PHYS 410: Homework 3

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There are 3 MATLAB files included with this assignment:

1. infection.m
2. prelim_analysis.m
3. infection_analysis.m

To run one instance of the simulation, call *infection(density, pvac, plot)*. For example, *infection(0.35, 0.4, true)*.

1 Preliminary Analysis

To run the preliminary analysis on the simulations for the various densities and percent of population immunized, simply call *prelim_analysis* on the command line with no arguments. Note that this may take about 4.5 minutes to run, but one instance of the results are reproduced below, and plotted in the first three figures. The function returns nine values:

1. The optimal vaccination rate for low density (0.25)
2. The average total cost for the optimal rate with low density
3. The standard deviation of the total cost for low density
4. The optimal vaccination rate for medium density (0.35)
5. The average total cost for the optimal rate with medium density
6. The standard deviation of the total cost for medium density
7. The optimal vaccination rate for high density (0.5)
8. The total average for the optimal rate with high density
9. The standard deviation of the total cost for high density

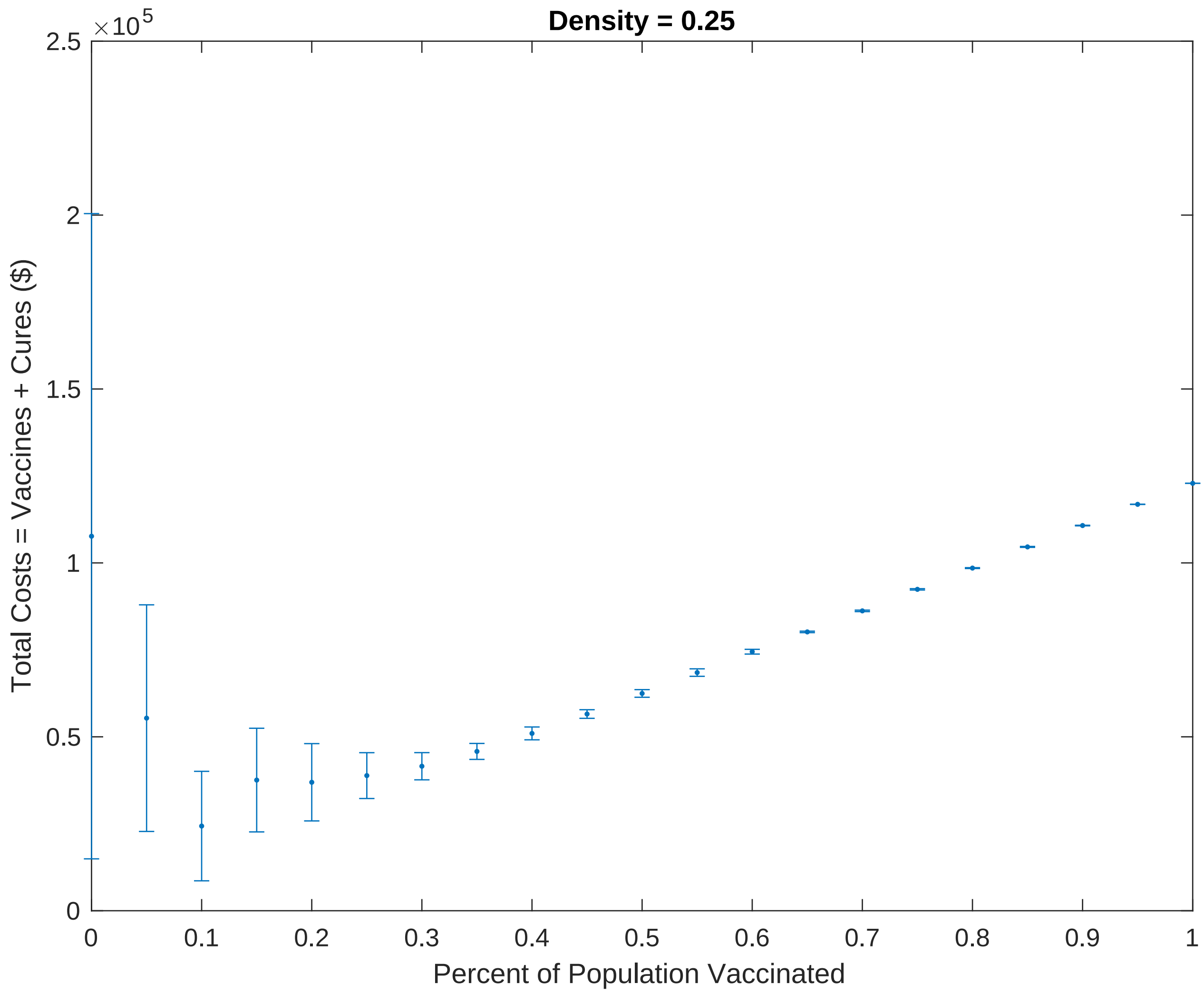
The optimal vaccination rate for now is just point with the minimum mean cost without accounting for errors. This is just to identify the approximate area to test for each density.

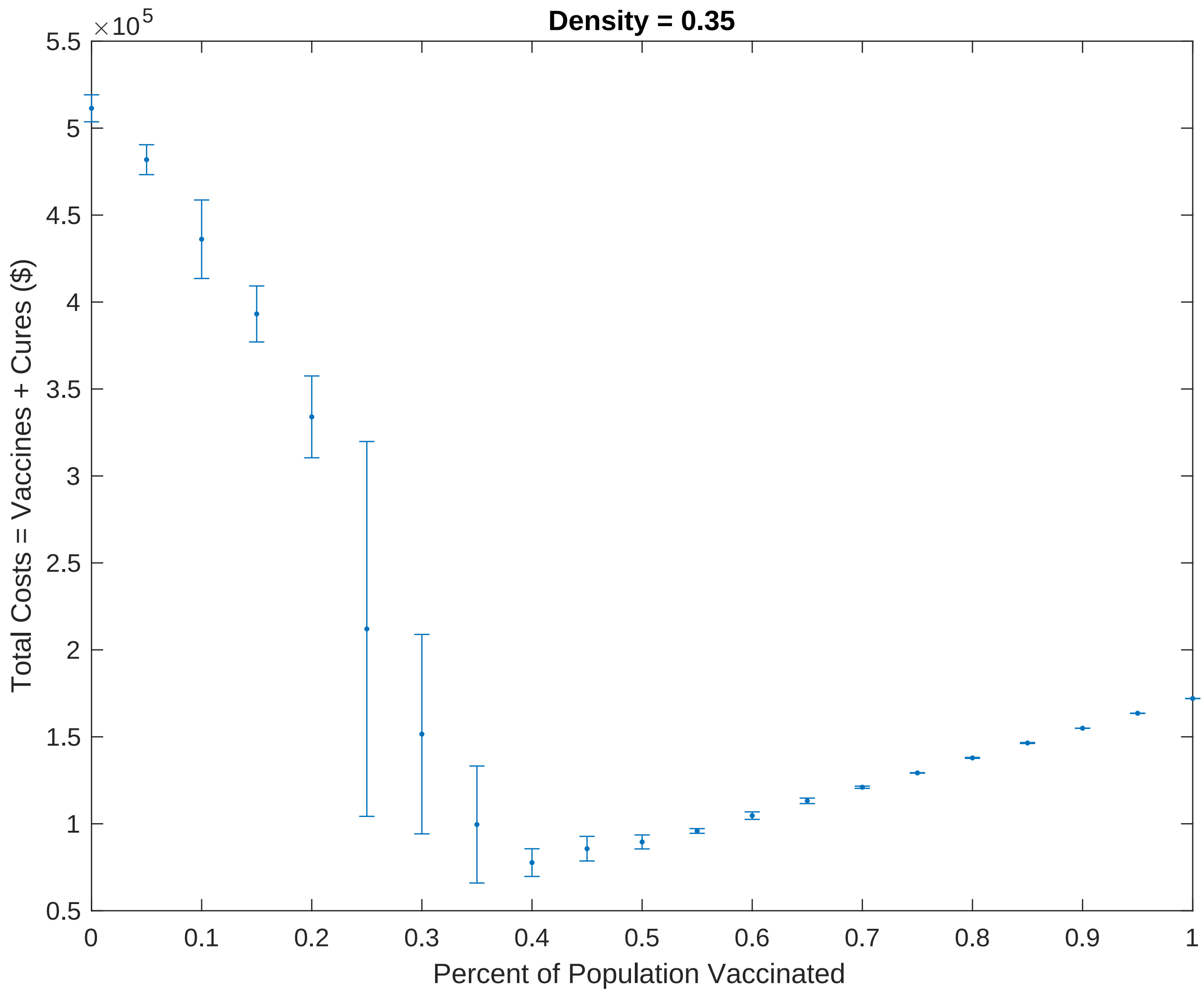
Density	**Approx. Optimal Vaccination Rate**	**Approx. Total Costs ($)**
LOW (0.25)	0.1	$2.43 \times 10^4 \pm 1.57 \times 10^4$
MED (0.35)	0.4	$7.77 \times 10^4 \pm 7.96 \times 10^3$
HIGH (0.5)	0.6	$1.55 \times 10^5 \pm 8.03 \times 10^3$

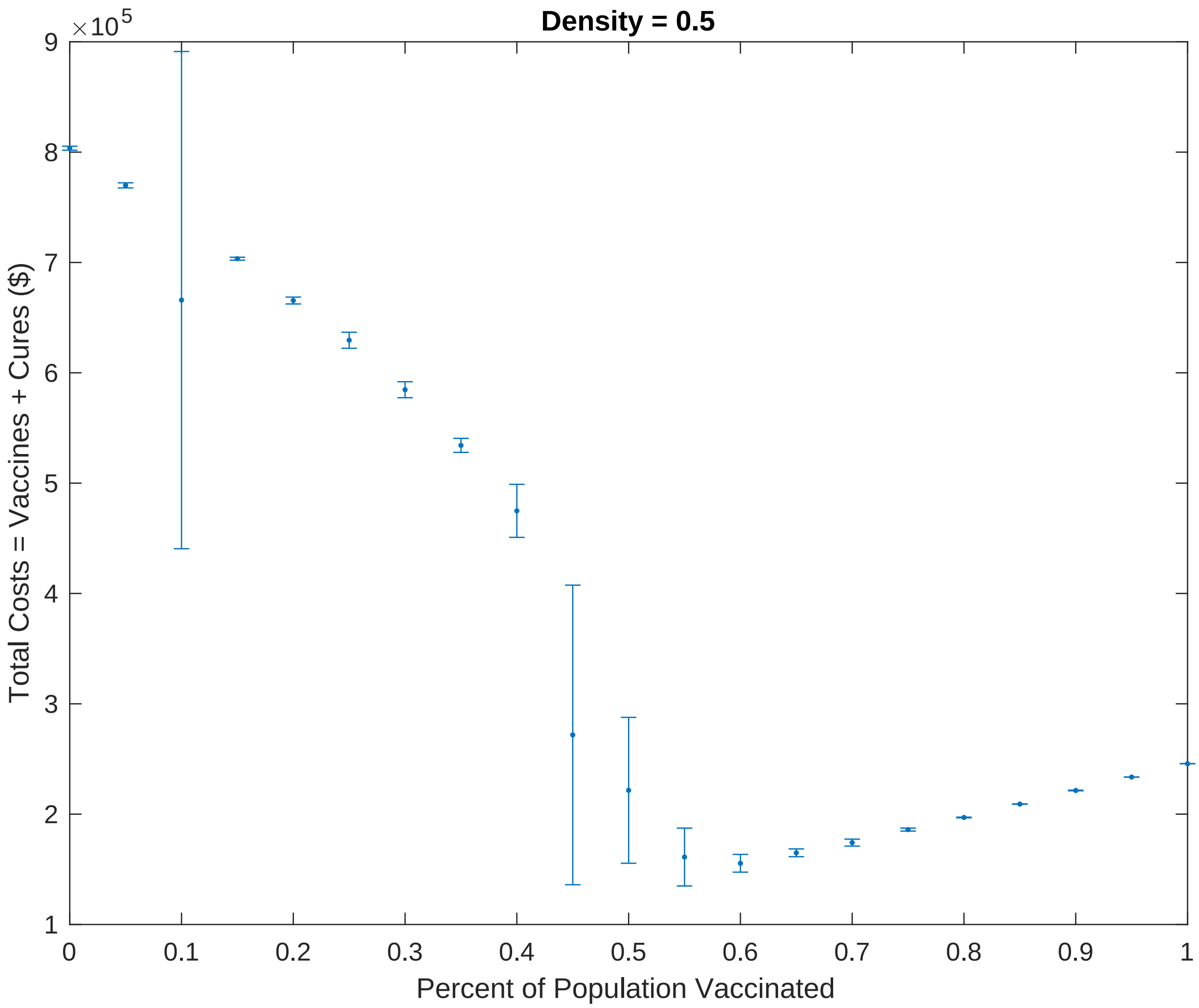
Table 1: Preliminary Optimal Vaccination Rates and Costs

For each density, I ran the simulation for 21 different pvac values ($pvac = 0, 0.05, 0.1, 0.15, ..., 1$), With 10 runs for each data point. I plotted pvac vs the average total cost with the standard deviation from the mean as the error. The fact that my answers for the optimal pvac contains only 1 significant figure reflects the uncertainty in their values.

I did not try to fit my data because I have no hypothesis for what function might fit my data. I also decided against interpolation because that does not take the errors into account and the errors do appear to be significant just from looking at the plots.


Density = 0.25
×10^5
2.5
2
1.5
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Total Costs = Vaccines + Cures ($)
Percent of Population Vaccinated

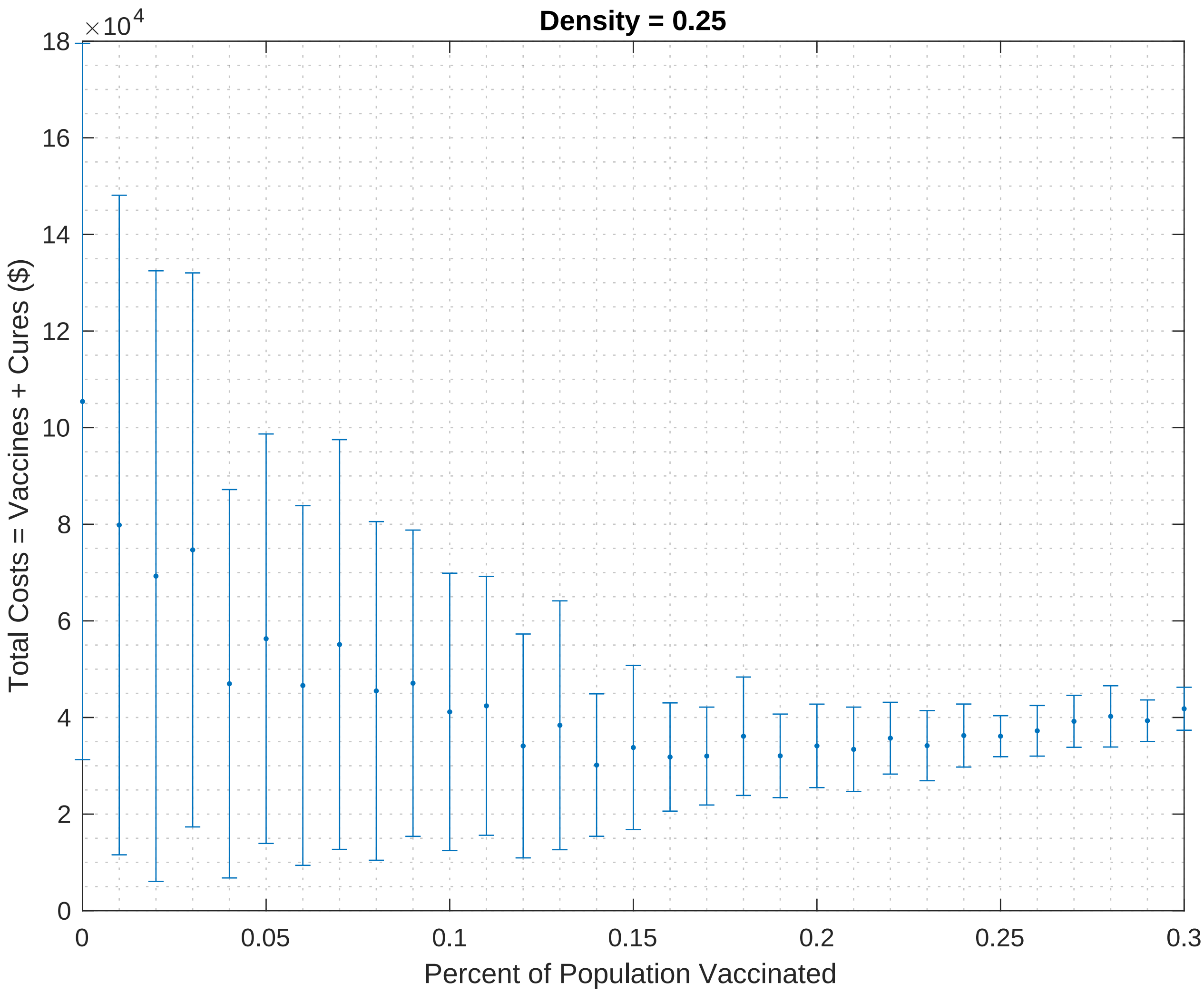

Density = 0.35
×10^5
Total Costs = Vaccines + Cures ($)
Percent of Population Vaccinated
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Density = 0.5
×10^5
9
8
7
6
5
4
3
2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Total Costs = Vaccines + Cures ($)
Percent of Population Vaccinated

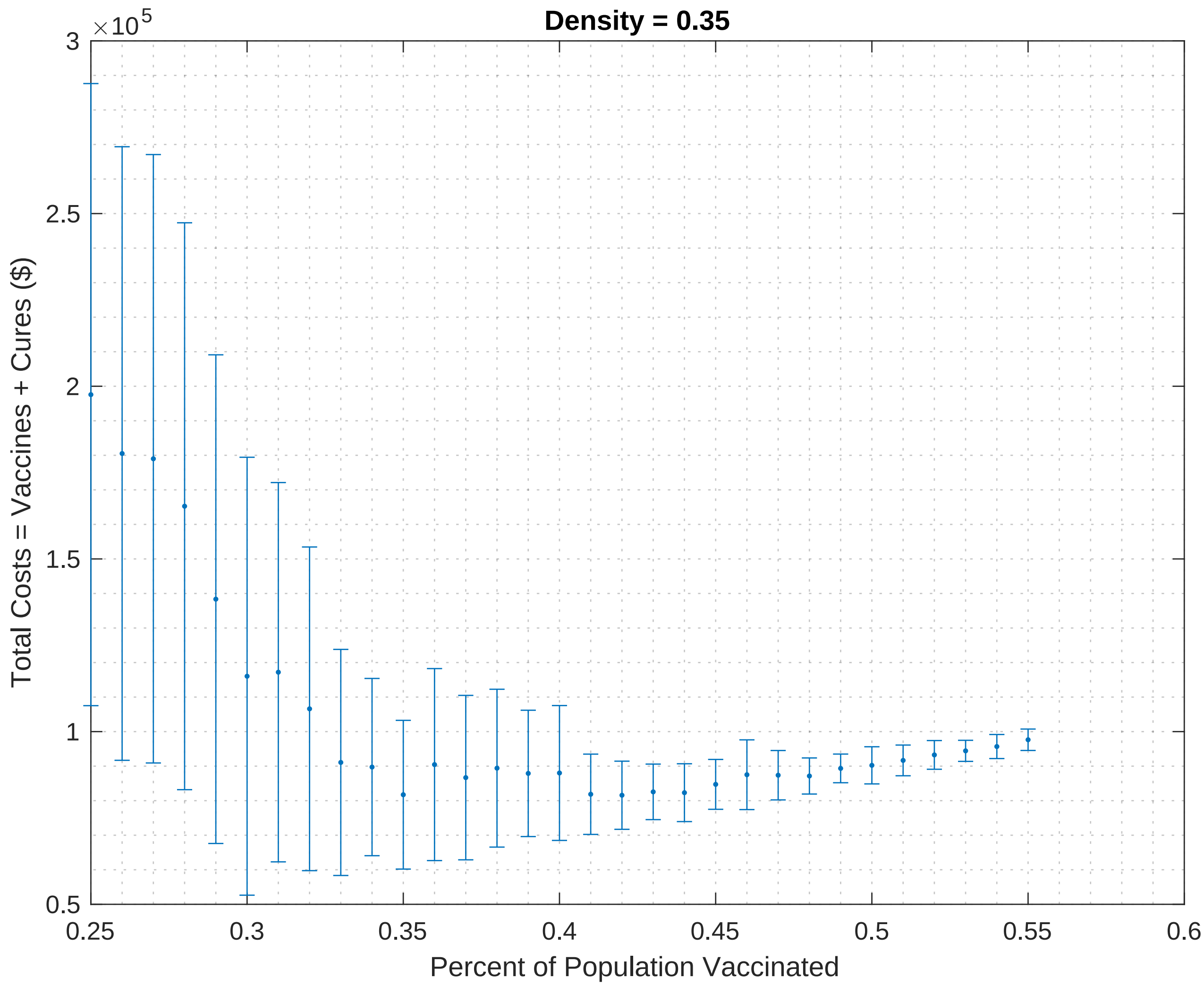
2 Further Analysis

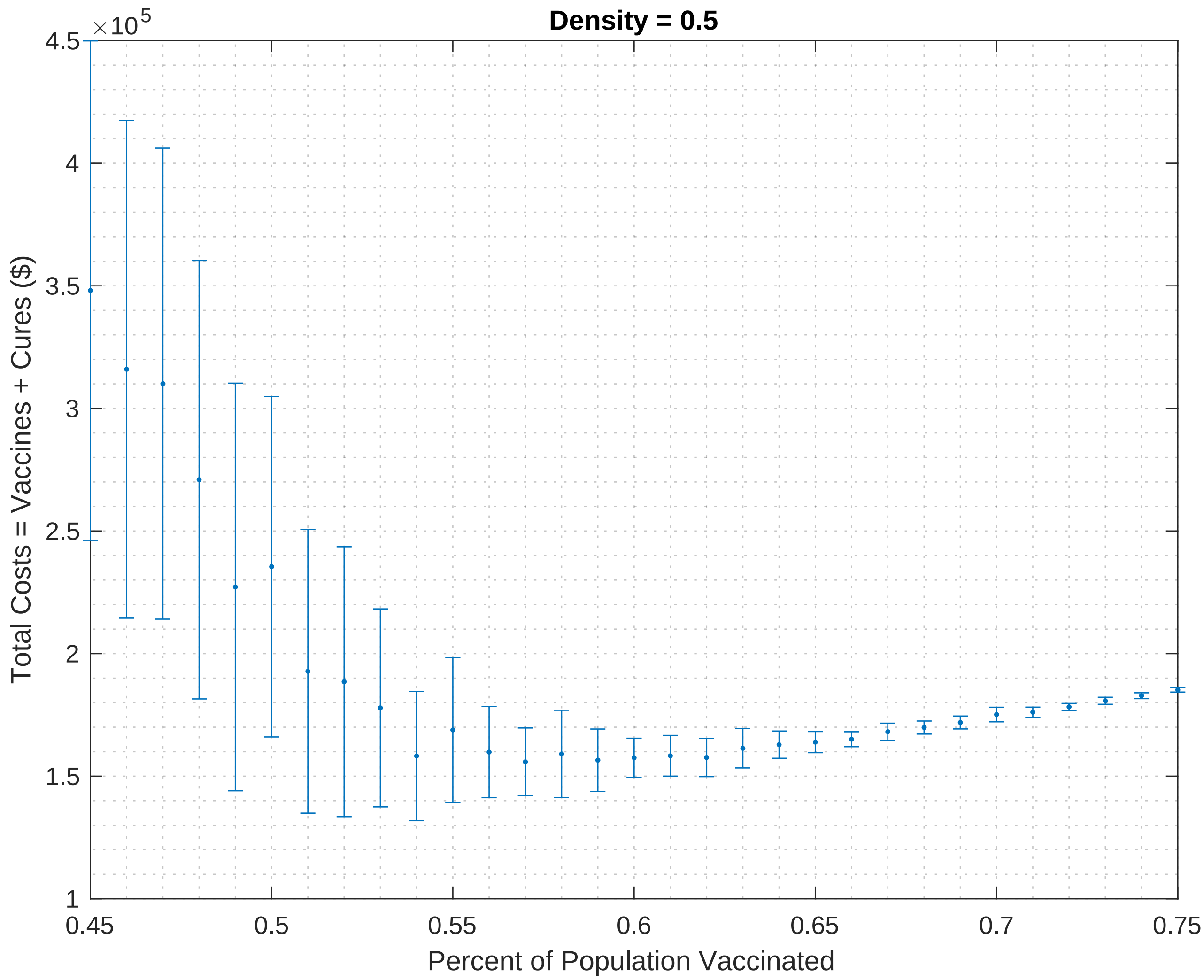
Next, I performed a more thorough analysis around the approx. min points to identify a better range for the optimal vaccination rate for each density. The script I ran is in *infection_analysis.m*. This ran the simulation 50 times for each point and takes around 40 minutes to run on my computer. The results are plotted below. Selecting the *pvacs* from the plot that had error intervals which overlapped with the error interval of the minimum average point, we get that the optimal vaccination rates are:

- For density = 0.25: $0 < pvac_{opt} < 0.3$
- For density = 0.35: $0.27 < pvac_{opt} < 0.53$
- For density = 0.5: $0.49 < pvac_{opt} < 0.69$



Density = 0.25
×10^4
18
16
14
12
10
8
6
4
2
0
Total Costs = Vaccines + Cures ($)
0
0.05
0.1
0.15
0.2
0.25
0.3
Percent of Population Vaccinated


Density = 0.35
×10^5
3
2.5
2
1.5
1
0.5
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
Total Costs = Vaccines + Cures ($)
Percent of Population Vaccinated



Density = 0.5
×10^5
4.5
4
3.5
3
2.5
2
1.5
1
Total Costs = Vaccines + Cures ($)
0.45
0.5
0.55
0.6
0.65
0.7
0.75
Percent of Population Vaccinated