the delay started.	10/26/2021 00:00
Delay End Date	Date when the delay ended.	6/8/2022 00:00

City Capital Projects Dataset Description

Key Variable	Description	Example
Reporting Period	Time period for which the report was generated (YYYYMM format).	202405
Managing Agency	The agency responsible for managing the project (9 total).	FDNY, NYPD, DOT, HRA
Borough	Borough where the project is located (6 total).	Manhattan
Sponsor Agency	The agency funding or sponsoring the project (20 total).	DCAS, DCLA, QPL, DEP
Agency Project Name	Name of the project undertaken by the agency.	CIG - David H. Koch Theater
Current Phase	The current stage or status of the project (4 total).	Design, Construction, Close-out
Completion Date Type	Indicates whether the date is a forecast or an actual completion.	Forecast, Actual
Variance (day)	The difference between planned and actual/forecast completion dates (in days).	137
Reason for Forecast Completion Change	Reasons provided for changes in the forecast completion date (11 total).	PROJECT DELAYED DUE TO CHANGES IN SCOPE/DESIGN
Completion Date	The forecasted or actual project completion date.	3/31/2025 00:00
Data Date	The date on which the data was recorded or updated.	7/11/2024 00:00
Total Budget	Funds allocated to the project.	17403000

Methodology

For DDC dataset:

Data Processing: **One-hot encoding** was used to represent categorical data, specifically the types of delays. Each delay type were converted into binary code. We took off Covid related Data and unclassified data. **Categorical Classification** allowed us to organize delays into specific categories and use **Pearson Correlation** to identify linear relationships between delay features and schedule impacted. And **Regression** to identify significant contributors to delays. We conducted **Grouped Analysis** to calculate average delayed days and **Random Forest Model** to forecast the expected delay period for each feature and feature importance after standardization.

For City Capital Projects dataset:

Data matching processing involved aligning two datasets by leveraging key identifiers such as “Agency Project Name” and “Reporting Period”. And inner join operation was employed, ensuring only records present in both datasets were retained. **Data filtering analysis** further refined the matched dataset by isolating records with valid entries in specific fields, particularly the column related to reasons for forecast completion changes.

DDC Dataset - Regression Analysis Post-Standardization

Context and Importance of Standardization

- Initial regression analysis revealed excessively large coefficients (Budget Issues: 128.46, Weather: -88.22), complicating interpretation.
- By standardizing the variables (mean = 0, SD = 1), coefficients are now comparable across delay types, enabling clearer insights.

$$Standardized\ Value = \frac{Original\ Value - Mean}{Standard\ Deviation}$$

- Budget and funding issues remain the most critical factor, significantly driving delays.
- Negative coefficients for Weather and Safety highlight suggest that delay caused by these factors are often managed through schedule adjustments, reflecting proactive planning and flexibility in project timelines.

Delay Type	Coefficient	P-value	Significant (Yes/No)
Delay_Type_Budget and Funding Issues	22.541352	0.000003	Y
Delay_Type_Permit Approval Delays	9.285251	0.054431	N
Delay_Type_Technical or Design Changes	9.236762	0.056123	N
Delay_Type_Client/Stakeholder Changes	8.945867	0.062435	N
Delay_Type_Regulatory Changes	0.944572	0.843862	N
Delay_Type_Labor Issues	-2.756497	0.565468	N
Delay_Type_Supply Chain Management	-5.622737	0.242361	N
Delay_Type_Safety and Health Issues	-10.350819	0.031213	Y
Delay_Type_Weather Conditions	-12.819467	0.007708	Y

DDC Dataset - Random Forest Feature Importance

- We also utilize the Random Forest model to conduct a feature importance analysis using standardized data.
- Budget and Funding issues remain the most important feature. Following Permit Approval delays and Client/Stakeholder Changes.
- Weather conditions were mostly predictable and they were able to change the project schedule based on the weather.

Delay Type (9 types)	Feature Importance
Delay_Type_Budget and Funding Issues	0.3054
Delay_Type_Permit Approval Delays	0.1893
Delay_Type_Client/Stakeholder Changes	0.1804
Delay_Type_Weather Conditions	0.1241
Delay_Type_Safety and Health Issues	0.0969
Delay_Type_Technical or Design Changes	0.0628
Delay_Type_Supply Chain Management	0.0249
Delay_Type_Regulatory Changes	0.0082
Delay_Type_Labor Issues	0.0079

DDC Dataset - Conclusions and Recommendations

Summary

All projects in our study are delayed, the sign of a coefficient does not alter the fact of the delay but rather helps gauge the degree to which each factor influences the delay.

- **Budget and Funding Issues**: Highest standardized coefficient (+22.54, $p < 0.001$), and feature importance score of 0.3054. Budget constraints and funding approval inefficiencies often create a bottleneck, delaying multiple project phases.
- **Permit Approval Delay:** Second highest standardized coefficient (-103.79), and importance score of 0.1893. Inefficient approval processes delay project initiation and execution, compounding other issues.
- **Client/Stakeholder Changes:** Positive coefficient (+14.89), highlighting its impact on resource reallocation and timeline adjustments. And Importance score of 0.1804. Frequent design or scope changes driven by stakeholders disrupt schedules and add complexity.

Together, these three categories emerge as the most critical factors contributing to delays, based on multiple analyses performed. These factors often trigger cascading effects, compounding delays across multiple project phases.

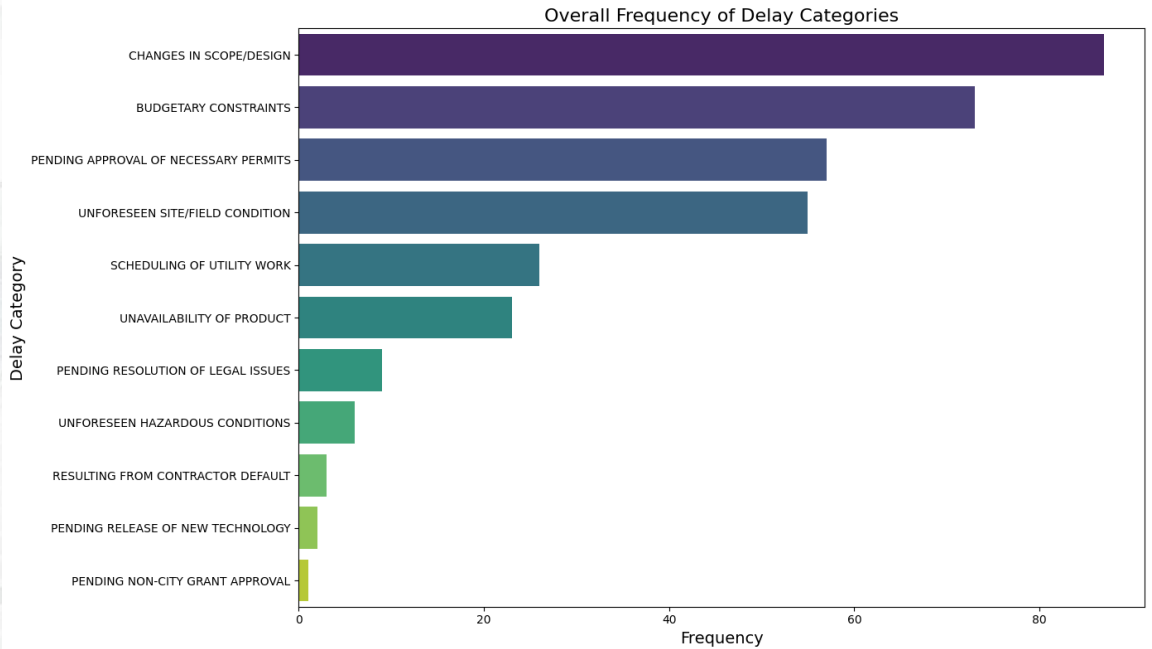
Limitation

The low R-squared value of approximately 0.4 for each individual condition suggests that the model explains only a portion of the variance in project delays.

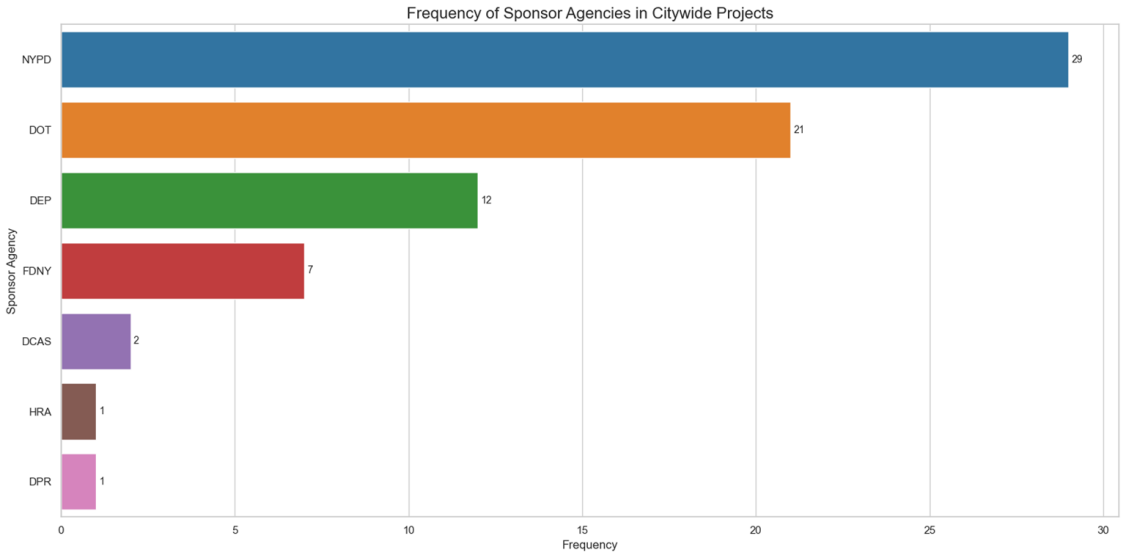
City Capital Projects Managed by NYC

- A total of 342 out of 8600 projects were delayed between 2023 and 2024 in New York City. These projects were classified into 11 delayed categories.
- Budget constraints, changes in scope/design, and pending approval issues appeared to be the most significant features among boroughs.

$$Frequency = \frac{Number\ of\ Projects\ in\ a\ Delay\ Category}{Total\ Number\ of\ Delayed\ Projects}$$



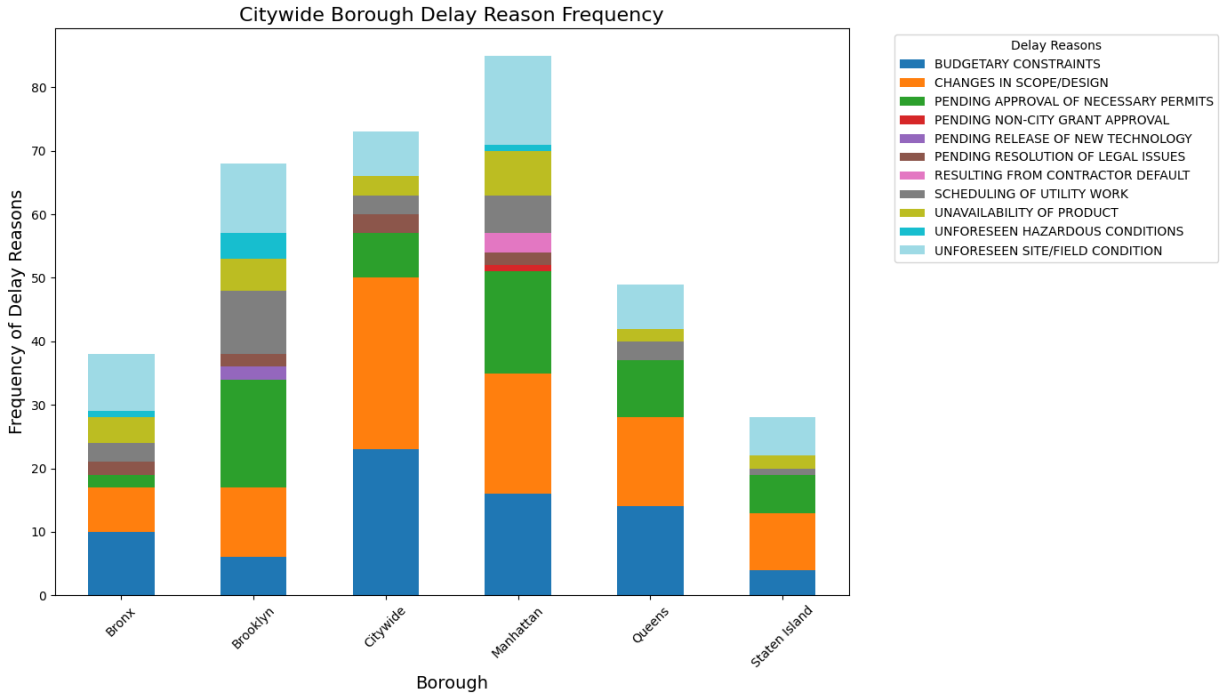
City Capital Projects Managed by NYC - Citywide



- **NYPD** and **DOT** clearly dominate Citywide projects, reflecting the city's priorities on safety and transportation.
- Agencies like **DEP** play a medium-scale role, emphasizing the significance of environmental concerns.
- The lower frequencies for **DCAS**, **HRA**, and **DPR** imply their involvement is more focused or specific to particular tasks.

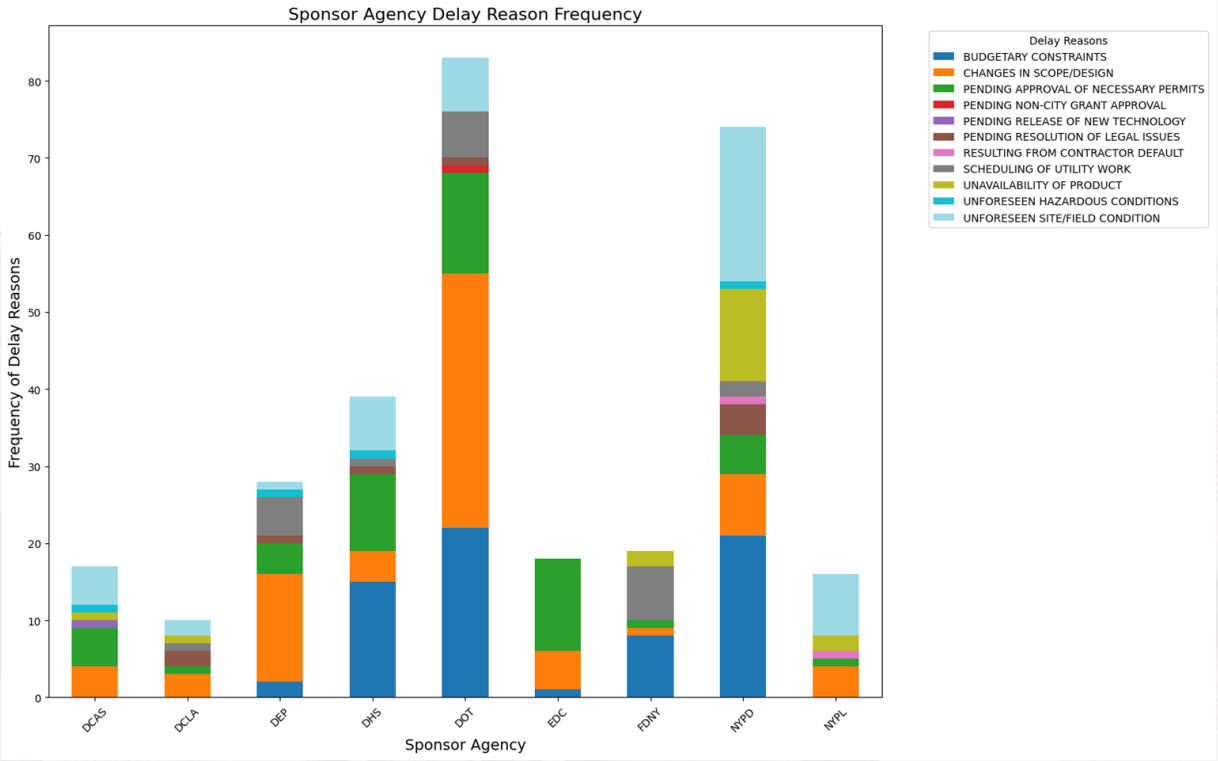
City Capital Projects Managed by NYC - Borough

- Manhattan experienced the most delayed projects, with the least delayed period (236 days) in average.
- Budget constraints, changes in scope/design, and pending approval issues appeared to be the most significant features among boroughs.



City Capital Projects Managed by NYC - Sponsor Agency

- **DOT** experienced the highest number of delays, significantly surpassing other agencies.
- **Budget constraints**, **design scope changes**, and **approval delays** were the primary causes of project delays.



Conclusion

- **Budget and Funding Issues**:

  Both datasets consistently highlighted budget and funding delays as the primary cause of project setbacks. In the DDC dataset, this factor had the highest feature importance score (0.3054), while the City Capital Projects dataset confirmed its prevalence across boroughs and agencies.

- **Permit Approval and Regulatory Delays**:

  The DDC dataset revealed that delays in permit approvals disrupt project initiation, with a notable feature importance score of 0.1893. Similarly, the City Capital Projects dataset emphasized this issue, particularly in large-scale infrastructure projects managed by agencies like the Department of Transportation (DOT).

- **Stakeholder and Design Changes**:

  Changes driven by stakeholders significantly impacted timelines in both datasets. The DDC dataset highlighted frequent disruptions caused by design changes, while citywide data showed that this issue was most prevalent in Manhattan and DOT projects.

- **Borough-Level and Citywide Trends**:

  The City Capital Projects dataset revealed borough-level disparities, such as Manhattan's shorter average delay period despite a high volume of delayed projects, reflecting efficient mitigation strategies. The DDC dataset corroborated citywide trends, with issues like budget constraints and permit delays consistently affecting multiple boroughs.

Future Directions

- **Integrated Recommendations:**

  Addressing Budget and Funding Delays

  Improving Inter-Agency Coordination

  Enhancing Stakeholder Management

  Borough-Specific Strategies

- **Model Improvements:**

  Incorporate additional data, such as concurrent delays and time-series analysis.

  Refine delay classifications to enhance prediction accuracy.

- **Policy Implications:**

  Enhance risk assessment capabilities and promote sustainable construction practices.

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THANK YOU

Special thanks to Terri Matthews for facilitating this collaboration through the Town+Gown program which bridges academia and city government