Addressing Child Care Deserts: Strategic Solutions For New York Families

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Abstract

The critical issue of child care deserts has garnered increasing government attention as many young children, particularly those under age five, face limited access to adequate child care in New York State. To address this problem, the NYS government has committed to increasing the availability of child care slots by expanding existing facilities and constructing new ones. Given budget limitations, capacity requirements, distance constraints, and fairness considerations, this study develops three optimization models to determine the optimal expansion and construction strategies, as well as the best locations for new facilities. Our results provide actionable insights for minimizing government funding needs, thereby helping to alleviate child care deserts. Nonetheless, efforts to maximize social coverage of child care revealed an infeasibility in fully eliminating child care deserts under current constraints. Achieving this goal, along with enhancing overall well-being, may necessitate increased funding and a realistic approach to regional disparities in child care availability—a complex, long-term social challenge.

1 Introduction

Child care deserts refer to the regions where inadequate registered child care slots are available to families (CAP, n.d.), becoming a large problem for the NYS government. According to data from the Center for American Progress, 64% of people in New York live in a child care desert–ranking New York among the top 5 states with the greatest shortages nationwide–with 57% of the highest-income neighborhoods as well as 63% of the lowest-income neighborhoods living in areas lacking licensed child care providers (2024). In response to this issue, the NYS government plans to build new child care facilities and expand current ones to improve child care availability and support for families.

To address this problem, however, we face several challenges. Given the limited budgeting, we should consider the most cost-efficient strategies to meet all the requirements and ensure sufficient child care slots, particularly for children under 5. Besides, to prevent over-concentration, the new facilities should be constructed in appropriate locations within each zip code. Furthermore, the government strives to maintain a fair distribution of child care slots across all regions.

To meet the above requirements, we develop three optimization models to find the most suitable strategy for facility expansion and new construction, either minimizing the total cost or maximizing the social coverage index. Through this approach, our findings could help the NYS government successfully achieve its goal of diminishing the child care deserts and enhancing the support for parents with young children in New York.

2 Background

With more than half of Americans encountering the problem of insufficient child care providers (CAP, 2024), child care deserts have raised an increasing concern in the US. The lack of child care could affect not only the quality of life for parents and children but also the overall economy. Due to this inadequacy, more parents, especially mothers, choose to stay at home to look after their kids instead of reentering the workforce, which could lead to labor force shortages and further affect the economy (Hoff & Kaplan, 2021). When parents decide to care for their children and not go to work, household income may suffer. It would reinforce poverty and hamper economic mobility. Additionally, insufficient care could increase risks for child abuse and neglect, and the early quality of education could have lifelong impacts on children by influencing their social, emotional, and cognitive development ("The Impacts Of Lack Of Child Care Centers", n.d.).

New York State, with a large amount of population, a mix of urban and economic diversity, and a high demand for child care, makes it more vulnerable to the child care issue. Based on the data from the NYS Department of Labor, 94% of fathers and 68% of mothers with children under 6 have jobs and require child care support. Approximately 844,100 out of 1.4 million children in this age group in New York live in households where parents are in the labor force, but the State's registered child care providers can only meet half of the demand (2023).

The NYS government commits to addressing child care deserts in 3 ways: increase supply, expand affordability, and support the child care workforce ("3 Ways Federal Investments", 2022). The cost of child care has surged these years in New York. It costs more than $20,000 a year for a family to pay for child care, which is more than the average cost of housing and college tuition in this region (Child Care Aware of America, n.d.). There is also a shortage of workers in child care sector. The underpaid child care workforce results in over 100,000 workers switching their jobs with livable salaries in 2022 (FRED, 2024).

Given the above facts, this report will focus on increasing supply through the expansion of existing facilities and the construction of new ones to solve the child care problems. With the following 3 optimization models, we will discuss how each model could effectively reduce the child care deserts by providing the most cost-efficient strategy and maximizing the social coverage index.

3 Method

3.1 Research Design

3.1.1 Sample and Data

This study uses New York State as a case study, analyzing the availability of child care slots at the zip code level and proposing strategies for expanding and establishing new facilities. Population data provides a foundation to assess regional demand variations for child care services, factoring in differing construction cost structures, the distributional balance of facilities by zip code, and equity considerations at the state level. By constructing three optimization models, this study aims to mitigate child care deserts while minimizing statewide funding requirements. Special emphasis is placed on care services for children aged 0-5, with a focus on meeting increased capacity needs for this age group and maximizing the overall social coverage index.

The data pre-processing involves the following steps:

a) Region Categorization. Regions are categorized into high-demand and normal-demand areas for child care services based on zip-code level income and employment data. High-demand areas are defined as those with an employment rate of at least 60% and an average annual income of $60,000 or less.

b) Population Estimation. The total population of children between two weeks and 12 years old is estimated by summing the populations of those under 5 years old, those aged 5 to 9, and 60% of those aged 10 to 14.

c) Slot Demand Thresholds. Demand thresholds for child care slots are calculated for children under 12 in high-demand and normal-demand areas, defined as half and one-third of the child population, respectively. For children under 5, the threshold is set at two-thirds of the population within the same age range.

d) Total Capacity Calculation. The total capacity for children under 5 at existing facilities is computed as the sum of infant, toddler, and preschool capacities, along with five-twelfths of the general child capacity.

3.1.2 Parameters

The following parameters are used in the model:

Parameters	Description
Indices and Sets	
$i \in I$	Set of existing facilities.
$j \in J$	Set of new facilities at potential locations.
$s \in S$	Set of facility sizes, where $S = \{\text{small, medium, large}\}$.
$z \in Z$	Set of zip codes.
Facility Parameters	
$\text{cap}_{i,z}$	Current capacity of existing facility i in zip code z for children aged 0–12.
$\text{cap}_{i,z}^{0\sim5}$	Current capacity of existing facility i in zip code z for children aged under 5.
cost_s	Construction cost for a new facility of size s. $c_s = \begin{cases} 65,000, & \text{small size} \\ 95,000, & \text{medium size} \\ 115,000, & \text{large size} \end{cases}$
slot_s	Total number of slots in a new facility of size s. $\text{slot}_s = \begin{cases} 100, & \text{small size} \\ 200, & \text{medium size} \\ 400, & \text{large size} \end{cases}$
$\text{slot}_s^{0\sim5}$	Number of slots for children aged under 5 in a new facility of size s.
$d_{i,j}$	Distance between existing facility i and new facility j.
d_{j_1,j_2}	Distance between new facilities j_1 and j_2.
Population Parameters	
pop_z	Population of children aged 0–12 in zip code z.
$\text{pop}_z^{0\sim5}$	Population of children aged under 5 in zip code z.
employ_z	Employment rate in zip code z (as a percentage).
income_z	Average income per year in zip code z.

3.1.3 Assumptions

To develop a practical and solvable model for eliminating childcare deserts, we make the following assumptions:

Assumption 1: For Problem 1, new childcare facilities can be established anywhere within a zip code without location-specific constraints. For Problems 2 and 3, however, new facilities must be located at designated potential sites.

Assumption 2: The costs of constructing new facilities are fixed and known, as detailed in a subsequent section, enabling consistent cost calculations across all zip codes. Regarding expansion costs, Problem 1 assumes a simplified cost structure, whereas Problems 2 and 3 consider a more realistic and complex structure.

Assumption 3: The population data for children aged 0–12 and under 5 in each zip code is accurate and up to date. This ensures that the demand estimates are reliable and that the model addresses the actual needs of each area.

Assumption 4: The employment rate and average income per zip code are accurate and can be used to classify areas into high-demand or normal-demand categories.

Assumption 5: The capacity of existing facilities can be expanded up to certain limits without significant regulatory or logistical hurdles, and the expansion does not exceed the maximum allowable capacity per facility.

Assumption 6: Specialized equipment costs for new slots for children under 5 are consistent across all facilities.

3.1.4 Model Construction

Three optimization models are established and solved using Gurobi in Python. The specific model construction methods are explained in the following sections.

Variables	Description
Expansion Variables	
$x_{i,z}$	Number of additional slots to expand at existing facility i in zip code z.
$x_{i,z}^{0\sim5}$	Number of additional slots to expand for children aged under 5 at existing facility i in zip code z.
$x_{i,z}^{5\sim12}$	Number of additional slots to expand for children aged 5-12 at existing facility i in zip code z.
Construction Variable	
$y_{s,z}$	Number of new facilities of size s in zip code z.

3.2 Model Specification for Problem 1

Problem 1 envisions an ideal scenario in which new facilities can be constructed anywhere in the state without location-specific constraints. It also assumes a simplified cost structure, including a fixed, capacity-based marginal cost.

3.2.1 Decision Variables

The following decision variables are used in problem 1:

3.2.2 Objective Function

The objective of the model is to minimize the total cost, which includes both the expansion costs of existing facilities and the construction costs of new facilities.

- Mathematical Representation:

$$\text{Min cost} = \sum_{i,z} \text{expansion cost}_{i,z} + \sum_{s,z} \text{construction cost}_{s,z}$$

- Construction Cost Calculation:

$$\text{construction cost}_{s,z} = \sum_{s,z} \text{cost}_s \times y_{s,z}$$

- Expansion Cost Calculation:

$$\text{expansion cost}_{i,z} = \left(\frac{x_{i,z}}{\text{cap}_{i,z}}\right) \times (20000 + 200 \times \text{cap}_{i,z}) + 100 \times x_{i,z}^{0\sim5}$$

The expansion cost is proportional to the proportion of the increase in capacity according to the problem description. The cost includes a baseline cost of \$20,000 and a capacity-based cost of \$200 per existing slot. Also, an additional \$100 per slot is added for new slots for children under 5. We ignore the existing facilities with a current capacity of zero to avoid the occurrence of outliers.

3.2.3 Constraints

Constraints used are listed below:

a) Total Slots Requirement

To ensure that each zip code is no longer classified as a childcare desert, the total available slots must meet or exceed the demand threshold:

$$\sum_i (\text{cap}_{i,z} + x_{i,z}) + \sum_s (y_{s,z} \times \text{slot}_s) > \text{threshold}, \ \forall z$$

$$\text{threshold} = \begin{cases} \frac{1}{2} \times \text{pop}_z, & \text{high-demand area} \\ \frac{1}{3} \times \text{pop}_z, & \text{normal-demand area} \end{cases}$$

b) Slots Requirement for Children Aged 0-5

To satisfy the policy ensuring sufficient access for children under 5:

$$\sum_i \left(\text{cap}_{i,z}^{0\sim5} + x_{i,z}^{0\sim5}\right) + \sum_s \left(y_{s,z} \times \text{slot}_s^{0\sim5}\right) \geq \frac{2}{3} \times \text{pop}_z^{0\sim5}, \ \forall z$$

c) Maximum Capacity

Since the maximum increase in capacity is 20% of the current size and the total capacity after expansion cannot exceed 500 slots per facility, the expansion at existing facilities is limited by:

$$x_{i,z} \leq \min(0.2 \times \text{cap}_{i,z}, 500 - \text{cap}_{i,z}),\ \forall i, z$$

d) Age Group Allocation

The total expansion at each facility must be allocated between the two age groups:

$$x_{i,z}^{0\sim 5} + x_{i,z}^{5\sim 12} = x_{i,z},\ \forall i, z$$

e) Non-negativity and Integer Constraints

All decision variables are non-negative integers:

$$x_{i,z},\ x_{i,z}^{0\sim 5},\ x_{i,z}^{5\sim 12},\ y_{s,z} \in Z^{+},\ \forall i, s, z$$

3.3 Model Specification for Problem 2

Problem 2 addresses a more realistic scenario, where new facilities are built only in potential locations available for building a facility in New York State. Additionally, a tiered cost structure is applied for expansion, and a minimum distance between facilities is set to prevent over-concentration within the same region.

When considering the distance constraints, we compute distance between facilities using Haversine formula and exclude the existing facilities that lack latitude and longitude coordinates.

3.3.1 Decision Variables

For the construction of new facilities, a series of binary variables $\mathrm{y}_{\mathrm{j,s,z}}$ is introduced to replace $\mathrm{y}_{\mathrm{s,z}}$, indicating whether a new facility is to be built at each potential location.

Variables	Description
Expansion Variables	
$x_{i,z}$	Number of additional slots to expand at existing facility i in zip code z.
$\delta_{1,i,z}$	Number of additional slots when the expansion rate is within the 0-10% range at existing facility i in zip code z.
$\delta_{2,i,z}$	The slot increment corresponding to the portion where the expansion rate exceeds 10% but under 15% at existing facility i in zip code z.
$\delta_{3,i,z}$	The slot increment corresponding to the portion where the expansion rate exceeds 15% but does not exceed 20% at existing facility i in zip code z.
$x_{i,z}^{0\sim 5}$	Number of additional slots to expand for children aged under 5 at existing facility i in zip code z.
$x_{i,z}^{5\sim 12}$	Number of additional slots to expand for children aged 5-12 at existing facility i in zip code z.
Construction Variable	
$y_{j,s,z}$	Whether to build a new facility of size s at potential location j in zip code z.

3.3.2 Objective Function

Similar to Problem 1, the objective remains the minimization of total cost; however, in this case, a tiered expansion cost structure is incorporated into the model.

$$\text{Min cost} = \sum_{i,z} \text{expansion cost}_{i,z} + \sum_{j,s,z} \text{construction cost}_{j,s,z}$$

$$\text{construction cost}_{j,s,z} = \sum_{j,s,z} \text{cost}_s \times y_{j,s,z}$$

$$\text{expansion cost}_{i,z} = (20000 + 200 \times \text{cap}_{i,z}) \times \frac{\delta_{1,i,z}}{\text{cap}_{i,z}} + (20000 + 400 \times \text{cap}_{i,z}) \times \frac{\delta_{2,i,z}}{\text{cap}_{i,z}}$$

$$+(20000 + 1000 \times \text{cap}_{i,z}) \times \frac{\delta_{3,i,z}}{\text{cap}_{i,z}} + 100 \times x_{i,z}^{0\sim5}$$

For x (total number of additional slots to expand) at existing facility i in zip code z,

$$x = \delta_1 + \delta_2 + \delta_3$$

Where

$$0.1 \times \text{cap} \times w_1 \leq \delta_1 \leq 0.1 \times \text{cap}$$
$$0.05 \times \text{cap} \times w_2 \leq \delta_2 \leq 0.05 \times \text{cap} \times w_1$$
$$0 \leq \delta_3 \leq 0.05 \times \text{cap} \times w_2$$
$$w_1 \geq w_2$$

Define

$$w_1 = \begin{cases} 1 & \text{if } \delta_1 \text{ is at its upper bound} \\ 0 & \text{otherwise} \end{cases}$$

$$w_2 = \begin{cases} 1 & \text{if } \delta_2 \text{ is at its upper bound} \\ 0 & \text{otherwise} \end{cases}$$

3.3.3 Constraints

Constraints used are listed below:

a) Total Slots Requirement

$$\sum_i (\text{cap}_{i,z} + x_{i,z}) + \sum_{s,j} (y_{j,s,z} \times \text{slot}_s) > \text{threshold}, \ \forall z$$

b) Slots Requirement for Children Aged 0-5

$$\sum_i \left(\text{cap}_{i,z}^{0\sim5} + x_{i,z}^{0\sim5}\right) + \sum_{s,j} \left(y_{j,s,z} \times \text{slot}_s^{0\sim5}\right) \geq \frac{2}{3} \times \text{pop}_z^{0\sim5}, \ \forall z$$

c) Maximum Capacity

$$x_{i,z} \leq \min(0.2 \times \text{cap}_{i,z}, 500 - \text{cap}_{i,z}), \ \forall i, z$$

d) Age Group Allocation

$$x_{i,z}^{0\sim5} + x_{i,z}^{5\sim12} = x_{i,z}, \ \forall i, z$$

e) Facility Construction Constraint

At most one new facility can be constructed at each potential location:

$$\sum_s y_{j,s,z} \leq 1, \ \forall j, z$$

f) Minimum Distance

In each region, a minimum distance of 0.06 miles is maintained between any two facilities, whether newly constructed or existing.

For the distance between every pair of new facilities (j_1, j_2):

$$d_{j_1,j_2} \geq 0.06 - M \times (2 - y_{j_1,s,z} - y_{j_2,s,z}), \ \forall j, z$$

For the distance between every pair of new facility j and existing facility i:

$$d_{i,j} \geq 0.06 - M \times (1 - y_{j,s,z}), \ \forall i, j, z$$

M is defined as an extremely large number.

g) Non-negative Integer and Binary Constraints

$$x_{i,z}, \ x_{i,z}^{0\sim5}, \ x_{i,z}^{5\sim12} \in Z^+, \ y_{j,s,z} \in \{0, 1\}, \ \forall i, s, z$$

3.4 Model Specification for Problem 3

Problem 3 focuses on enhancing the fairness of child care distribution across all regions and promoting statewide social well-being within a defined budget. The key objectives are: (a) Maximize Social Coverage Index: Increase the ratio of available child care slots to the child population, with particular emphasis on children under 5 years of age; (b) Ensure Fairness: Maintain equitable coverage rates across all zip codes, with coverage rate differences not exceeding 10%; and (c) Budget Compliance: Keep the total cost of expansions and new constructions to within a budget of $1,000,000,000.

3.4.1 Decision Variables

The variables in this section are defined and set identically to those in Problem 2.

3.4.2 Objective Function

The goal is to maximize the social coverage index (SCI):

$$\text{Max SCI} = 2\left(\frac{\sum_z \left(\sum_i \left(\text{cap}_{i,z}^{0\sim5} + x_{i,z}^{0\sim5}\right) + \sum_{j,s} \text{slot}_s^{0\sim5} \times y_{j,s,z}\right)}{\sum_z \text{pop}_z^{0\sim5}}\right) + \left(\frac{\sum_z \left(\sum_i \left(\text{cap}_{i,z} + x_{i,z}\right) + \sum_{j,s} \text{slot}_s \times y_{j,s,z}\right)}{\sum_z \text{pop}_z}\right)$$

3.4.3 Constraints

In addition to the constraints in Problem 2, there are two additional constraints:

a) Budget Constraint

$$\text{cost} = \sum_{i,z} \text{expansion cost}_{i,z} + \sum_{j,s,z} \text{construction cost}_{j,s,z} \leq 1000000000$$

b) Fairness Constraint

$$|\text{Coverage Rate}_{z_1} - \text{Coverage Rate}_{z_2}| \leq 0.1, \ \forall z_1, z_2 \in Z$$

Where

$$\text{Coverage Rate}_z = \frac{\sum_i (\text{cap}_{i,z} + x_{i,z}) + \sum_{j,s} (\text{slot}_s \times y_{j,s,z})}{\text{pop}_z}$$

4 Results

4.1 Problem 1

The minimum total cost for addressing childcare deserts across the specified regions in New York State is calculated to be **$316,223,126.92**. This budget allocation includes both the expansion of existing childcare facilities and the construction of new ones, aimed at meeting the required thresholds in each zip code.

A total of 49,543 expansion slots were added across the existing facilities, with 47,655 of these slots specifically designated for children aged 0–5, to comply with policy requirements ensuring adequate access for younger children. Additionally, 975,200 new slots were created through the construction of new facilities across various zip codes.

To achieve the required capacity, the project involved the expansion of 1,952 existing facilities and the construction of 2,691 new facilities. The new constructions primarily focused on high-demand zip codes where expanding existing facilities alone was insufficient to meet the demand.

According to Figure 1, the initial slots, final slots after expansion and construction, and the demand threshold across the first 50 zip codes. The aim of having the 50 areas is just used to represent the effects brought by the entire model. The green bars represent the demand threshold for each zip code, while the blue and orange bars represent the initial and final number of slots, respectively. This visualization demonstrates that in all zip codes, the final slots meet or exceed the demand threshold, effectively eliminating the classification of these areas as childcare deserts. Figure 2 compares the total number of slots added through expansion and construction methods. The majority of new slots

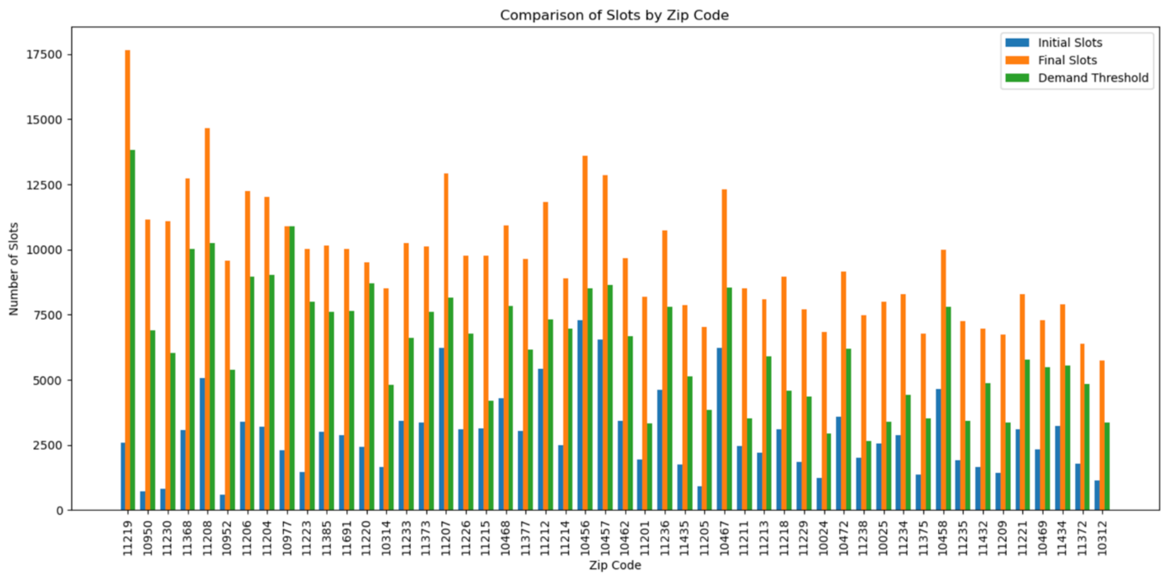

Figure 1: Comparison of Slots by Zip Code

were created through the construction of new facilities, as shown by the significantly higher bar for construction. The huge gap between the amounts of expansion and construction highlights the reliance on new facilities to meet demand in areas where existing facilities had limited capacity for expansion.

The distribution of new facilities by size is presented by Figure 3. Large facilities account for 85.4% of all new constructions, followed by medium (6.1%) and small (8.5%) facilities. The preference for large facilities aligns with the goal of efficiently addressing child care deserts by maximizing the number of slots added per facility. Large facilities were preferred in areas with high demand, as they offer a more cost-effective solution for increasing capacity.

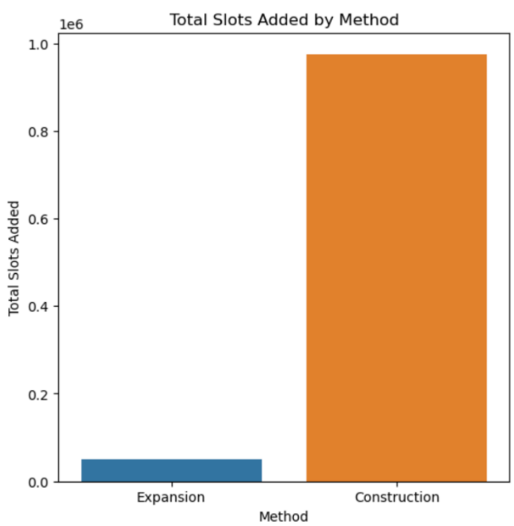

Figure 2: Total Slots Added by Method

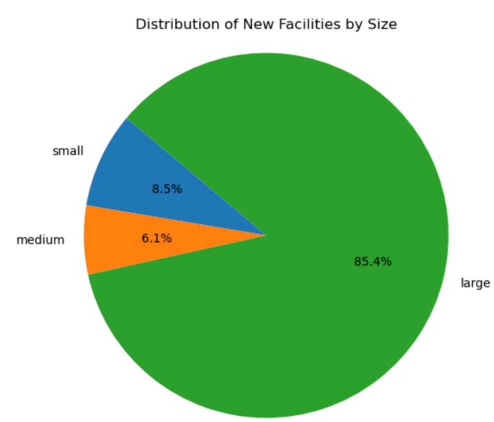

Figure 3: Distribution of New Facilities by Size

Overall, the combination of expanding existing facilities and constructing new, primarily large-sized facilities enabled New York State to meet the required childcare slots across all target zip codes. The approach ensures compliance with state policies, particularly regarding the provision of slots for children aged 0–5. The results confirm that this solution effectively addresses the issue of childcare deserts within the allocated budget.

4.2 Problem 2

In Problem 2, the optimization model was enhanced by incorporating a more realistic cost structure for capacity expansion , featuring a progressive marginal cost, and additional constraints to prevent clustering of new facilities within a close distance. These changes resulted in an increase in total cost (totaling **$324,360,881.27**) and led to adjustments in the overall expansion and construction strategy compared to Problem 1.

Figure 4 compares initial capacities, final capacities, and demand thresholds across zip codes. The orange bars representing final capacities indicate that each zip code has reached or exceeded its respective demand threshold. The adjustments to expansion costs in Problem 2 influenced the distribution of capacity additions, with certain zip codes relying more on new facilities than on expansions. Additionally, the distance constraint led to a more spatially distributed addition of facilities, ensuring compliance with the minimum distance rule while avoiding over-concentration in high-demand areas.

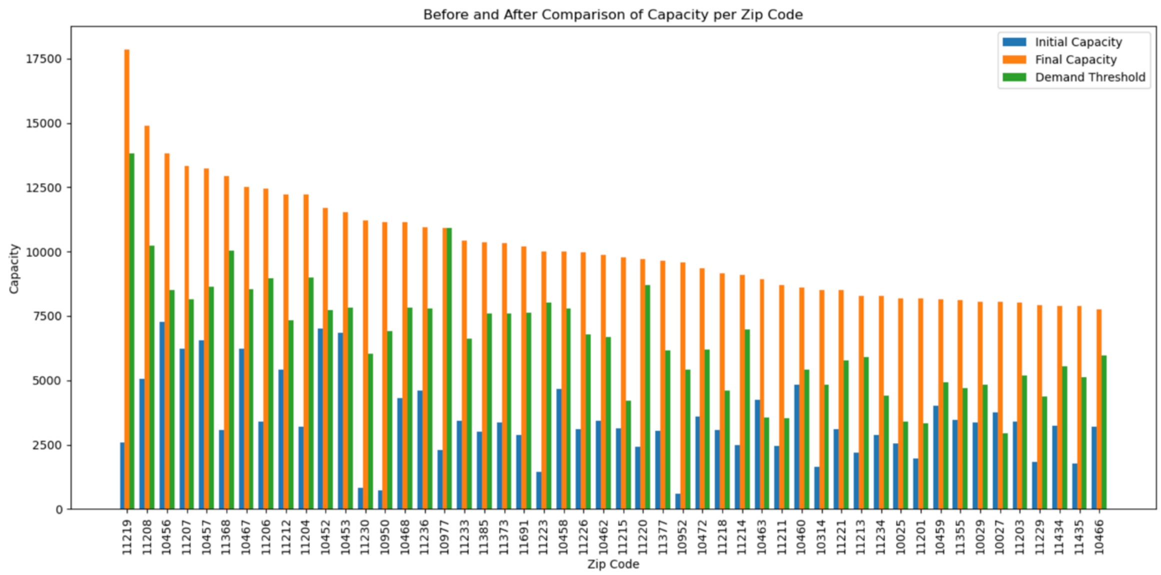

Figure 4: Before and After Comparison of Capacity per Zip Code

The difference in the total capacity added through facility expansion versus new facility construction is illustrated in Figure 5. Similar to Problem 1, the vast majority of the capacity increase came from constructing new facilities, reflecting the high costs and limitations associated with expanding existing facilities under the new cost structure. Specifically, the realistic cost adjustments for expansions above 10% made construction a more economical choice when larger increases in capacity were necessary.

According to Figure 6, it shows the distribution of newly constructed facilities by size. Large facilities continued to dominate the construction decisions, constituting approximately 84.2% of all new facilities. This trend highlights the preference for fewer, larger facilities to meet demand efficiently under the constraints. Compared to Problem 1, where the construction distribution also leaned heavily toward large facilities, this result further underscores the impact of the distance constraint and the cost stages for expansion, as these factors make large, single constructions more favorable.

The additional cost structure for expansions and distance constraints introduced in Problem 2 led to a noticeable shift in strategy compared to Problem 1. In Problem 1, expansions played a slightly more prominent role due to the simpler cost model. However, in Problem 2, the increased cost of larger expansions (beyond 10% and 15% thresholds) and the restriction on facility proximity made constructing large, new facilities a more economical and feasible solution. Consequently, the total cost in Problem 2 was higher than in Problem 1 due to the increased complexity and additional spatial planning required to meet the updated requirements.

Overall, the refined model in Problem 2 provides a more realistic plan for addressing childcare deserts in New York State, accounting for both financial and spatial constraints while ensuring compliance with policy guidelines.

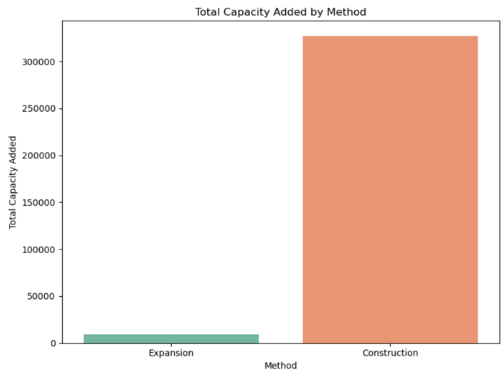

Figure 5: Total capacity Added by Method

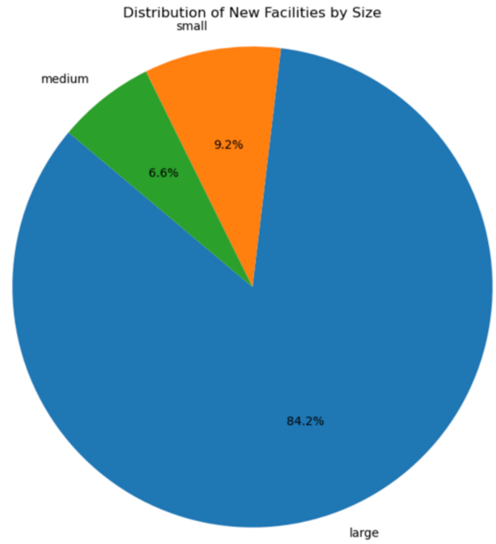

Figure 6: Distribution of New Facilities by Size

4.3 Problem 3

Upon running the model with the updated budget constraint of $1 billion, Gurobi Optimizer returned the following: **Model is infeasible or unbounded**. This indicates that the solver could not find a feasible solution that satisfies all the constraints within the defined bounds, or the model is unbounded.

The infeasibility may indicate disparities in child care service distribution among different regions.

Potential Causes:

a) Insufficient Budget:

The $1 billion budget is inadequate to cover the necessary expansions and constructions required to meet the coverage thresholds and fairness constraints.

b) Overly Restrictive Fairness Constraint:

The requirement that the coverage rates between any two zip codes differ by no more than 0.1 may be too strict, especially given budget limitations.

5 Conclusion

This study supports the NYS government's efforts to eliminate child care deserts by developing three optimization models that guide the strategic expansion of existing facilities and the construction of new ones. These models offer a budget-conscious framework to either minimize funding needs or maximize social coverage, ensuring that child care accessibility requirements and constraints are effectively met across New York State.

Our first model identifies the optimal number of slots to expand and facilities to build in order to minimize the total budget, with particular consideration for slots for children under the age of 5. Sharing the goal of minimizing funding, the second model is enhanced to incorporate a progressive cost structure and a distance constraint, determining the number of slots to expand and construct as well as the locations for new facilities. The third model aims to maximize the statewide social coverage index, adding a fairness constraint to ensure slots are equitably distributed across all regions. While the first two models successfully find cost-efficient strategies and identify large, new facilities as the economical and feasible solution for increasing child care services, the final model yields an infeasible result due to insufficient funding or overly strict fairness requirements. To achieve a viable construction plan, expanding the budget or adjusting the fairness constraint is necessary.

In summary, our findings underscore that a combination of expansion and strategic new facility construction can effectively mitigate child care deserts and provide better child care options for families in need. Expanding child care access enables more parents to pursue employment, enhancing family income, promoting economic mobility, and boosting life quality, while also increasing labor force participation and driving economic growth. However, achieving complete coverage may require additional resources and a balanced approach to fairness and budget considerations, pointing to the long-term complexity of resolving child care disparities across diverse regions.

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