Evolutionary Dynamics with variable fitness on network structure

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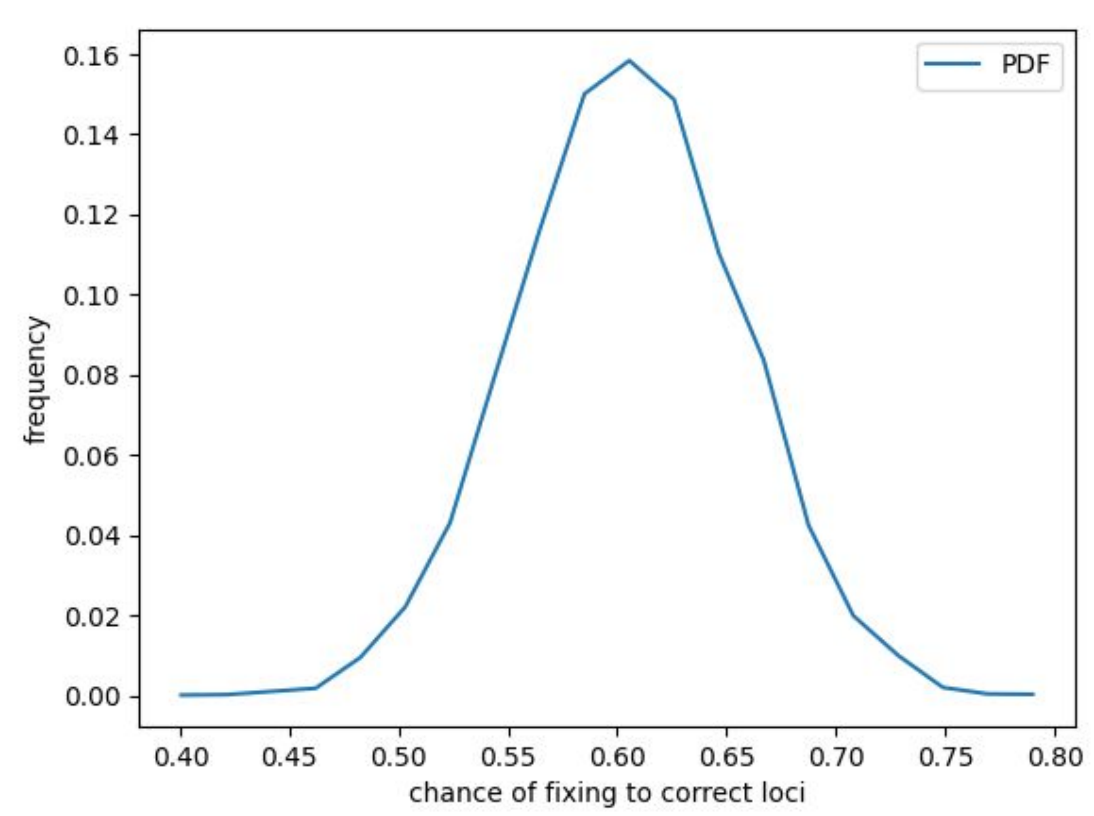
Introduction

In evolutionary dynamics, we are considering the problem of a mutant being introduced to a population of wild-type individuals.
Previous studies have shown the effect of selection, often denoted by parameter *s,* on the probability of fixation. In such settings, we often assumes the wild-type to have fitness 1 whereas the mutant would have fitness (1+s). Intuitively, a selection advantage to the mutant, as represented by a selection advantage, help increase the probability of fixation.
However, in nature or evolutionary algorithms, the effect of beneficial mutations may not be reflected in fitness in such a straightforward manner. Often, environmental factors play a part, or randomness and stochasticity alone could contribute to a non-negligible variance.
Here, we are interested in the role of variance in shaping fixation and distinction. Specifically, we study how variance changes probability of fixation in different settings

Random Walk distribution

The intuition behind this part of the project is that we could consider each node in a network as a clone of organism or a multicellular organism.
In many cases, we often evaluate the fitness of a node in terms of an external simulation or game.
However, we have found out that while traditional evolutionary dynamics studies often assumes fixed fitness, the fitness from any stochastic simulation could have a decent amount of variability.

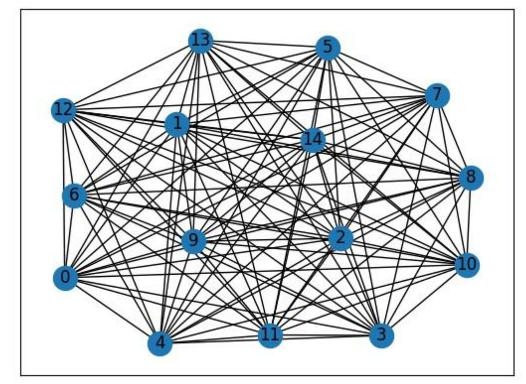


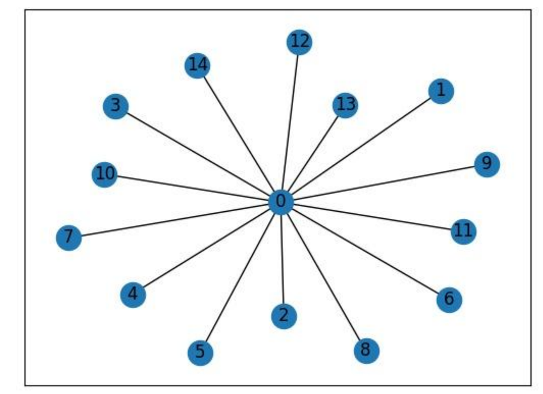
Here is the *pdf* of entering a correct region of absorbing states in a 1D random walk. For a mean of 0.6 we are having a sample standard deviation of 0.05.

Problem Set-Up

Graphical Models

For our simulations, we primarily considered two types of network structures.



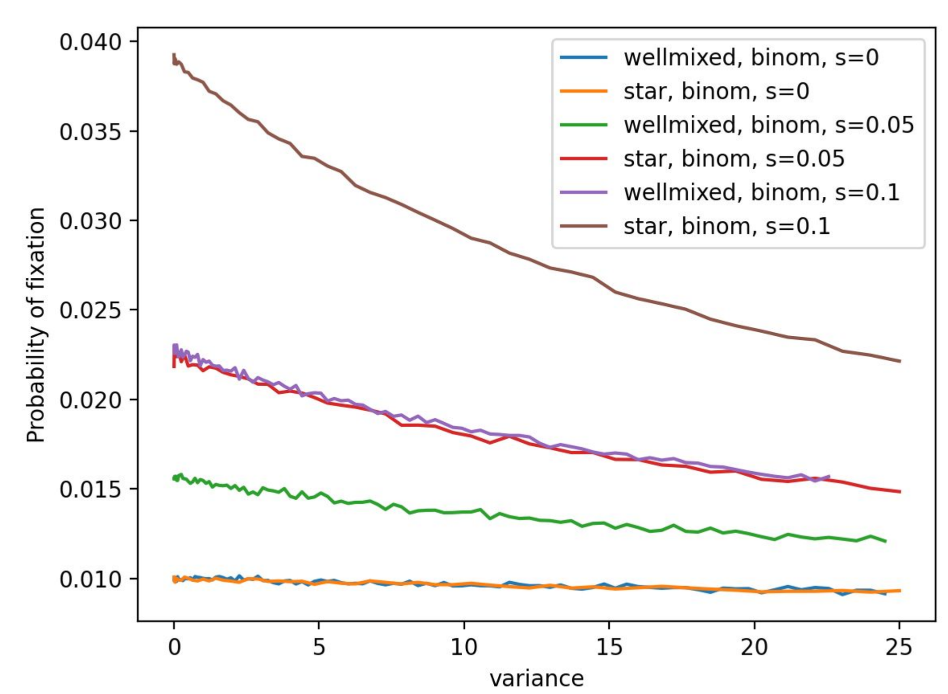


Moran Birth-Death Process

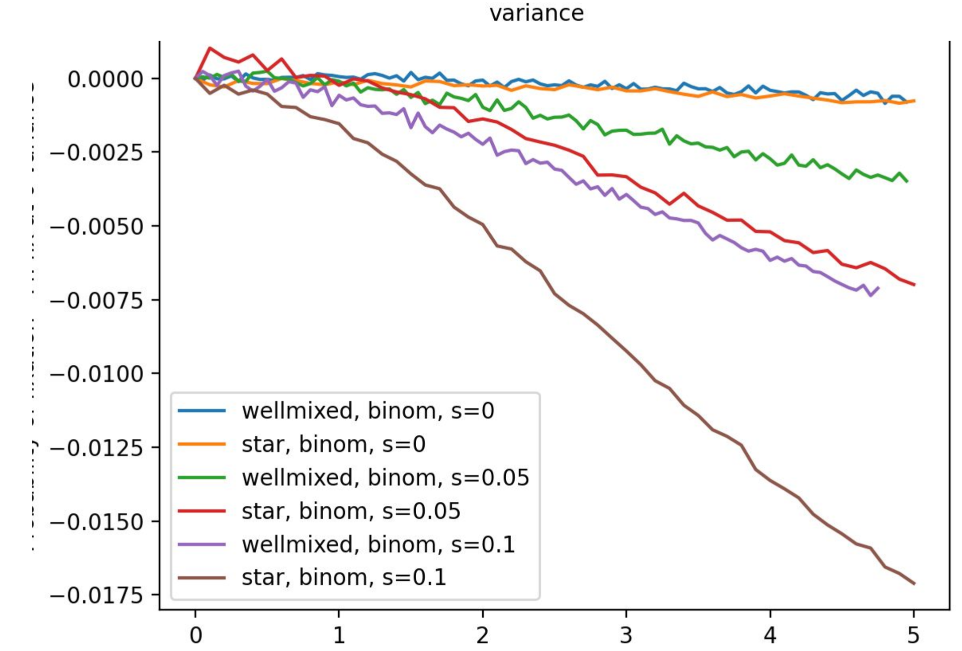
At every time step, one node is selected based on probability proportion to its fitness.
In a wellmixed network, it has equal probability of replacing any other node in the graph. In a network with structure, the node will randomly replace one of its neighbors.
This process continues until either all the nodes became mutant (fixation), or all the nodes are wild-type (extinction)

Results

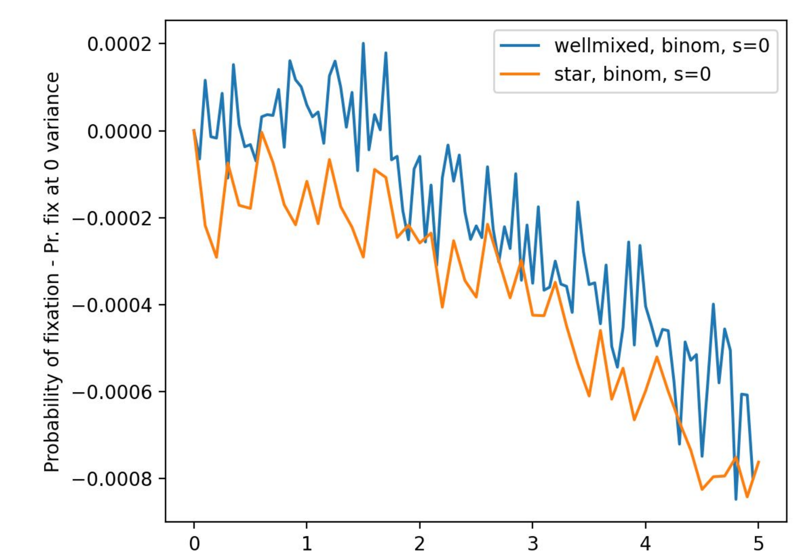
We managed to see that variance do have an effect on probability of fixation, whether in a wellmixed population or In a structured network.

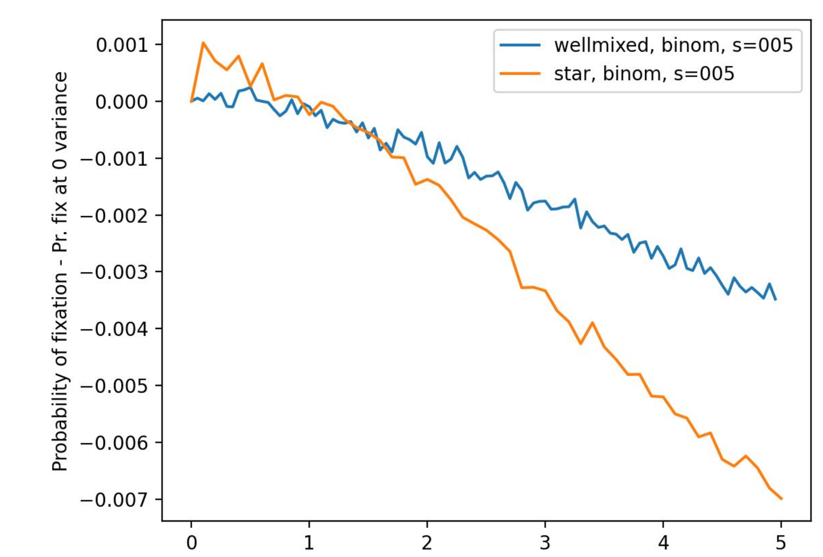


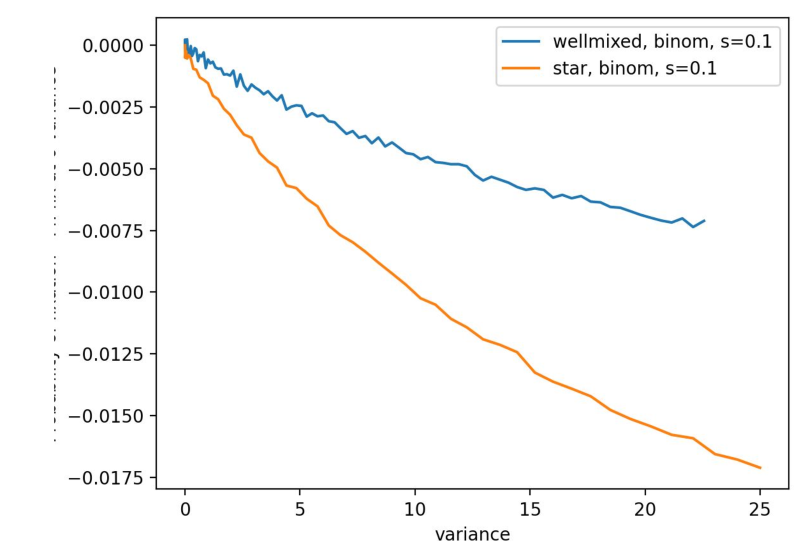
Probability of fixation in different settings, across different variance



Y-axis is probability of fixation - probability of fixation with the same model but zero variance
It provides a direct look at the effect of variance







Here are more direct comparisons of how variance play a role in probability of fixation in wellmixed network and stars, again under different selection strength.

Discussion

In this project, we have made some interesting little discoveries. By investigating the distribution produced by group random walk, we realized that there is a non-negligible variance present as we try to link it to fitness.
We then discovered the role of variance in shaping probability of fixation. Specifically, we find it interesting that selection *s* has an amplification effect on the role of variance.
We also note that such effect can also be observed in star graphs. Specifically, variance has a stronger effect on star graphs given same mean and selection.
Future work would be to understand the reason behind the differences in how variance changes probability of fixation for different types of networks.

Acknowledgement

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