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Function central limit theorem for Susceptible-Infected process on configuration model graphs: Further insights into the accuracy of the correlation equations

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We study a stochastic compartmental susceptible-infected (SI) epidemic process on a configuration model random graph with a given degree distribution over a finite time interval. We split the population of graph nodes into two compartments, namely, S and I, denoting susceptible and infected nodes, respectively. In addition to the sizes of these two compartments, we study counts of SI-edges (those connecting a susceptible and an infected node), and SS-edges (those connecting two susceptible nodes). We describe the dynamical process in terms of these counts and present a functional central limit theorem (FCLT) for them when the number of nodes in the random graph grows to infinity. To be precise, we show that these counts, when appropriately scaled, converge weakly to a continuous Gaussian vector semimartingale process in the space of vector-valued càdlàg functions endowed with the Skorohod topology. Based on the results obtained, we further investigate the accuracy of the so-called correlation equations from ecology literature. We show that for a certain class of degree distributions, called Poisson-type (PT) distributions, the pair approximation approach is exact in the sense that it correctly estimates the limiting first order moments of the various count variables.

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