

# Project I: Eliminating Child Care Deserts in New York State through Optimization

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*Child care*, commonly referred to as day care, involves the supervision and care of children, typically ranging from two weeks to 12 years of age<sup>1</sup>. This service is particularly vital for working parents, offering a professional environment for children while their caregivers are engaged in employment<sup>2</sup>.

An ongoing challenge in the United States (US) is the prevalence of “child care deserts”—regions where the demand for licensed child care far exceeds available slots. Over half of American children live in such areas<sup>3</sup>. For instance, due to the limited availability of child care services, many regions in New York State are designated as “child care deserts.” This classification is determined by several factors, including:

- The total number of available child care slots;
- The population of children requiring care;
- The percentage of employed parents;
- The average income in the area.

Specifically, in high-demand areas—defined as regions where at least 60% of parents are employed or the average income is \$60,000 or less per year—an area is considered a child care desert if the number of available slots is less than or equal to half the population of children aged two weeks to 12 years. In normal-demand areas (where employment and income levels do not meet the high-demand criteria) the threshold is lower: an area is classified as a child care desert if the available slots are less than or equal to one-third of the population of children within the same age range.

In this project, we will focus on the issue of child care deserts in New York State (NYS). It is important to consider specific policies that apply to NYS, such as the increased capacity requirements for children aged 0-5. Babies and toddlers, in particular, tend to need child care more than older children, which is expected to be reflected in the state’s policy. Beyond addressing overall demand, the NYS government ensures that children under the age of 5 have sufficient access to care. This means that the number of available slots for children in this age group must be at least two-thirds of the population of children aged 0-5.

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<sup>1</sup>Bradley, R. H., & Vandell, D. L. (2007). Child care and the well-being of children. *Archives of pediatrics & adolescent medicine*, 161(7), 669-676.

<sup>2</sup>Adams, G., & Henly, J. R. (2020). Child care subsidies: Supporting work and child development for healthy families.

<sup>3</sup><https://www.americanprogress.org/series/child-care-deserts/>

## The Problem of Budgeting

The New York State (NYS) government aims to eliminate child care deserts by increasing the number of child care slots across all regions. The goal is to ensure that no area remains classified as a child care desert. To achieve this, the state will provide funding to either:

1. **Build new facilities**, or
2. **Expand existing ones.**

There are three possible sizes for new construction, each with specific capacities and costs (see page 4 and the supplemental materials). *Note that building new facilities can take more than one year. Therefore, expansions based on newly built facilities are not included in the current plan.*

In the first step, NYS considers an idealistic (optimistic) scenario. The objective is to estimate the **minimum total funding** required to eliminate child care deserts in each area. This scenario assumes that:

1. New facilities can be built anywhere in the state. Any number of new facilities may be constructed in any area.
2. Expansions are limited to a maximum of 120% of current capacity, or up to 500 additional slots per facility. (Some existing facilities may already exceed this limit.)
3. Expansion costs depend on the scale of the increase. Larger facilities are cheaper to expand on a per-slot basis.
4. To expand capacity by 100% or more, the state must pay a baseline cost of \$20,000, plus \$200 per existing slot.

In addition, new slots for children under age five require **\$100 per slot** for specialized equipment.

**Your task:** As consultants, determine the **minimum total funding** required for the state to eliminate child care deserts in **each zip code**.

## The Problem of Realistic Capacity Expansion and Location

After reviewing the idealistic scenario, NYS officials provided additional recommendations to better reflect the complexity of expanding child care facilities and choosing appropriate locations for new ones.

**Recommendations on costs.** Officials recognized that, due to space limitations, it is not possible to expand the capacity at existing facilities beyond 20%, and the marginal cost of expanding slots in existing facilities should depend on the scale of the expansion. In other words, the larger the expansion, the higher the marginal cost per scale of the expansion.

Motivated by this, instead of using the previous cost function, the officials propose a more realistic approach where the cost of adding slots follows a model where higher the expansion, higher the increase in the cost of adding more slots <sup>4</sup>.

<sup>4</sup>Think of it this way: when you only increase the number of slots by a small amount, it's relatively cheap. However, as you add more and more slots, the cost to add additional slots becomes higher, reflecting the increased difficulty of expansion.

To break it down:

- For small expansions (up to 10% more than the current capacity), the expansion cost is lower. As before, it's calculated based on a baseline cost (\$20,000), and the capacity-based cost for (\$200 per each existing slot).
- Once you start expanding beyond 10% but stay under 15%, the expansion costs rise more steeply. Now, for more expansion, the cost is higher than it was for the initial 10%. There is a baseline cost (\$20,000), and the capacity based cost (\$400 per each existing slot).
- Finally, if you're expanding between 15% and 20%, the costs rise significantly. Here, the capacity based cost increases to \$1000 per each existing slot. This reflects the reality that very large expansions are the most costly due to space constraints and other logistical issues.

The cost function is given as follows:

$$c_{ext} = \begin{cases} (20,000 + 200n_f) \cdot x/n_f & 0 < x/n_f \leq 0.1, \\ (20,000 + 400n_f) \cdot x/n_f & 0.1 < x/n_f \leq 0.15, \\ (20,000 + 1,000n_f) \cdot x/n_f & 0.15 < x/n_f \leq 0.2, \end{cases}$$

where  $n_f$  is the current number of slots at facility  $f$  and  $x_f$  represent the number of slots to be expanded (added) to that facility.

In essence, the closer expansions get to the 20% limit, the more expensive each slot becomes. Beyond 20%, costs are assumed to be prohibitively high, effectively ruling out further expansion.

**Recommendations on locations.** At the same time, NYS officials have been evaluating potential locations for new facilities. To avoid an over-concentration of child care centers in specific regions, they recommend imposing a distance limitation between facilities, within each area. This means that, within each area, no two facilities, whether new or existing, can be located too close to one another. The minimum distance between any facility should be at least 0.06 miles.

**Your task:** Help the NYS government determine the **minimum amount of funding** needed to achieve their goals, considering both the more complex cost structure and the distance limitation for facility placement.

## The Problem of Fairness (*Optional but Highly Recommended*)

To address the issue of child care deserts, governments have introduced significant funding to help child care providers maintain and expand their services. In New York State (NYS), the government has received a total of \$2.2 billion to improve the availability of child care services statewide. However, beyond simply eliminating child care deserts, the government also wants to ensure that access to child care is distributed fairly across all regions, while maximizing overall social coverage.

One key fairness measure officials recommend is to minimize the gap in child care availability between different areas. Specifically, they want to ensure that the difference in the ratio of available child care slots to the total population of children between any two areas does not exceed 0.1. This means that no region should be significantly better or worse off than another in terms of child care access.

Under this fairness constraint, the government's goal is to maximize a social coverage index. This index is based on the weighted sum of child care coverage for two groups: children under 5 and children from 5 to 12, with a 2:1 weighting in favor of younger age group (that is, two thirds

of child care coverage ratio for children under 5, plus one third of that for children from 5 to 12). The higher weight reflects the greater importance of child care coverage for younger children in promoting overall social well-being.

**Your task** is to help the NYS government determine the best strategy to maximize this social coverage index while ensuring that no area is classified as a child care desert and staying within the \$100 million budget. If it is impossible to satisfy the fairness requirement under the given budget, report this issue.

## Appendix

### Available Data

- **child\_care\_regulated.csv**: This dataset contains the information of (existing) child care facilities in New York State.
- **population.csv**: This dataset contains the population of children in different ranges of ages (e.g., 0-5, 5-10, 10-14, etc.) in each zipcode region in New York State.
- **avg\_individual\_income.csv**: This dataset contains the average individual income in each zipcode region in New York State.
- **employment\_rate.csv**: This dataset contains the employment rate in each zipcode region in New York State.
- **potential\_locations.csv**: This dataset contains the potential locations available for building a facility in New York State.
- Estimating a single cost (to the state government) of building a new facility in NYS is a challenging task. To ease that process we provided these placeholder information inspired by this article. To build a new facility, you can assume the government needs to spend a fixed (one-time) amount of money based on the capacity of the facility:

Facility Size	Max # of Slots (Ages 0-5)	Cost of New Facility (\$) to NYS
100 slots (Small)	50 slots	65,000
200 slots (Medium)	100 slots	95,000
400 slots (Large)	200 slots	115,000

Table 1: Cost estimates for different sizes of child care facilities