# Supplementary Materials

## 1 Results of Real Data

The runtime analysis of two datasets are shown in figure 1. From the figures, the runtime decreases as the seed size becomes larger. When the seed size goes larger, the matrices to be optimized($B_i$ and $D_i$) becomes relatively smaller, which causes a faster computation in optimization.
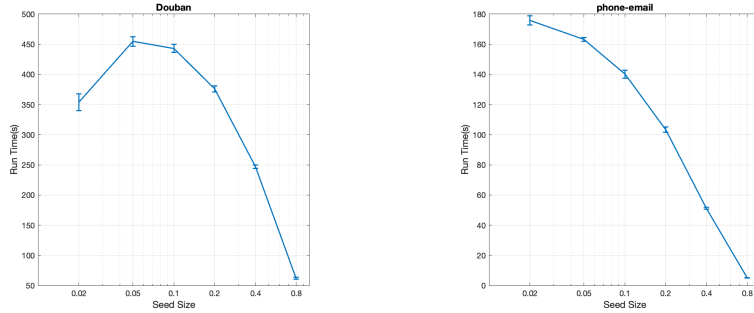


Fig. 1: **Runtime of Douban and phone-email dataset as a function of seed sizes.** The curves and errorbars show the mean and standard deviations among 5 runs.

## 2 Results of Synthetic Data

Figure 2 shows the runtime of the synthetic data. As noise level becomes higher, the runtime decreases a little. However, the curves are not so smooth and the standard deviations are not stable. This results show that adding noise might change the topological features of the graphs and affects runtime, but it is not a crucial factor of runtime.
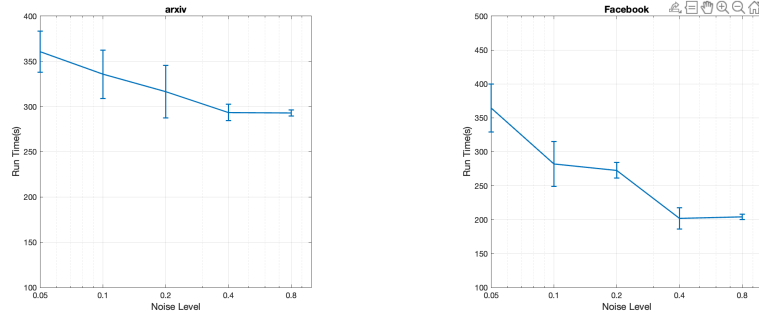
Fig. 2: **Runtime of synthetic datasets as a function of noise levels.** The seed sizes of all experiments are 0.5. The curves and errorbars show the mean and standard deviations among 5 runs.