Mafia Murders as a Complex System: Temporal Patterns and Statistical Modeling

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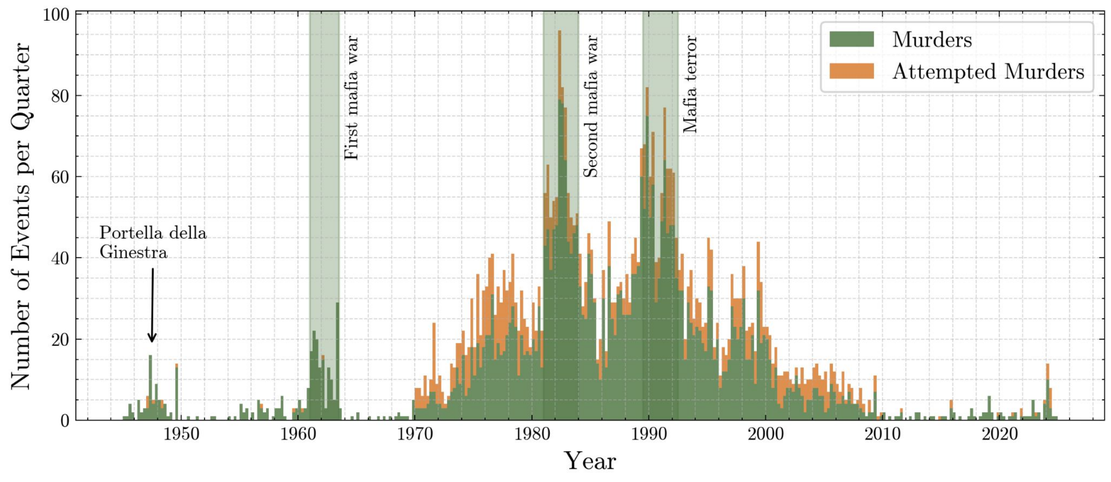
Background and motivation

The rise and fall of the mafia phenomenon in Sicily has profoundly shaped modern Italian history. Targeted homicides have been one of Cosa Nostra's principal instruments of control, serving not as isolated crimes but as strategic components of broader political agendas, reflecting the internal conflicts, power shifts, and territorial disputes of mafia clans. Viewing mafia killings through the lens of complex systems can uncover underlying temporal structures and inform historical and criminological interpretations. Here, we analyze a unique dataset spanning nearly eight decades of murders, offering a new quantitative perspective on the dynamics of mafia violence as cascades of events.

The data

In collaboration with the **Prosecutor's Office of Palermo**, we built a comprehensive archive of ~5000 events (murders or attempted murders) in Sicily, from 1945 to 2024, including name of the victims, date of the murder, street-level location and other qualitative notes; events are included when mafia involvement is suspected or cannot be ruled out.

The archive covers key periods, like the **First Mafia War** (1961 - 1963), the **Second Mafia War** (1981 - 1984) and the period of **Mafia terror** (1990 - 1993).



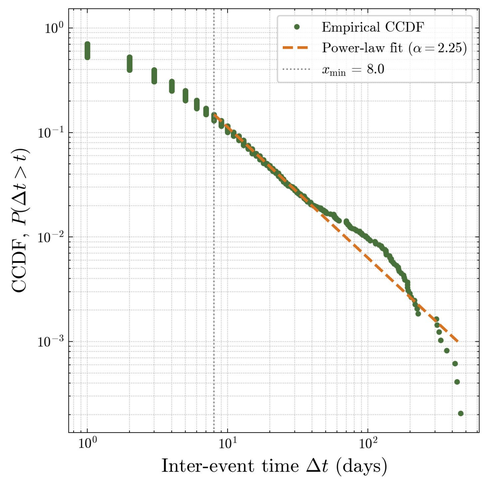
Methods

- Analysis of **inter-event time** distributions [1]
- Identification of **avalanches** (sequences of events separated by at most δt) of homicides similar to neuronal avalanches [2,3]
- Statistical modeling with Hawkes processes to capture **self-exciting** dynamics [4]

Results

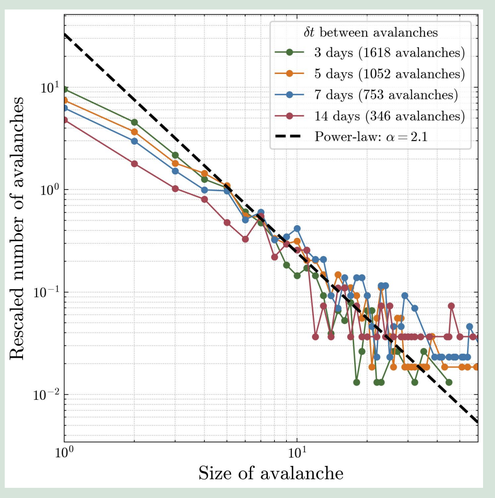
Inter-event time distribution

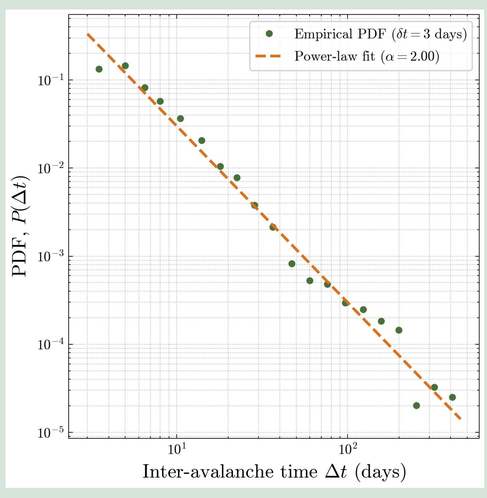
The distribution of days between consecutive events, as shown using the empirical complementary cumulative distribution function (CCDF), exhibits **power-law behaviour**, with some deviations on longer time-scales (over two months), suggesting bursty dynamics and memory effects.



Avalanches

The distribution of **avalanche sizes** at different δt, with appropriate scaling, collapse to a power-law similar to that of neuronal avalanches [2,3]. The waiting times of the avalanches are also described by a power-law with similar exponent. The results suggest that many events occur in **bursty cascades**, probably in response to each other, reflecting a tension release mechanism.

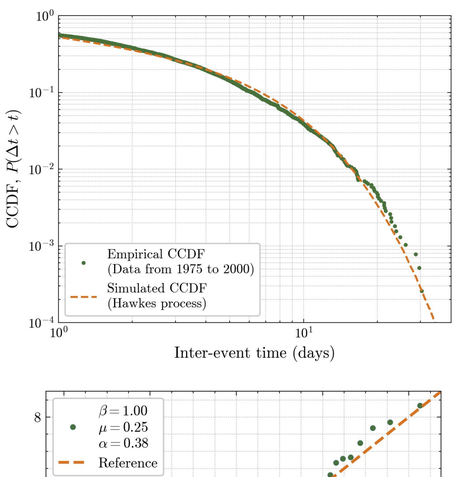


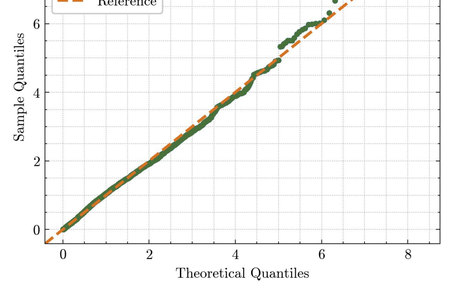


Self-exciting dynamics

In a Hawkes model, each event increases the probability of future events for a limited time [4]. We fit a Hawkes process to the most intense period (1975–2000), finding it better than a memoryless Poisson process. This indicates the presence of **self-exciting behavior**; the branching ratio is ~0.4, indicating that occasionally events ignite cascades.

$$\lambda(t) = \mu + \sum_{t_i < t} \alpha\, e^{-\beta(t - t_i)}$$





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