Preliminary Analysis of Citywide Project Delay Categories

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1 Introduction

Delays in construction projects are a common challenge in urban infrastructure management, leading to increased costs, disrupted schedules, and inefficiencies in service delivery. In a city as large and dynamic as New York City (NYC), understanding the root causes of project delays is critical for improving project outcomes and optimizing resource use. This study focuses on 342 delayed projects managed between 2023 and 2024, identified from NYC's Capital Projects Dashboard. These projects, out of a total of 8600 citywide projects, were classified into 11 delay categories, such as budgetary constraints, changes in scope/design, and pending approvals. These categories highlight common and recurring issues faced by public projects.

The objectives of this research are threefold:

- To identify the primary causes of construction delays in NYC projects.
- To analyze how delays vary across citywide projects, boroughs, and sponsor agencies.
- To propose targeted strategies to address the key delay factors and improve project performance.

This study employs a data-driven approach, combining frequency analysis with comparative assessments across different dimensions: citywide trends, borough-level variations, and sponsor agency performance. This research contributes to both academic understanding and practical solutions for managing public construction projects by providing a systematic analysis of delay categories and their distributions.

2 Data Description

This dataset is derived from the Capital Projects Dashboard, combining two data files: one detailing project schedules and variances and the other focusing on budget and schedule updates. The datasets were matched based on the 'Agency Project Name' and 'Reporting Period' columns, ensuring alignment between project-level schedule data and budget updates for comprehensive performance analysis. Data cleaning procedures were performed to prepare the dataset for analysis. These included standardizing column formats and handling discrepancies to facilitate accurate merging. The final dataset contains 343 delayed projects out of 8600 total citywide projects, providing a clear basis for analyzing project delays. The dataset includes the following core variables:

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.	DCAS
Borough	The borough or location associated with the project.	Manhattan
Sponsor Agency	The agency funding or sponsoring the project.	DCAS
Agency Project Name	Name of the project undertaken by the agency.	100 GOLD ST - BATHROOM RENOVATION
Current Phase	The current stage or status of the project (4 total).	Design
Completion Date Type	Indicates whether the date is a forecast or an actual completion.	Forecast
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

3 Methods and Results

3.1 Frequency Analysis

To systematically analyze the causes of delays in NYC capital projects, this study classifies the delays into 11 distinct categories based on the dataset. These categories represent the primary reasons for forecast completion changes and provide a structured framework for further quantitative analysis. The categories include:

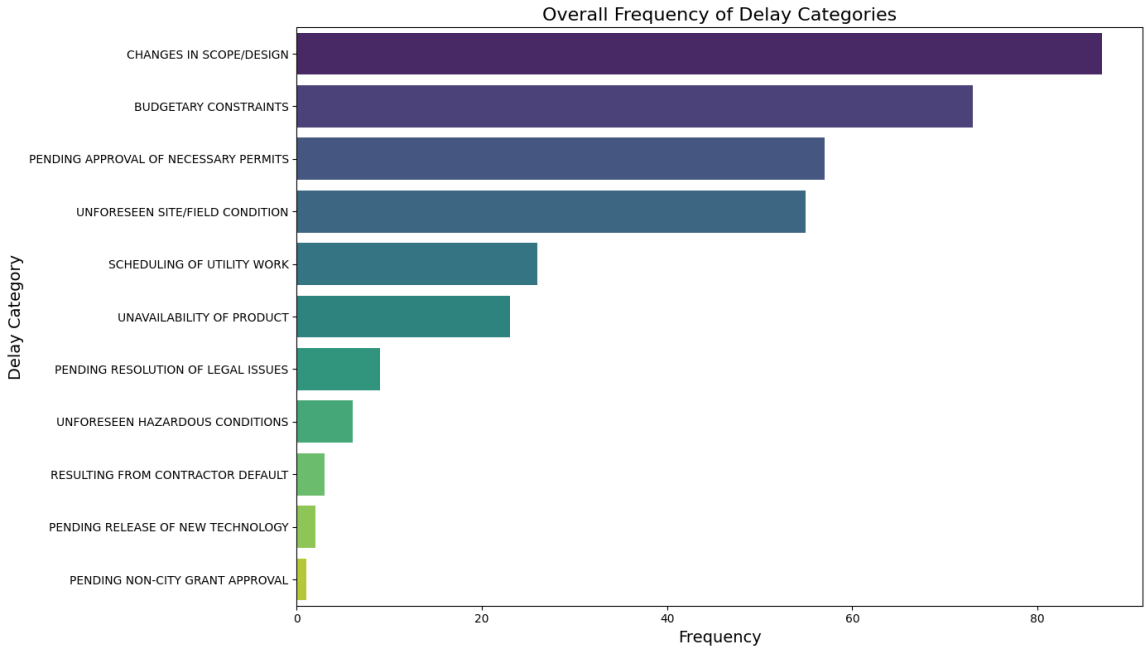
- Budgetary constraints
- Changes in scope/design
- Pending approval of necessary permits
- Pending resolution of legal issues
- Pending release of new technology
- Unforeseen site/field conditions
- Scheduling of utility work
- Unavailability of product
- Unforeseen hazardous conditions
- Resulting from contractor default
- Pending non-city grant approval

3.1.1 Frequency Analysis

The frequency analysis calculates the proportion of projects in each delay category relative to the total number of delayed projects. The following formula is applied:

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

The results, as shown in the following figure, reveal that changes in scope/design occur most frequently, followed by budgetary constraints and pending approval of necessary permits. These three categories account for a significant proportion of delays, highlighting the need for improved planning and approval processes. The analysis shows that changes in scope/design represent the most frequent cause of delays among NYC capital projects. This category alone accounts for a significant portion of the delays, indicating recurring challenges in managing project scope and design adjustments. Budgetary constraints follow closely, highlighting the impact of funding issues on project timelines. Additionally, pending approval of necessary permits ranks as the third most common delay category, reflecting administrative challenges that often prolong project completion.



Other notable delay categories include unforeseen site/field conditions and scheduling of utility work, which further emphasize the importance of effective site management and coordination with external stakeholders. Less frequent delay causes, such as pending release of new technology and non-city grant approvals, while less common, still contribute to project delays and should not be overlooked.

3.1.2 Average Delay Days by Type

While the frequency analysis reveals the prevalence of each delay category, the average variance in days highlights the severity of delays within each category. The variance is calculated as the difference between the planned and actual (or forecast) completion dates for projects in a given category. The formula used is as follows:

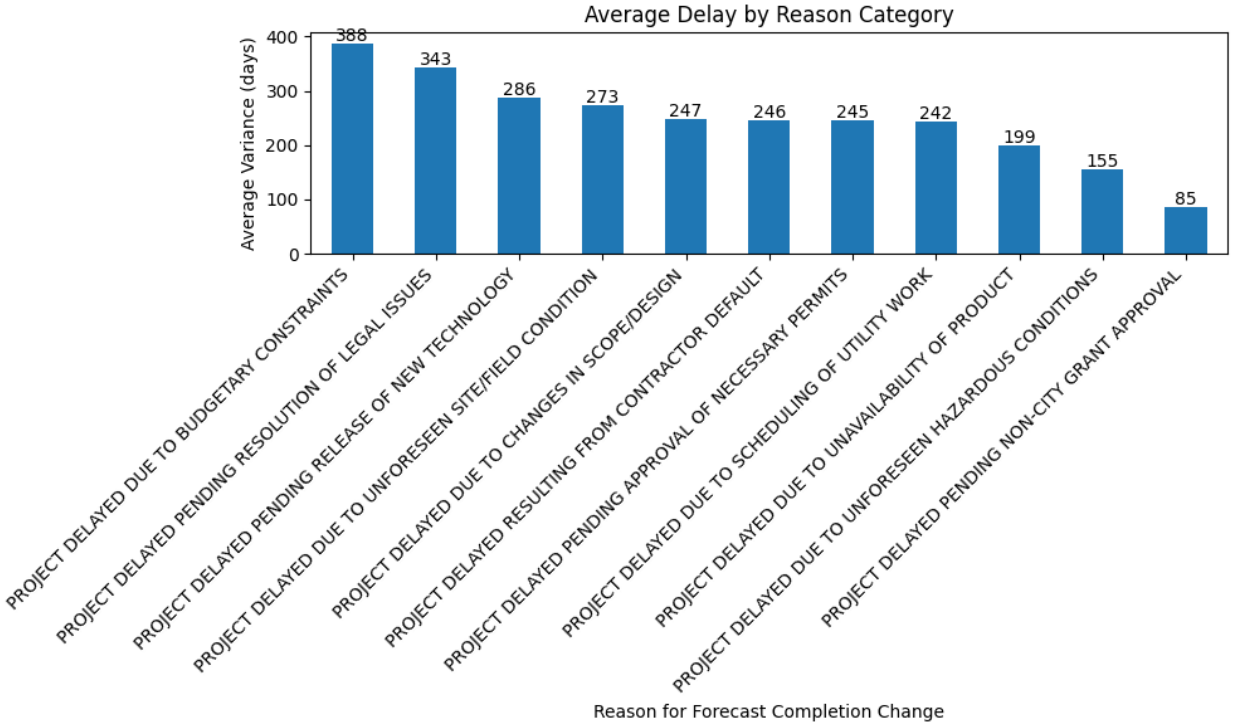
$$\boldsymbol{Average\ Variance\ (Days)} = \frac{\sum_{i=1}^{n} \ (\boldsymbol{Actual\ Completion\ Date\ -\ Planned\ Date})_i}{\boldsymbol{n}}$$

The results, summarized in the following table, show that delays caused by budgetary constraints have the largest average variance, with projects delayed by approximately 388 days on average. This is followed by delays due to the pending resolution of legal issues (343 days) and the release of new technology (287 days). In contrast, delays caused by non-city grant approvals have the smallest average variance, averaging 85 days:

Reason for Forecast Completion Change	Average Variance (Days)
Project Delayed Due to Budgetary Constraints	387.853333
Project Delayed Pending Resolution of Legal Issues	342.545455
Project Delayed Pending Release of New Technology	286.500000
Project Delayed Due to Unforeseen Site/Field Condition	272.916667
Project Delayed Due to Changes in Scope/Design	246.989011
Project Delayed Resulting from Contractor Default	246.166667
Project Delayed Pending Approval of Necessary Permits	245.150000
Project Delayed Due to Scheduling of Utility Work	242.423077
Project Delayed Due to Unavailability of Product	198.833333
Project Delayed Due to Unforeseen Hazardous Conditions	154.857143
Project Delayed Pending Non-City Grant Approval	85.000000

3.1.3 Average Delay by Reason Category

This section provides a detailed analysis of the average variance in days for each delay category. The average variance quantifies the severity of delays, representing the difference between the planned and actual or forecast completion dates. The results highlight the specific impact of each delay cause as follows:

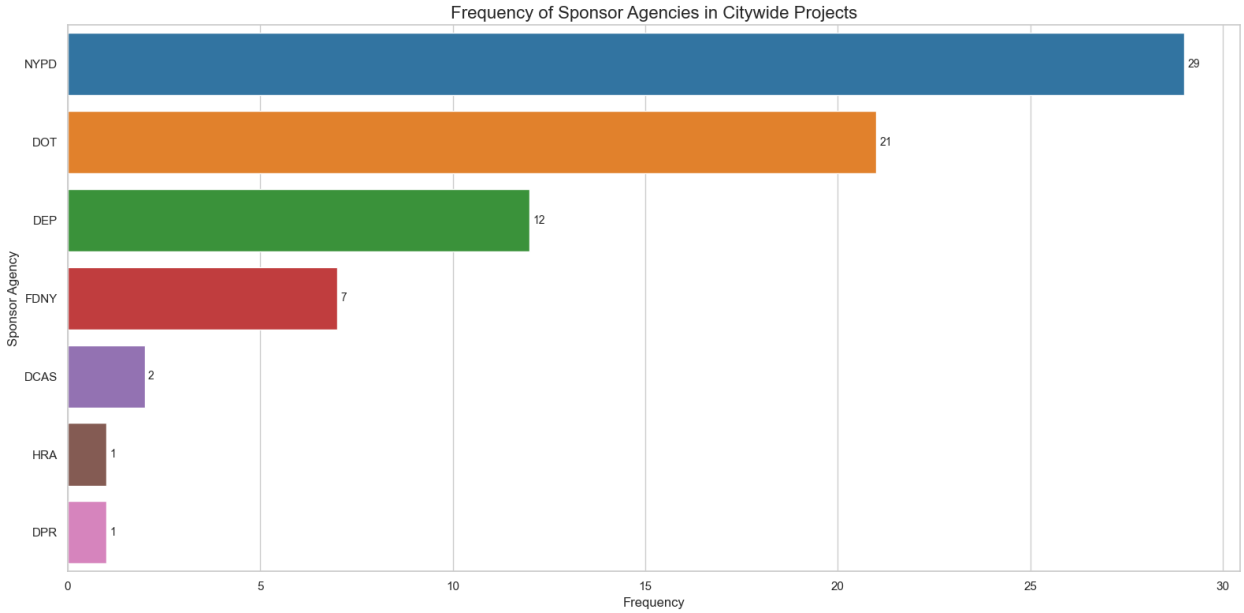


- Project Delayed Due to Budgetary Constraints (388 days): Delays caused by budgetary constraints result in the longest average delay, approximately 388 days. This underscores the significant impact of funding issues on project timelines.
- Project Delayed Pending Resolution of Legal Issues (343 days): If a project is delayed due to pending resolution of legal issues, the average delay is approximately 343 days, reflecting administrative or contractual challenges.
- Project Delayed Pending Release of New Technology (287 days): Delays caused by waiting for the release of new technology lead to an average delay of approximately 287 days. This highlights the role of technological dependencies in project progress.
- Project Delayed Due to Unforeseen Site/Field Conditions (273 days): Projects encountering unforeseen site or field conditions experience delays of approximately 273 days on average, indicating the unpredictable nature of site-related issues.

- Project Delayed Due to Changes in Scope/Design (247 days): Delays resulting from changes in scope or design average around 247 days, emphasizing the need for stable planning and design processes.
- Project Delayed Resulting from Contractor Default (247 days): If a project is delayed due to contractor default, the average delay is approximately 247 days, similar to delays caused by scope/design changes.
- Project Delayed Pending Approval of Necessary Permits (246 days): Delays pending the approval of necessary permits lead to an average delay of 246 days, highlighting the importance of streamlined administrative procedures.
- Project Delayed Due to Scheduling of Utility Work (243 days): Scheduling conflicts with utility work result in an average delay of approximately 243 days, reflecting coordination challenges with external entities.
- Project Delayed Due to Unavailability of Product (199 days): Delays caused by unavailability of critical products average 199 days, indicating supply chain and procurement-related issues.
- Project Delayed Due to Unforeseen Hazardous Conditions (155 days): If unforeseen hazardous conditions arise, the average delay is approximately 155 days, showing the importance of risk assessments and safety planning.
- Project Delayed Pending Non-City Grant Approval (85 days): Projects delayed due to pending non-city grant approvals have the shortest average delay of approximately 85 days, suggesting a relatively smaller impact compared to other causes.

3.2 Citywide Analysis

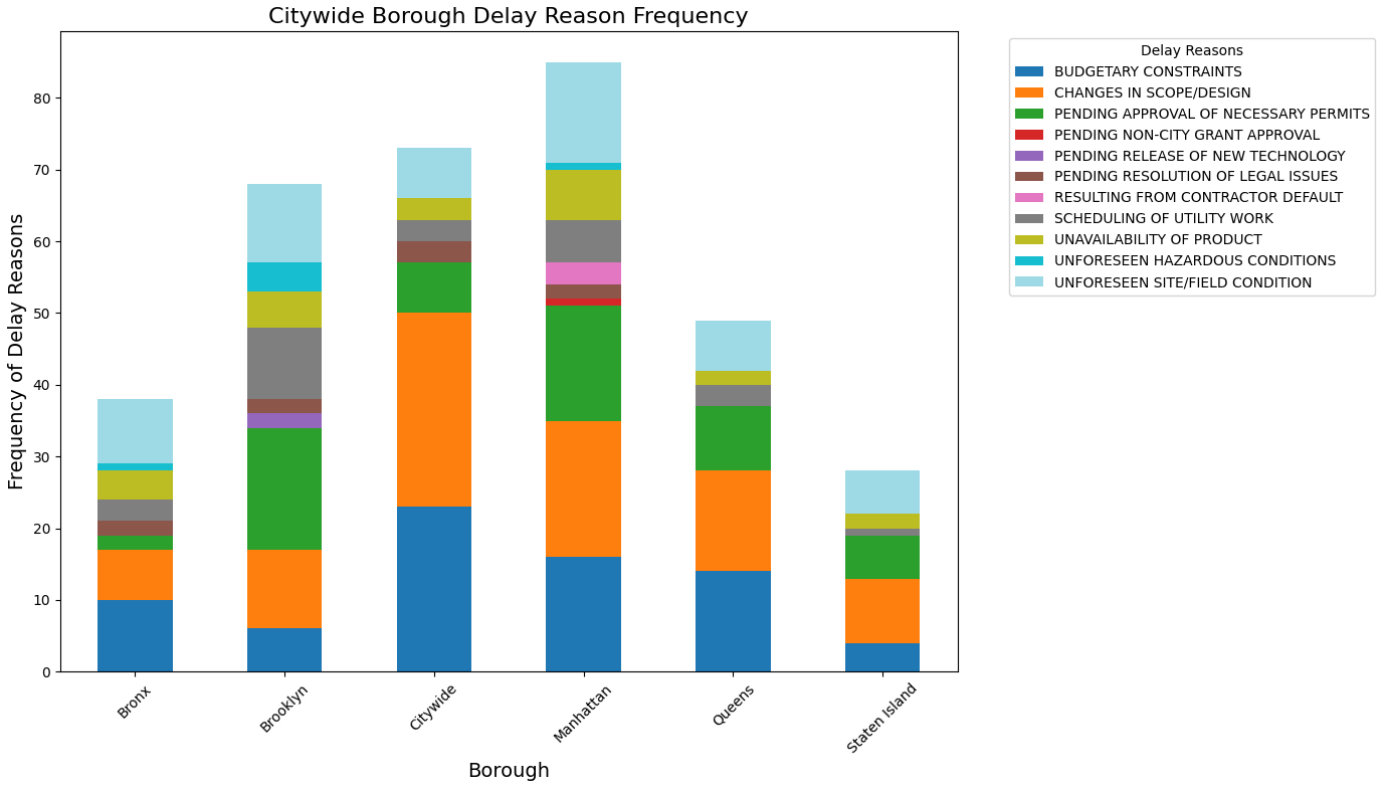
This chart illustrates the frequency distribution of sponsor agencies involved in citywide projects. The data reveals significant disparities in the level of participation among agencies, with certain entities playing a dominant role in sponsoring projects. This suggests their centrality to specific domains of urban development and management. The distribution highlights the alignment of agency involvement with their respective mandates and areas of specialization, shedding light on the strategic priorities of citywide initiatives.



- **NYPD**: With the highest frequency of 29 projects, NYPD emerges as the most prominent sponsor agency. This dominance underscores its crucial role in initiatives related to public safety, law enforcement, or community welfare.
- **DOT**: DOT closely follows with 21 projects. This indicates its major involvement in infrastructure and transportation-related projects, aligning with its mandate to ensure efficient urban mobility and infrastructure development.
- **DEP**: DEP sponsors 12 projects, reflecting its active role in environmental conservation and utility-related initiatives such as water management and sustainability efforts.
- **FDNY**: With 7 projects, FDNY contributes to projects likely focused on emergency response, fire safety, and community preparedness, showcasing its specialized focus.
- **DCAS**: DCAS is associated with 2 projects, indicating a more administrative or logistical role in citywide operations, which might include building management or workforce services.
- **HRA and DPR**: Each of these agencies sponsors a single project. This limited involvement may reflect their narrower focus or the specialized nature of their contributions to citywide initiatives.

3.3 Borough Analysis

This section illustrates the delay categories frequencies among Boroughs including citywide.The bar chart below visualizes the distribution of delay categories across different boroughs. Each bar represents a borough, with segments showing the frequency of each delay reason. Additionally,

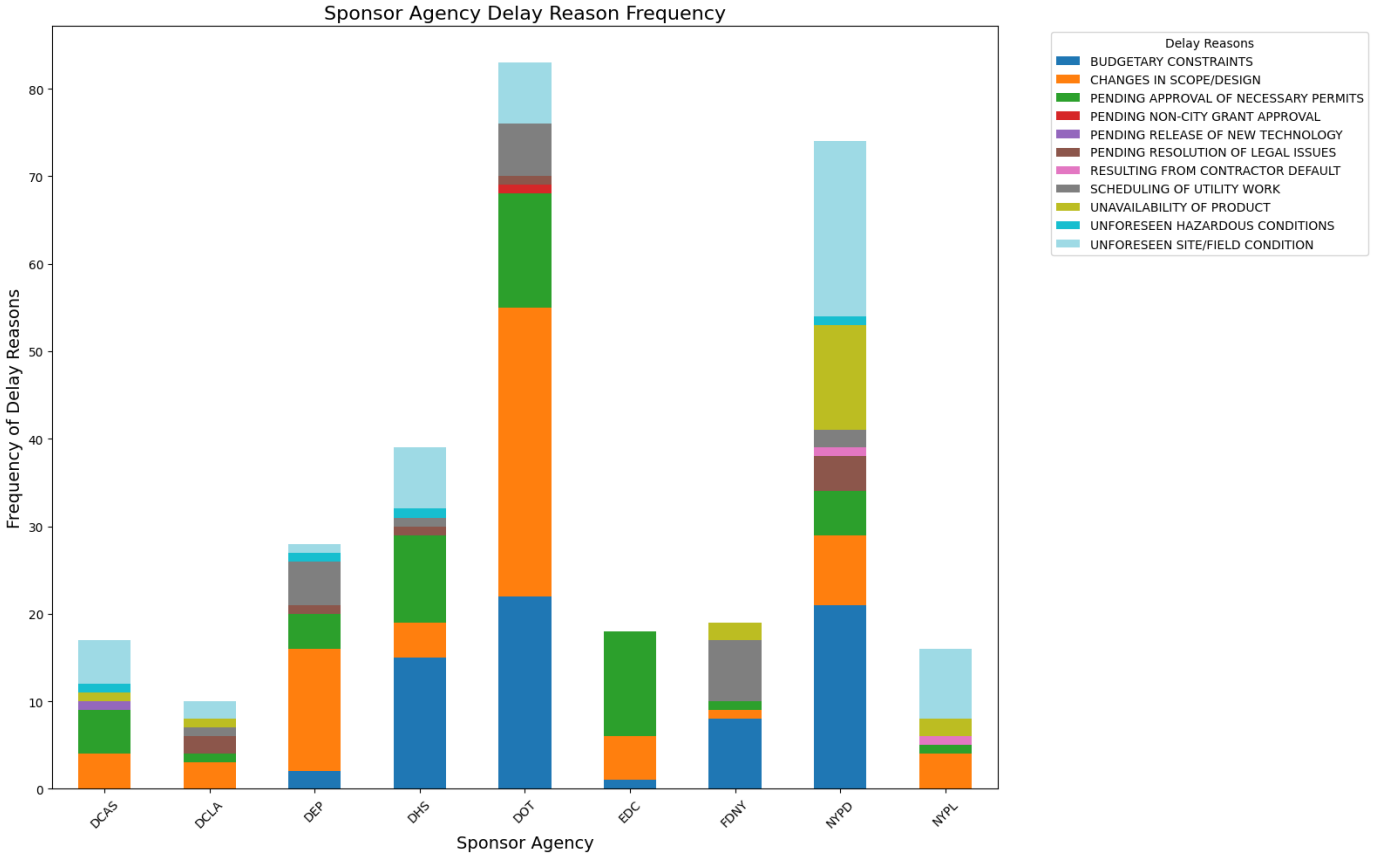


- The most common delays in citywide projects are caused by "Changes in Scope/Design" (27 occurrences) and "Budgetary Constraints" (23 occurrences). Significant delays also occur in Manhattan, where "Changes in Scope/Design" (19 occurrences) and "Budgetary Constraints" (16 occurrences) are the leading causes. Other notable delays include "Pending Approval of Necessary Permits" (16 occurrences), "Unforeseen Site/Field Conditions" (14 occurrences), and "Unavailability of Product" (7 occurrences). Interestingly, while Manhattan has the highest number of delayed projects, it experiences the shortest average delay period.
- In Brooklyn, "Pending Approval of Necessary Permits" (17 occurrences) is the most common cause of delays, followed by "Changes in Scope/Design" (11 occurrences) and "Unforeseen Site/Field Conditions" (11 occurrences).

- The Bronx generally experiences fewer delays, with the most significant issues being "Budgetary Constraints" (10 occurrences) and "Unforeseen Site/Field Conditions" (9 occurrences). However, the Bronx has the longest average delay period among all boroughs.
- Queens faces delays similar to other boroughs, with "Changes in Scope/Design" (14 occurrences) and "Budgetary Constraints" (14 occurrences) being the main factors. Administrative delays, such as "Pending Approval of Necessary Permits" (9 occurrences), also play a role.
- Staten Island, despite having fewer delays overall, "Changes in Scope/Design" (9 occurrences) and "Unforeseen Site/Field Conditions" (6 occurrences) occured the most frequent in this borough.
- In conclusion, while each borough has unique challenges, the most common causes of delays across all boroughs are budgetary limitations and changes in scope or design. Administrative delays, such as waiting for approvals or permits, also contribute significantly to project setbacks. These findings are consistent with previous analyses of the DDC dataset and importance scores.

3.4 Sponsor Agency Analysis

This section highlights the frequency of delay categories across sponsor agencies. For clarity and better visualization, only agencies with at least 10 delayed projects were included in the analysis. This approach ensures that the data focuses on the most significant contributors to project delays while excluding outliers with minimal representation.



- DCAS experiences a variety of delays, with "Pending Approval of Necessary Permits" (5 occurrences) and "Unforeseen Site/Field Conditions" (5 occurrences) being the most significant contributors. While the agency faces fewer delays overall, "Changes in Scope/Design" and "Budgetary Constraints" are less frequent reasons for delay. Despite these challenges, DCAS shows a relatively moderate level of delay impact compared to other agencies.
- DCLA primarily faces delays due to "Changes in Scope/Design" (3 occurrences) and "Pending Approval of Necessary Permits" (1 occurrence). While these delays are significant, they are relatively limited in frequency. The department's delays seem to be mostly administrative and design-related, with fewer complications arising from budgetary or unforeseen issues.

- DEP's delays are most commonly caused by "Changes in Scope/Design" (14 occurrences) and "Pending Approval of Necessary Permits" (4 occurrences), with a smaller number of delays due to "Budgetary Constraints" and "Unforeseen Hazardous Conditions".
- DHS faces delays due to "Budgetary Constraints" (15 occurrences) and "Pending Approval of Necessary Permits" (10 occurrences), which are the leading causes. "Changes in Scope/Design" (4 occurrences) also contribute to project setbacks. The department's delays seem primarily driven by financial and administrative factors, possibly reflecting the complexities of funding and coordinating projects related to homelessness services. The high frequency of permit-related delays suggests that the agency is heavily affected by regulatory processes.
- DOT faces significant delays, particularly due to "Changes in Scope/Design" (33 occurrences) and "Scheduling of Utility Work" (6 occurrences). "Pending Approval of Necessary Permits" (13 occurrences) and "Unforeseen Site/Field Conditions" (7 occurrences) further contribute to the agency's delays.
- EDC’s delays are primarily caused by "Pending Approval of Necessary Permits" (12 occurrences) and "Changes in Scope/Design" (5 occurrences).
- FDNY experiences delays due to "Scheduling of Utility Work" (7 occurrences) and “Budgetary Constraints” (8 occurrences) and "Unavailability of Product" (2 occurrences) seems indicate that FDNY’s delays are concentrated in operational factors.
- NYPD faces delays primarily due to "Unavailability of Product" (12 occurrences) and "Unforeseen Site/Field Conditions" (20 occurrences).These factors could be related to the specialized nature of police equipment and the unpredictable nature of site conditions.
- NYPL experiences fewer delays compared to other agencies, with the most common causes being "Changes in Scope/Design" (4 occurrences) and "Pending Approval of Necessary Permits" (1 occurrence). The library's projects are primarily delayed by administrative issues and design changes.

4 Conclusion

This study provides a comprehensive analysis of the factors contributing to delays in citywide projects in New York City, utilizing data from the NYC Capital Projects Dashboard for 2023–2024. The findings underscore several critical issues that warrant attention for improving project performance and efficiency:

- **Budgetary Constraints**: Budgetary limitations emerged as the most significant cause of project delays, with an average delay of 388 days, highlighting the profound impact of financial challenges on project timelines. This finding aligns with previous studies on the importance of resource allocation in public infrastructure projects.
- **Regulatory and Administrative Delays**: Permit approvals and other regulatory processes were identified as major sources of delay, particularly in large-scale infrastructure projects. These issues reflect inefficiencies in administrative coordination and approval mechanisms that often prolong project initiation and completion.
- **Design and Scope Changes**: Modifications in project design and scope were among the most frequently observed causes of delay, with an average delay of 247 days. This finding underscores the importance of establishing robust planning and design frameworks to minimize disruptions during the project lifecycle.
- **Borough-Level Disparities**: The analysis revealed notable borough-level differences in project delays. For instance, Manhattan, despite hosting the highest number of delayed projects, experienced shorter average delays, whereas the Bronx exhibited the longest delays. These variations point to localized factors influencing project execution, such as resource distribution and project complexity.
- **Agency-Specific Trends**: Sponsor agencies exhibited varying delay profiles based on their operational mandates. While agencies such as NYPD and DOT faced significant delays due to scope changes and unforeseen site conditions, smaller agencies like DCAS were predominantly affected by administrative delays.

In conclusion, the findings highlight the need for targeted strategies to address financial constraints, streamline regulatory processes, and enhance project planning and stakeholder engagement. Future research could focus on exploring innovative project management practices and policy interventions to mitigate delays and optimize resource utilization in urban infrastructure projects. This study contributes to the broader discourse on public project management by providing empirical insights into the systemic challenges affecting citywide development initiatives.

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