# Comparative Analysis Of Gravity Model, Neural Network, And Graph Neural Network For Traffic Demand Modeling In Urban Areas

- Relative Fields: Transportation Engineering, Traffic Engineering, Machine Learning, Neural Network with Pytorch


- Steps:
  - code out the GM Model. We did this in 4 different approach. 1-exponentional  2-power  3-tanner  4-guess
  - The last approach (Guess) is made by me and is a new approach.
  - Model the NN and GNN
  - connect all details to get the results all together.

| Region | Method | 90% | 80% | 70% | 60% | 50% | 40% | 30% | 20% | 10% | 5% | 3% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SiouxFalls** | **GM_exp** | 75% | 73% | 82% | 75% | 77% | 73% | 78% | 76% | 72% | 77% | 75% |
| | **GM_power** | 75% | 78% | 81% | 78% | 78% | 75% | 74% | 71% | 67% | 81% | 57% |
| | **Neural_Net** | 63% | 65% | 70% | 35% | 52% | 63% | 63% | 44% | 43% | 37% | 1% |
| | **Graph_Neural_Net** | 66% | 63% | 72% | 63% | 58% | 70% | 69% | 58% | 60% | 59% | 60% |
| **Anaheim** | **GM_exp** | 92% | 90% | 92% | 89% | 93% | 93% | 94% | 92% | 93% | 90% | 92% |
| | **GM_power** | 92% | 91% | 92% | 89% | 93% | 93% | 94% | 92% | 93% | 90% | 92% |
| | **Neural_Net** | 87% | 86% | 87% | 80% | 86% | 88% | 87% | 83% | 81% | 46% | 0% |
| | **Graph_Neural_Net** | 89% | 90% | 88% | 85% | 88% | 80% | 81% | 86% | 85% | 76% | 88% |
| **Chicago** | **GM_exp** | 12% | 12% | 13% | 12% | 11% | 12% | 11% | 14% | 13% | 12% | 14% |
| | **GM_power** | 16% | 13% | 16% | 15% | 17% | 13% | 11% | 13% | 16% | 12% | 5% |
| | **Neural_Net** | 31% | 31% | 32% | 33% | 31% | 32% | 26% | 28% | 19% | 6% | -33% |
| | **Graph_Neural_Net** | 17% | 19% | 20% | 17% | 20% | 19% | 19% | 14% | 21% | 20% | 17% |



R2 - SiouxFalls



R2 - Anaheim



R2 - Chicago
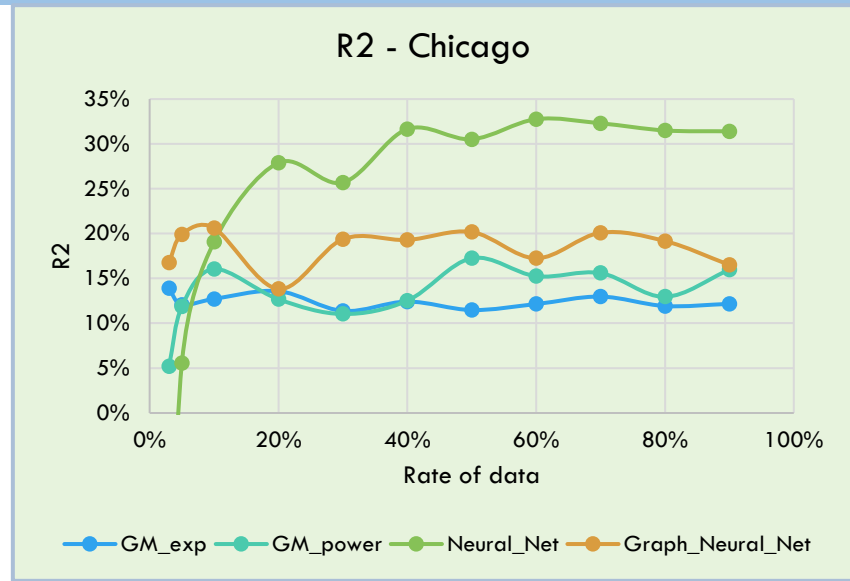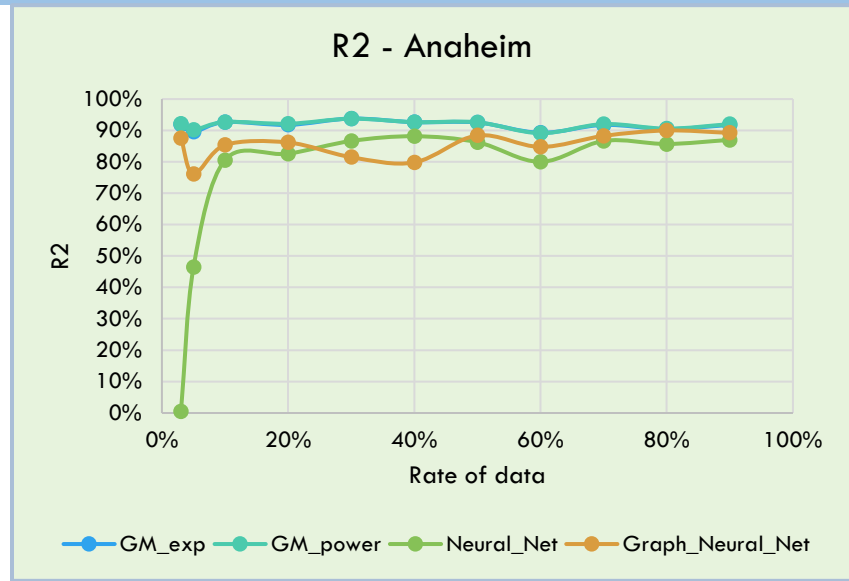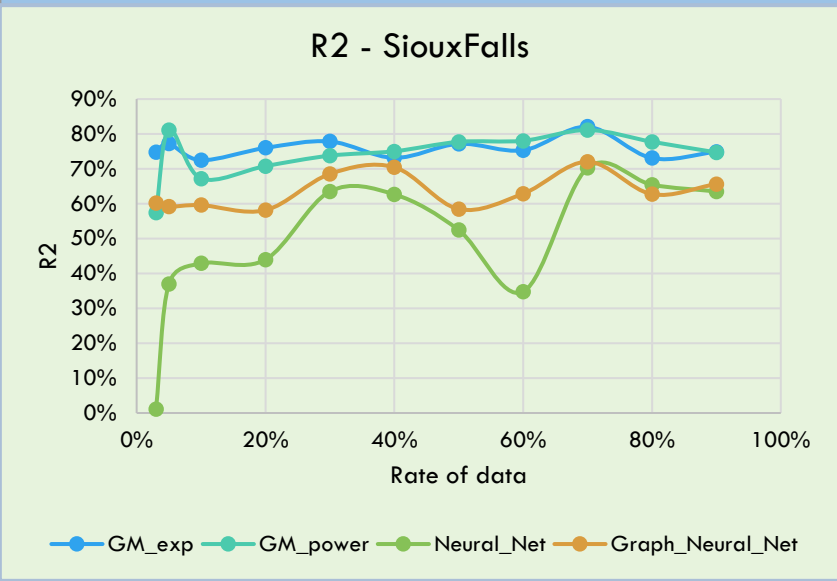
| Region | Method | 90% | 80% | 70% | 60% | 50% | 40% | 30% | 20% | 10% | 5% | 3% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SiouxFalls | GM_exp | 0.0482 | 0.0456 | 0.0568 | 0.0507 | 0.0483 | 0.0448 | 0.0517 | 0.0531 | 0.0684 | 0.1075 | 0.1207 |
| | GM_power | 0.0480 | 0.0426 | 0.0552 | 0.0468 | 0.0474 | 0.0425 | 0.0540 | 0.0560 | 0.0714 | 0.1000 | 0.1299 |
| | Neural_Net | 0.0631 | 0.0558 | 0.0701 | 0.0785 | 0.0716 | 0.0561 | 0.0669 | 0.0818 | 0.1114 | 0.1868 | 0.2266 |
| | Graph_Neural_Net | 0.0813 | 0.0861 | 0.0619 | 0.0654 | 0.1351 | 0.1007 | 0.1008 | 0.0883 | 0.1072 | 0.0690 | 0.0818 |
| Anaheim | GM_exp | 0.0079 | 0.0102 | 0.0104 | 0.0112 | 0.0116 | 0.0119 | 0.0125 | 0.0120 | 0.0161 | 0.0262 | 0.0402 |
| | GM_power | 0.0079 | 0.0102 | 0.0103 | 0.0112 | 0.0117 | 0.0120 | 0.0126 | 0.0120 | 0.0161 | 0.0259 | 0.0398 |
| | Neural_Net | 0.0127 | 0.0168 | 0.0188 | 0.0171 | 0.0216 | 0.0216 | 0.0223 | 0.0204 | 0.0407 | 0.0870 | 0.1113 |
| | Graph_Neural_Net | 0.0185 | 0.0144 | 0.0213 | 0.0255 | 0.0294 | 0.0243 | 0.0565 | 0.0219 | 0.0471 | 0.0224 | 0.0164 |
| Chicago | GM_exp | 0.0022 | 0.0026 | 0.0026 | 0.0028 | 0.0037 | 0.0045 | 0.0048 | 0.0059 | 0.0078 | 0.0093 | 0.0110 |
| | GM_power | 0.0022 | 0.0026 | 0.0027 | 0.0028 | 0.0037 | 0.0046 | 0.0049 | 0.0060 | 0.0078 | 0.0095 | 0.0113 |
| | Neural_Net | 0.0038 | 0.0044 | 0.0043 | 0.0042 | 0.0054 | 0.0064 | 0.0068 | 0.0083 | 0.0118 | 0.0175 | 0.0291 |
| | Graph_Neural_Net | 0.0053 | 0.0037 | 0.0044 | 0.0054 | 0.0078 | 0.0062 | 0.0043 | 0.0070 | 0.0069 | 0.0158 | 0.0135 |

| Region | Method | 90% | 80% | 70% | 60% | 50% | 40% | 30% | 20% | 10% | 5% | 3% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SiouxFalls** | GM_exp | 0.2626 | 0.2559 | 0.2816 | 0.2667 | 0.2618 | 0.2529 | 0.2745 | 0.2732 | 0.3143 | 0.3844 | 0.4069 |
| | GM_power | 0.2635 | 0.2459 | 0.2857 | 0.2576 | 0.2619 | 0.2462 | 0.2848 | 0.2874 | 0.3258 | 0.3687 | 0.4374 |
| | Neural_Net | 0.0073 | 0.0059 | 0.0100 | 0.0130 | 0.0125 | 0.0058 | 0.0095 | 0.0142 | 0.0277 | 0.1315 | 0.1640 |
| | Graph_Neural_Net | 0.0160 | 0.0305 | 0.0087 | 0.0081 | 0.0943 | 0.0391 | 0.0457 | 0.0286 | 0.0495 | 0.0096 | 0.0178 |
| **Anaheim** | GM_exp | 0.1315 | 0.1540 | 0.1565 | 0.1552 | 0.1617 | 0.1683 | 0.1664 | 0.1652 | 0.1902 | 0.2378 | 0.2665 |
| | GM_power | 0.1312 | 0.1536 | 0.1570 | 0.1561 | 0.1614 | 0.1695 | 0.1674 | 0.1645 | 0.1909 | 0.2348 | 0.2652 |
| | Neural_Net | 0.0007 | 0.0011 | 0.0015 | 0.0016 | 0.0025 | 0.0017 | 0.0027 | 0.0020 | 0.0152 | 0.0309 | 0.0899 |
| | Graph_Neural_Net | 0.0038 | 0.0025 | 0.0022 | 0.0086 | 0.0076 | 0.0057 | 0.0599 | 0.0022 | 0.0567 | 0.0029 | 0.0011 |
| **Chicago** | GM_exp | 0.1034 | 0.1157 | 0.1091 | 0.1153 | 0.1336 | 0.1406 | 0.1500 | 0.1581 | 0.1931 | 0.2092 | 0.2289 |
| | GM_power | 0.1022 | 0.1153 | 0.1083 | 0.1141 | 0.1315 | 0.1401 | 0.1501 | 0.1581 | 0.1907 | 0.2084 | 0.2313 |
| | Neural_Net | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.0003 | 0.0003 | 0.0006 | 0.0007 | 0.0021 | 0.0018 | 0.0036 |
| | Graph_Neural_Net | 0.0005 | 0.0001 | 0.0003 | 0.0010 | 0.0009 | 0.0005 | 0.0002 | 0.0006 | 0.0009 | 0.0041 | 0.0017 |
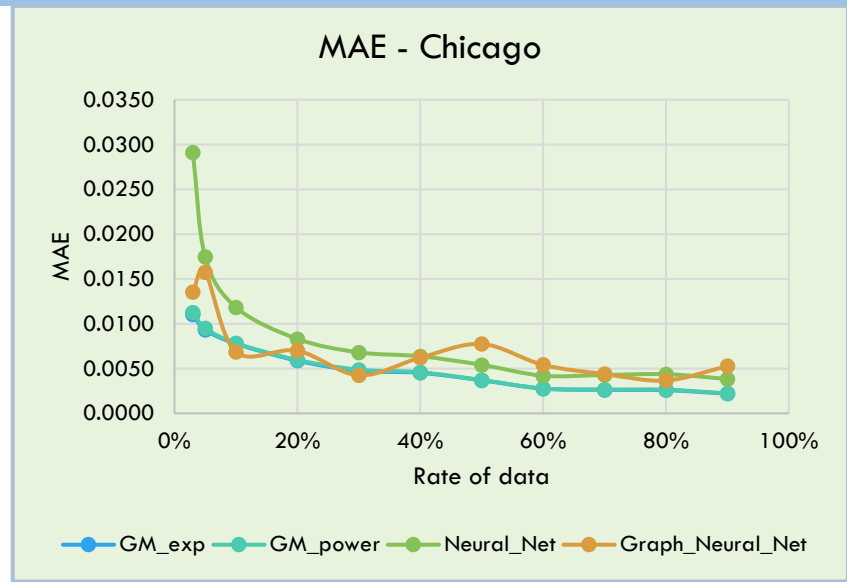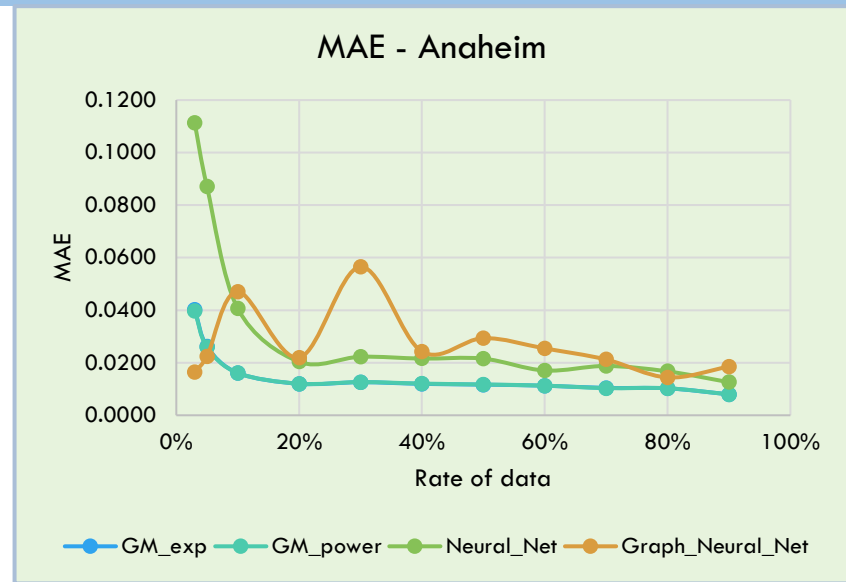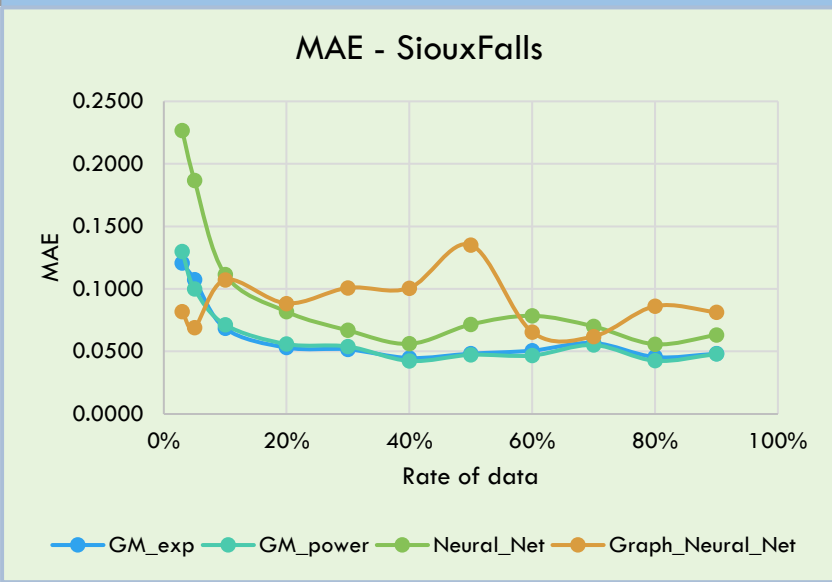


RMSE - SiouxFalls



RMSE - Anaheim



RMSE - Chicago