

¹ The title

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11

Abstract

12 One or two sentences providing a **basic introduction** to the field, comprehensible to a
13 scientist in any discipline.

14 Two to three sentences of **more detailed background**, comprehensible to scientists
15 in related disciplines.

16 One sentence clearly stating the **general problem** being addressed by this particular
17 study.

18 One sentence summarizing the main result (with the words “**here we show**” or their
19 equivalent).

20 Two or three sentences explaining what the **main result** reveals in direct comparison
21 to what was thought to be the case previously, or how the main result adds to previous
22 knowledge.

23 One or two sentences to put the results into a more **general context**.

24 Two or three sentences to provide a **broader perspective**, readily comprehensible to
25 a scientist in any discipline.

26 *Keywords:* keywords

27 Word count: X

²⁸

The title

²⁹

Introduction

³⁰ Community Labor United

³¹ Community Labor United (CLU) is a non-profit organization, operating in the Greater
³² Boston Area, that works with other community-based establishments and labor unions
³³ across Massachusetts to cultivate strategic campaigns that protect and promote the interests
³⁴ of low and middle-income working class families (???). Their overall goal is to promote
³⁵ policies that advocate for accessible jobs, healthcare, childcare, housing and environmental
³⁶ justice for working class households (???). Through their Our Care That Works coalition
³⁷ that launched publicly this year, Community Labor United aims to bring together various
³⁸ local cooperative groups to confront the child care crisis in Massachusetts. More specific to
³⁹ this research, CLU was interested in examining the inconsistencies in childcare within the
⁴⁰ Greater Boston Area, caused by the negligence of the Department of Early Education and
⁴¹ Care (EEC). This investigative exploration into childcare provision gaps within the Greater
⁴² Boston Area will allow Community Labor United to communicate to the EEC the demand
⁴³ for the standardization of childcare within Massachusetts.

⁴⁴ EEC Literature Review

⁴⁵ The Department of Early Education and Care's mission is to maintain the growth and
⁴⁶ development of all children, by providing quality childcare programs and resources for
⁴⁷ families within their communities (???). However, the research lead by Community Labor
⁴⁸ United and their affiliated organizations shows that the EEC has been unable to effectively
⁴⁹ execute their commitment for low and middle-income working class families.

50 We will be adding more limitations after we receive some literature from Sarah about
51 the EEC and childcare! (Sorry, friend)

52 **Research Question**

53 As stated before, the general goal for this research was to examine the inconsistencies
54 in the EEC by highlighting childcare provision gaps in the Greater Boston Area. More
55 specifically, this project focused on illustrating a disparity in operating hours and capacity
56 for childcare providers on the neighborhood level and census tract level. Because Community
57 Labor United is concentrated on understanding how the low and middle-income households
58 are impacted by the current childcare system, our project focused on emphasizing the
59 childcare demands needed for working class families. Additionally, CLU was interested in
60 concentrating on early education provision care, which encompasses childcare for children
61 ages five and under. For hours, we looked at how the non-typical work week is affected by
62 the early education provision that is currently supplied, since people with low and
63 middle-incomes work at times that operate outside the typical 9:00am - 5:00pm job. We
64 wanted to understand if there were a sufficient number of childcare facilities that could offer
65 early education provision outside Monday - Friday, 7:30am - 6:00pm, for people in the
66 Greater Boston Area. Similarly for capacity, we wanted to highlight the lack of available
67 slots for early education provision for working households with children age five and under.
68 This is because working-class families typically have all parents in the household in the
69 workforce, so it is crucial that the childcare capacity supply matches the demand.

70 Individually, the child provision gaps in hours and capacity shows how the Department
71 of Early Education and Care has neglected low and middle-income families in specific ways.
72 However, we also think it's important to understand how the interaction between lack of
73 available childcare hours and lack of early education provision spots impact these households
74 overall. To best convey that interaction, we compiled our visualizations and supporting

75 information on an easily accessible platform. This allows for the user to quickly navigate the
76 various maps for hours and capacity, and also share these findings with all appropriate
77 parties. It is our hope that Community Labor United will be able to use the visualizations
78 we've created to motivate the Department of Early Education to make reforms to the current
79 childcare system to be more accommodating for all families in Massachusetts, regardless of
80 occupation or availability.

81 **Method**

82 In order to quantify the gap in supply and demand for childcare in Boston, we decided
83 to focus on the capacity of the existing childcare providers in comparison to the number of
84 children who need childcare, as well as the hours that providers are able to provide childcare
85 in comparison to the hours when childcare is most needed by those who work outside
86 standard hours. These areas were chosen because both for their urgency in affecting access
87 to and need for childcare, as well as for the lack of existing research that exists on the gaps
88 between the childcare that exists and the childcare that is needed.

89 **Data**

90 The data from our main analyses consisted of two data sources, one addressing the
91 supply side of the gaps in childcare, and the other addressing the demand. The supply data
92 source we used was given to us by *Community Labor United*, and it was a collection of
93 providers from the Department of Early Education and Care (EEC) in Massachusetts. The
94 initial dataset consisted of 8,318 observations, with each row representing a childcare
95 provider in Massachusetts. Since our project focused specifically on the Boston area, we
96 filtered the dataset to contain only cities in Boston, which left us with 764 remaining
97 childcare providers. The cities included were Allston, Boston, South Boston, Brighton,

98 Charlestown, Dorchester, East Boston, Hyde Park, Jamaica Plain, Mattapan, Roslindale,
99 Roxbury, and West Roxbury. Cities with the highest concentration of providers included
100 central Boston (100), Dorchester (203) and Roxbury (70).

101 There is no existing dataset that tells us about childcare demand specifically, so to
102 answer this question we used census data, specifically the *American Community Survey*
103 (ACS), and filtered for certain variables of interest. The following methodology will discuss
104 specific variables in detail, but data was derived from the 2016 American Community Survey
105 and was filtered for Suffolk County, Massachusetts.

106 We wanted to convey the gap in childcare by a geography that would be big enough to
107 generalize findings, but small enough that we could be specific and not overlook any areas
108 that might have findings of interest. Through consultation with CLU, we decided on convey
109 our results by the neighborhood level. To do this, we accessed Boston neighborhood
110 shapefile data (???) and assigned each EEC childcare provider to a certain neighborhood.
111 Since the census data of interest was only accessible by tract, we developed a file that
112 matched each census tract to a neighborhood, and included both tract geometry and
113 neighborhood geometry to allow for easy mapping. More about this process is discussed in
114 the challenges section.

115 Capacity

116 Supply

117 To get a sense of the slots available for early education provision, we took the EEC
118 dataset and filtered only for providers that provide early education childcare. We first used
119 R and Python to clean the variables. We then used the tidyverse package to group the
120 providers by census tract, and calculated the total number of slots for early education
121 childcare in each tract. Since we were interested in looking at differences on both the tract

122 level and the neighborhood level, we repeated this process for neighborhood so that we also
123 had the total number of slots for early education childcare in each neighborhood. We merged
124 these datasets with the respective geometry for each geography, to allow us to map the
125 results.

126 **Demand**

127 Demand for capacity of childcare was assessed through the use of the 2016 ACS. The
128 tigris and tidycensus packages were used in congruence with an API key to access census
129 data in R. We chose the ACS as opposed to other forms of census data because it was the
130 only survey that was easily compatible with R that also had all data available for all
131 variables of interest on the tract level for Suffolk County.

132 To quantify the number of children that need childcare, we used the ACS variable
133 “B23008”, which gives estimates per tract of the total number of children under 6 years old,
134 as well as the number of children under 6 in two-parent households with both parents in the
135 labor force, as well as single parent households (either mother or a father) with the parent in
136 the labor force. We then added up these three variables, with the assumption that anybody
137 with all parents in the labor force would need childcare. To get a percentage of children
138 under 6 with all parents in the labor force, we divided this number by the total number of
139 children under 6. All calculations were per tract.

140 **Maps**

141 Three maps were made as a final product for visualizing the gap in capacity. Two of
142 these maps (Figure 1 and Figure 2) looked at supply and demand at the tract level, mapping
143 the raw number of children under 6 with all parents in the workforce as well as the raw
144 number of slots available for early ed care per tract, to be compared. The third map (Figure

145 3) quantified the difference in supply and demand by neighborhood, as a ratio of children
146 under 6 with parents in the workforce to available childcare slots. Since it is unrealistic that
147 one would restrict their childcare search to within their census tract, a rather small
148 boundary, we wanted to give a more realistic range of how far a childcare search might go,
149 hence the rationale for grouping by neighborhood.

150 **Hours.**

151 **Supply**

152 Our main focus with the question of hours was to get a sense of the providers who
153 provided childcare outside of the typical standard workday, which we defined as anytime
154 outside of 7:30am-6pm on weekdays. We did not include weekday care since there were only
155 a few providers that provided any weekend care at all. Therefore to get our dataset for
156 supply, we created a variable based on the information about hours in the EEC dataset to
157 flag any provider that provided care during nonstandard hours, and summarized the number
158 of slots they had for those hours.

159 **Demand**

160 One large problem with census data is that in any workday related variables, it
161 assumes workers work 5 days a week, with the same number of hours every day. This
162 definition contradicts the purpose of our study, which is to investigate those who work
163 nonstandard hours. Therefore, the only census variable that made sense to use when
164 investigating hours was the time leaving work. Using previous ACS methodology given to us
165 by CLU, we split the nonstandard times leaving for work into three categories: early
166 mornings if they leave for work anytime between 12am-6:29am, evenings if they leave for
167 work anytime between 11am-3:59pm, late evening/overnight if they leave for work anytime

168 between 4pm-11:59pm. We took the ACS variables corresponding to these responses in
169 variable B08302, and divided the number of people in each category by the total number of
170 people in the workforce to get a percentage of people in each category. We also summarized
171 the number of people in the three nonstandard time chunks to get a total percentage of
172 people leaving during any nonstandard hour.

173 Maps

174 Five maps were made to visualize the gap in supply and demand for hours. Three of
175 the maps were choropleth maps by tract visualizing the percentage of people who left at each
176 of the nonstandard times: early, evening, and late evening/overnight (See Figure 1 for an
177 example of this map). Another similar map was made by tract using the aggregate
178 percentage of all people leaving during any of these nonstandard hours. Finally, to visualize
179 supply, a map was made of the number of slots available for nonstandard hours of childcare
180 by provider by tract.

181 Results and Discussion

182 This section summarizes the data utilized and how the maps we create illustrate the
183 gap between demand and supply of childcare services for children under 6 in the Boston area.
184 We start by presenting the summary statistics of the data sets, analyzing each individual
185 map, and then proceed to analyze the relationship among them.

186 Summary Statistics

187 Table 1 in the appendix presents the summary statistics on the distribution of the
188 capacities of all providers and capacities available in neighborhoods and tracts. The mean

189 capacity of providers is 24.7, of all neighborhoods in Boston is 1469, and of tracts in Boston
190 is 169.2.

191 Table 2 in the appendix presents the summary statistics on the distribution of the
192 capacities of all providers that operate outside 7:30am-6:00pm during weekdays and the
193 capacities of them in neighborhoods and tracts.

194 **Graphs for Capacity**

195 In this section we conduct graphical analysis on the two variables we are interested in:
196 capacity and hours.

197 Figure 1 shows the number of children under 6 whose parents are in the labor force
198 (i.e., actively looking for jobs) on the level of neighborhoods. We are especially in them since
199 they are target consumers of childcare services for early ed. Being in the labor force means
200 that the parents might be too busy to pay enough attention and provide enough care to
201 their children, thus requiring the aid from childcare providers. According to the map, tracts
202 that have the largest number of children under 6 who would need childcare services are
203 mainly located in the east and west parts of Boston (i.e., upper and lower regions on the
204 map), including East Boston, West Roxbury, Hyde Park, and Dorchester.

205 Figures 2 shows the number of childcare slots available for children under 6 on the level
206 of tracts. The two tracts that contain more slots than others are located in Dorchester and
207 Downtown, but compared to Figure 2, the slots are apparently more evenly distributed
208 across tracts. It is worth paying attention to that providers in the regions where there is a
209 large number of children under 6, including the east and west parts of Boston, do not provide
210 enough number of slots to feed the need of families in these areas. The difference between
211 supply and demand explains the high desert ratio in these regions as shown in Figure 3.

212 We first visualize the gap between supply and demand for childcare services for early
213 education through the capacity variables. Figure 1 shows the ratio of children under age 5 to
214 the cumulative child care capacity in the neighborhoods of Boston. The darker the red color,
215 the more children are competing to obtain a licensed child care slot, and therefore the harder
216 it is for a child to obtain the childcare service he/she needs. According to the graph, East
217 Boston, Charlestown, South Boston, Dorchester, Mattapan, Roslindale, Hyde Park, and
218 West Roxbury could be classified as child care deserts. To solve this issue, more childcare
219 providers should be established in those neighborhoods and current providers should expand
220 their capacities. To get a closer look at the capacity, the two figures below show the demand
221 and supply of capacities by tracts.

222 **Graphs for Hours**

223 In this section, we look into the working hours of families and the operating hours of
224 providers to examine whether there is a mismatch.

225 Figure 4 shows the percentage of parents in tracts who depart for jobs early in the
226 morning. On average, people who live in the East Boston and West Boston areas (north and
227 south areas on the map) leave earlier for works than people who live in other regions. These
228 are also the regions where there are relatively larger number of children under 6 in need of
229 childcare services. The tracts where the largest percentages of people leave for jobs early are
230 located at are waterfront areas of South Boston and Dorchester.

231 Figure 5 shows the percentage of parents in tracts who leave for home in the late
232 evening. On average, people who live in the East Boston, West Boston areas (north and
233 south areas on the map), and waterfront tracts Brighton and Allston leave from workplaces
234 for home later than people who live in other regions. The tracts where the largest
235 percentages of people leave for home later than usual are located at Roxbury and the

236 waterfront areas of Jamaica Plain.

Figure 6 shows the percentage of parents in tracts who depart for home from the workplace overnight. On average, people who live in South Boston and West Boston areas (north and south areas on the map) leave later for home than people who live in other regions. These are also the regions where larger percentage of people leave early and where there are relatively larger number of children under 6 in need of childcare services. The tracts where the largest percentages of people leave for jobs early are located at are waterfront areas of South Boston and Dorchester.

Figure 7 shows the number of slots available for early by providers that open before 7:30am and close after 6pm during weekdays. It indicates that there is a significant lack of capacities in regions where families have a difficult commute time. In general, people from working families living in East Boston, West Boston, South Boston, and the waterfront areas of Allston, Brighton, and Jamaica Plain are most in need of off hour childcare services. However, we could see that there are only a few slots offered by childcare providers that operate off hour available for children in West Boston and South Boston, and none for children in South Boston and the waterfront areas of Allston, Brighton, and Jamaica Plain. Accordingly, more off hour slots should be provided in these regions.

Challenges and Limitations

254 Challenges

255 There are two main challenges that we deal with for this project. First is data cleaning
256 for the EEC dataset. The EEC dataset has a messy data format and a lot of columns that
257 contain information on several different variables. To extract information that we need to
258 create the capacity and hours variables, we utilize various functions and packages from R

259 and Python to clean, merge, and spread variables from the original dataset, such as
260 minimum age, rates, open and close time of providers.

261 Second is the geographical classification. One of the narratives of this project is to look
262 at the supply and demand by the tract and neighborhood levels, the information of which
263 are not provided in the original datasets we are given. We deal with this issue by geocoding
264 the providers' locations, deciding which polygon each provider falls within using the over
265 function from the rgeos package.

266 Limitations

267 First some of the variables from census datasets are based on assumptions different
268 from real life situations. Specifically, people's departure time for work is created based on
269 the assumption that people work for the same amount of hours everyday while the parents
270 we are most interested in are those that have irregular working hours.

271 Second, our general lack of ability to match census data variables with variables EEC
272 provide to compare different variables for the same construct. Although we successfully
273 create the desert ratio by using the capacity and children population from the EEC and
274 census datasets, there are many other variables the project could look into, such as income
275 level of citizens vs. subsidy of providers.

276 Third, there is a lack of data in the EEC dataset about important variables, such as
277 the capacity of each providers by age groups and subsidy amount in dollars. The absence of
278 these variables prevents us from looking more deeply into the supply for childcare services.
279 There are many variables that we clean but do not look into due to the limited amount of
280 time we have, such as subsidy, availability of drop-in and emergency services.

281

Discussion and Conclusion

282 To examine the inconsistencies in the EEC by highlighting childcare provision gaps in
283 the Greater Boston Area, we utilize EEC datasets and census datasets to create maps that
284 illustrate a disparity in operating hours and capacity for childcare providers on the
285 neighborhood level and census tract level. In a word, East Boston and West Boston
286 neighborhoods, including Allston, Boston, South Boston, Brighton, Charlestown, Dorchester,
287 East Boston, Hyde Park, Jamaica Plain, Mattapan, Roslindale, Roxbury, and West Roxbury,
288 are the regions where the gaps apparently exist. According to the visualizations of the
289 “capacity” variable, providers in East Boston and West Boston, where there is a large
290 number of children under 6, do not offer enough number of slots to feed the need of families
291 in these areas. Similarly, the maps on the “hours” variable indicate that there is a lack of
292 childcare off hour services for working families living in East Boston, West Boston, South
293 Boston, and the waterfront areas of Allston, Brighton, and Jamaica Plain are most in need
294 of off hour childcare services. According to the median income level map of Boston, most of
295 these neighborhoods are also regions where income levels are lower than the average income
296 level of the Boston area (???). The limited financial capability of citizens of these areas
297 might force them to work during irregular hours and to send their children to the childcare
298 providers. On the other hand, the providers in these regions could not provide enough slots
299 for children under 6 as they could not earn as much money from these low-income families as
300 they could from families in the central areas. To resolve the gap, the policy intervention and
301 support from EEC could be urgent.

302 In a word, our graphical analysis successfully illustrates the existence of the gap
303 between supply and demand for early ed childcare services in the Boston area. For
304 researchers who are interested in digging more deeply into this topic in the future, we
305 suggest several directions they could explore into. First, people could match more variables
306 on the demand for childcare services with variables on the supply for childcare services to

307 illustrate the existence of gaps. Second, people could try to obtain a more comprehensive
308 dataset from EEC to have a closer look at the supply of childcare services for different age
309 groups. Third, people could conduct a childcare survey by themselves to have first-hand
310 information directly from the providers and families in need of childcare services in Boston.
311 Fourth, people could encharge the studied area to the whole mass

312 **Appendix**

313 **Data analysis**

314 We used R (Version 3.4.1; R Core Team, 2017) and the R-packages *dplyr* (Version
315 0.8.0.1; Wickham, François, Henry, & Müller, 2019), *forcats* (Version 0.3.0; Wickham, 2018),
316 *ggformula* (Version 0.6; D. Kaplan & Pruim, 2017), *ggplot2* (Version 3.1.0.9000; Wickham,
317 2016), *lattice* (Version 0.20.35; Sarkar, 2008), *leaflet* (Version 2.0.2; Cheng, Karambelkar, &
318 Xie, 2018; Karambelkar & Schloerke, 2018), *leaflet.extras* (Version 1.0.0; Karambelkar &
319 Schloerke, 2018), *mapview* (Version 2.6.3; Appelhans, Detsch, Reudenbach, & Woellauer,
320 2018), *Matrix* (Version 1.2.10; Bates & Maechler, 2017), *mosaic* (Version 1.1.0; Pruim,
321 Kaplan, & Horton, 2017, 2016), *mosaicData* (Version 0.14.0; Pruim et al., 2016), *papaja*
322 (Version 0.1.0.9842; Aust & Barth, 2018), *purrr* (Version 0.3.2; Henry & Wickham, 2019),
323 *readr* (Version 1.1.1; Wickham, Hester, & Francois, 2017), *sf* (Version 0.7.2; Pebesma, 2018),
324 *stringr* (Version 1.4.0; Wickham, 2019), *tibble* (Version 2.1.1; Müller & Wickham, 2019),
325 *tidycensus* (Version 0.9; Walker, 2019), *tidyverse* (Version 1.2.1; Wickham, 2017), and *tigris* (Version 0.7; Walker, 2018) for all our
326 analyses.

328

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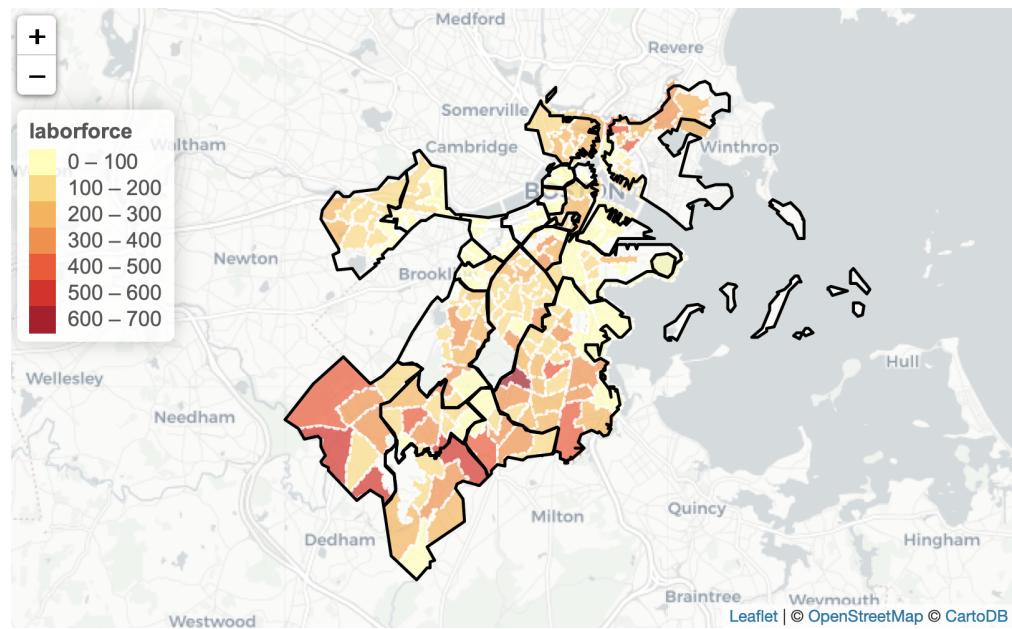


Figure 1. Demand: Number of Children Under 6 with Parents in the Labor Force

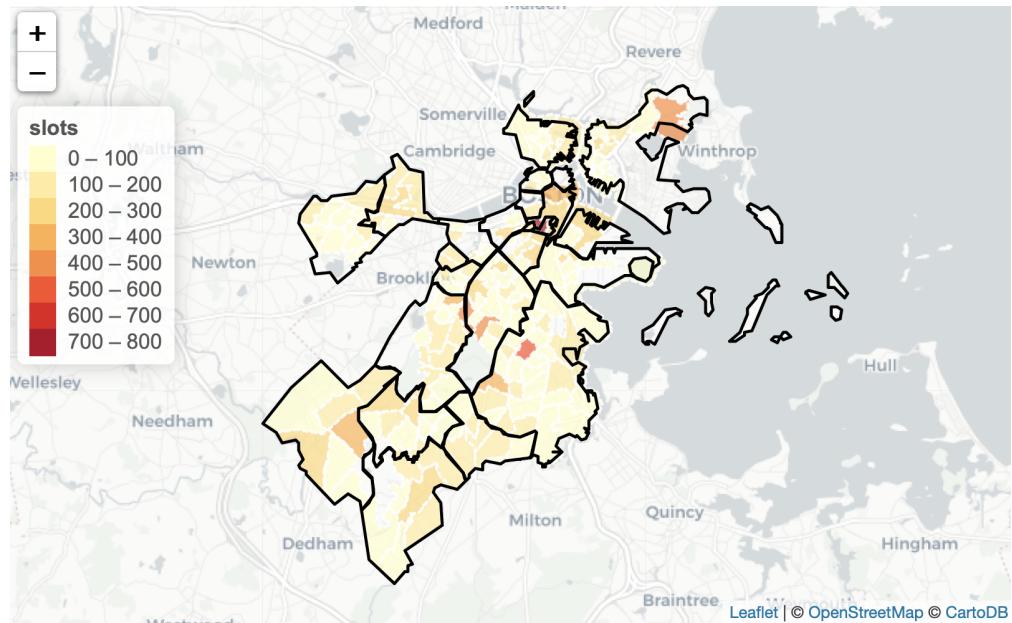


Figure 2. Number of slots available for early ed by tracts

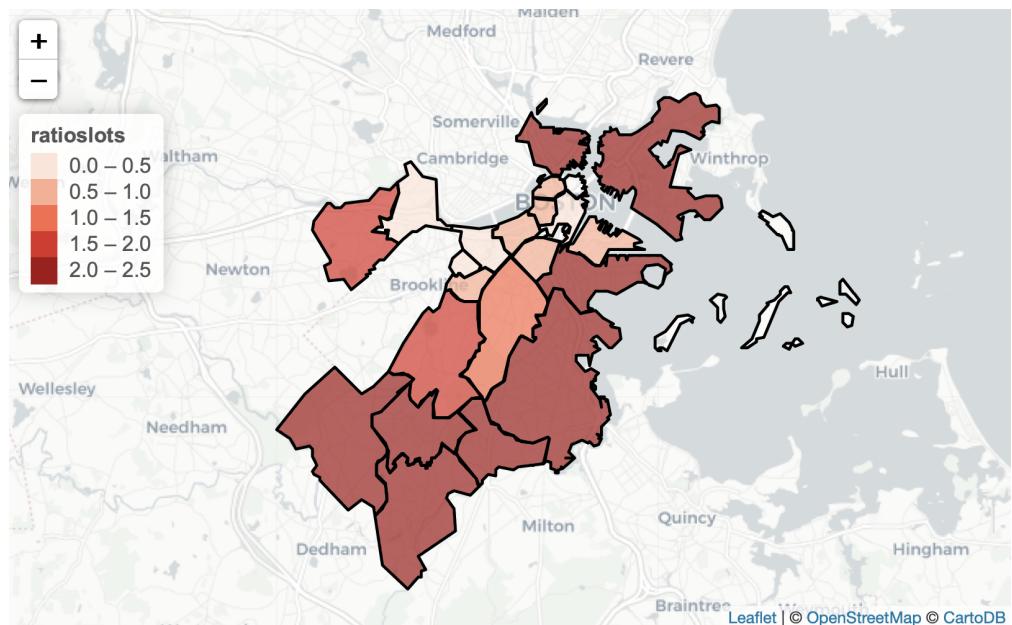


Figure 3. Gap between supply and demand of capacities

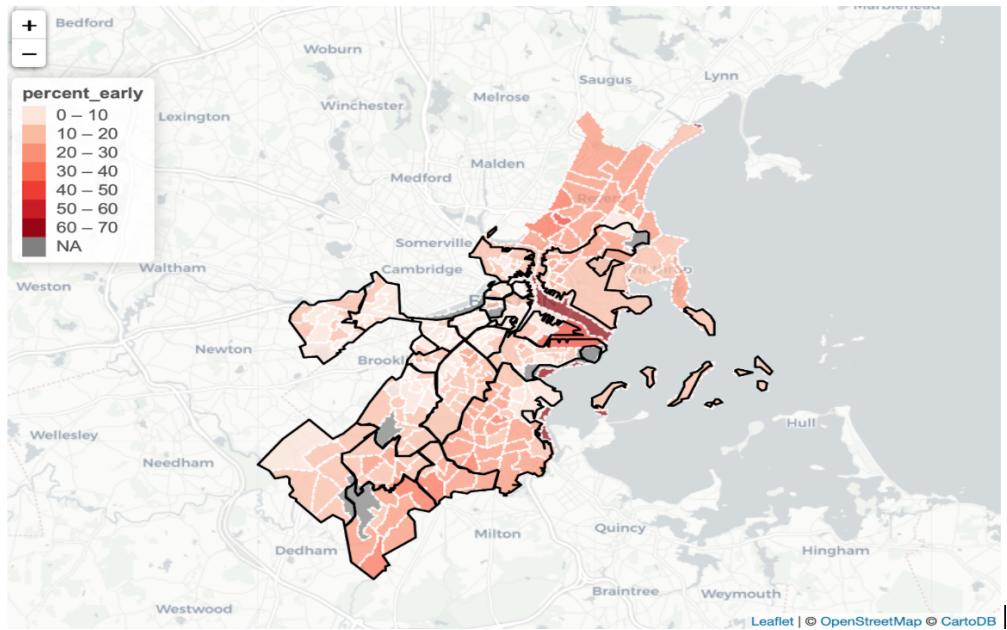


Figure 4. Demand: Percentage maps by tracts on people departure time for work in the morning

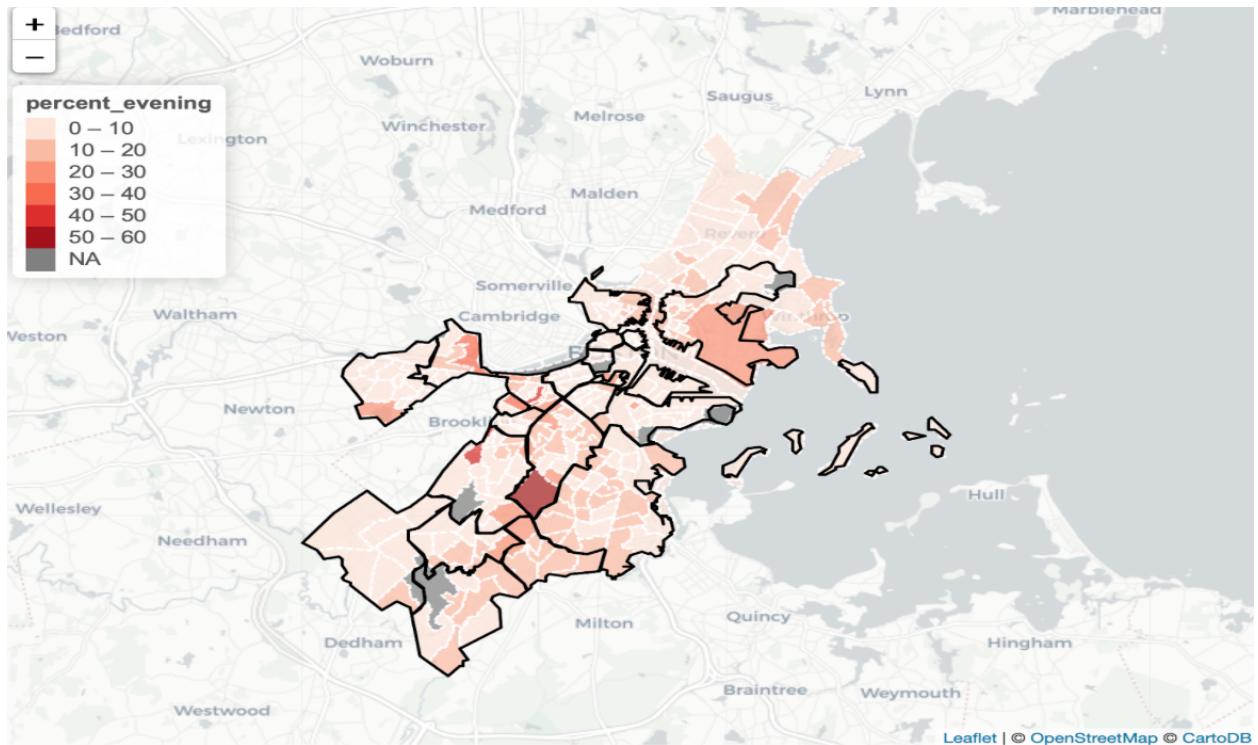


Figure 5. Demand: Percentage maps by tracts on people departure time for home in the evening

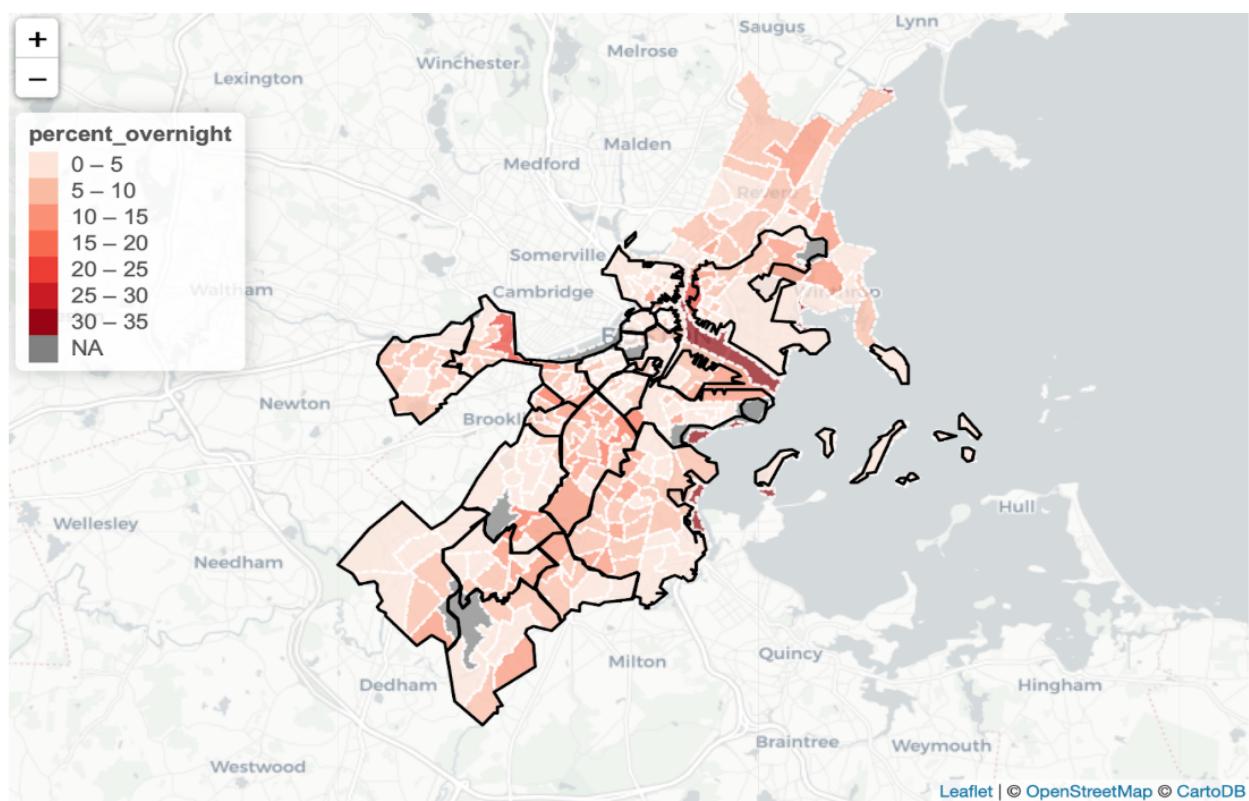


Figure 6. Demand: Percentage maps by tracts of people whose departure time for home is overnight

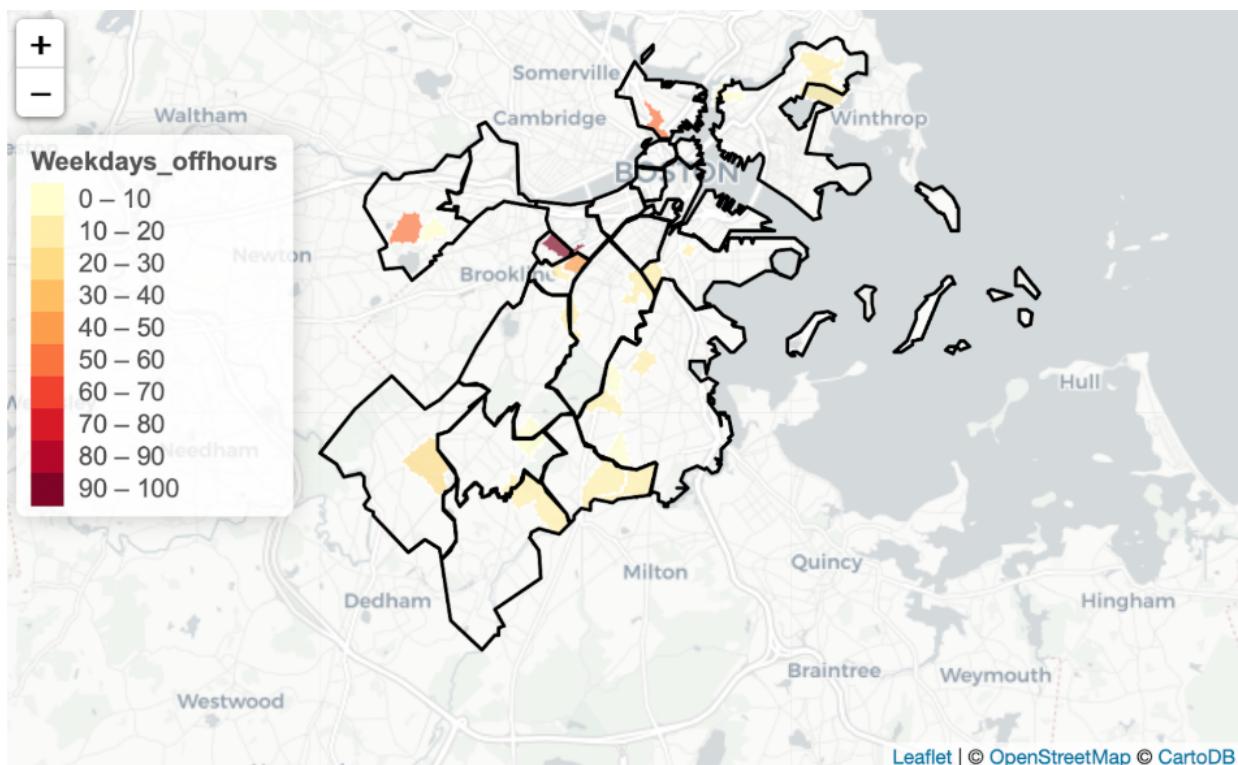


Figure 7. Supply: Number of slots in certain tracts by providers who operate off hour during weekdays for early ed.