DYNCOOPNET

cooperation & trade
on Networks of the First Global Age

Flávio L. Pinheiro & Jorge M. Pacheco

www.ciul.ul.pt/~ATP

Simón Ruiz Graph (SRG)

can mathematics help history ?

1. setup of the **SRG**
   - initial sub-graphs, and merging process
   - cleaning (& simplifying) the **SRG**
2. characterizing the **SRG**
3. evolution of Cooperation & Trade in the **SRG**
   - Prisoner's Dilemma
   - Coordination Dilemma

initial sub-graphs

initially we have **10** sub-graphs

Network	code	#nodes	#links
Friendship	001	3	2
Warning	002	5	2
Cheating	003	4	2
Collaboration	004	7	4
Trust	005	40	10
Economical	006	2	1
Family	007	21	7
Financial	**008**	**311**	**973**
Law	009	3	2
Social	010	9	4
Suspicion	011	4	1

all sub-graphs are
- directed
- contain loops

most are disconnected

financial sub-graph dominates

merging all the components to obtain a final graph

from all subgraphs we build a single one which is:

– undirected (all links became directional and devoid of origin)

– repeated links were eliminated

– loops were removed

– disconnected nodes were removed

Network	Size	maxDegree	Av. Degree	Degree Var.	APL	CC
Final Graph	304	229	4.38	188.46	2.46	0.35

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small-world

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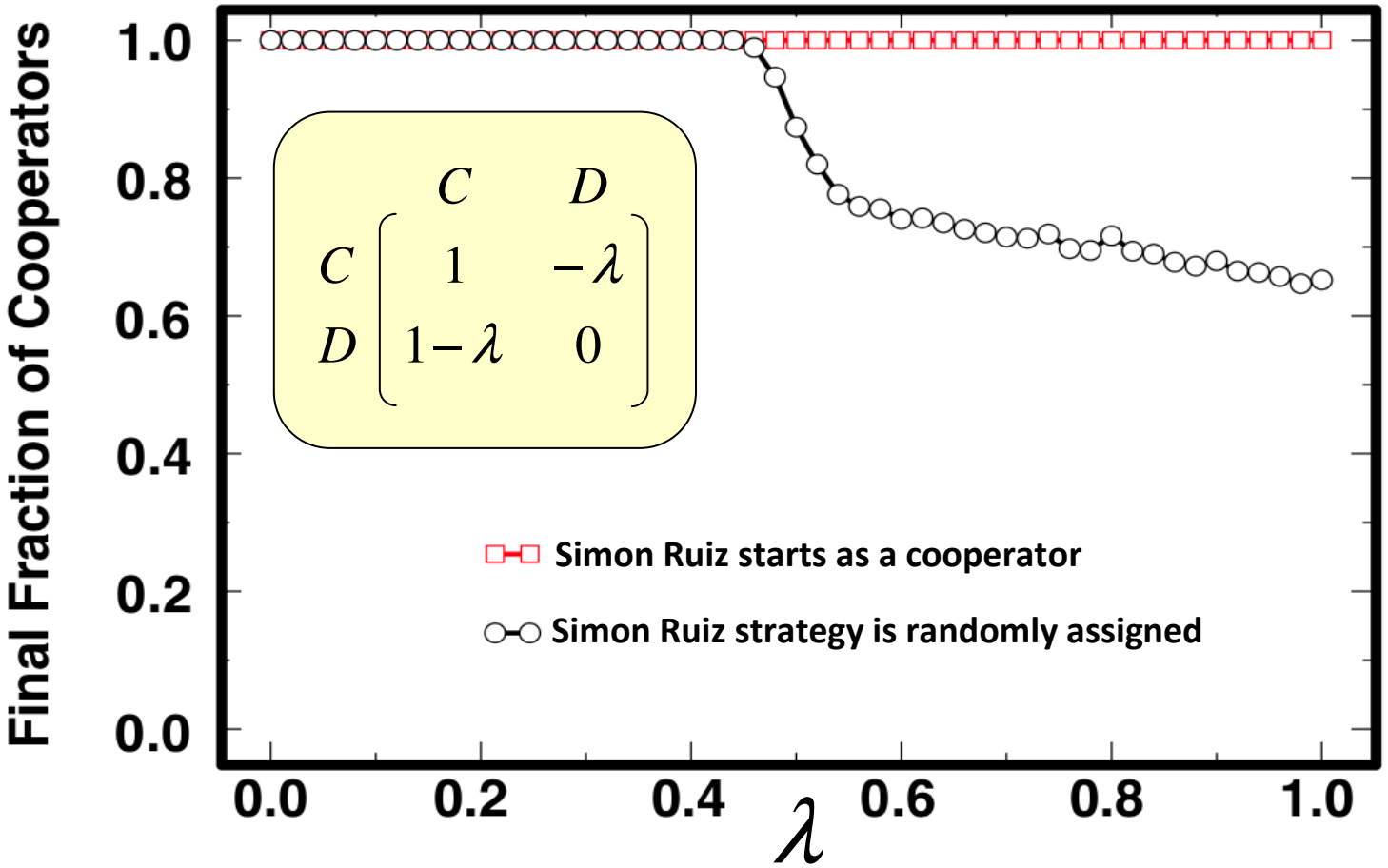
trade on SRG

coordination dilemmas

coordination dilemmas constitue the standard metaphor for trading

we use EGT approach in which traders updated their strategy under social learning



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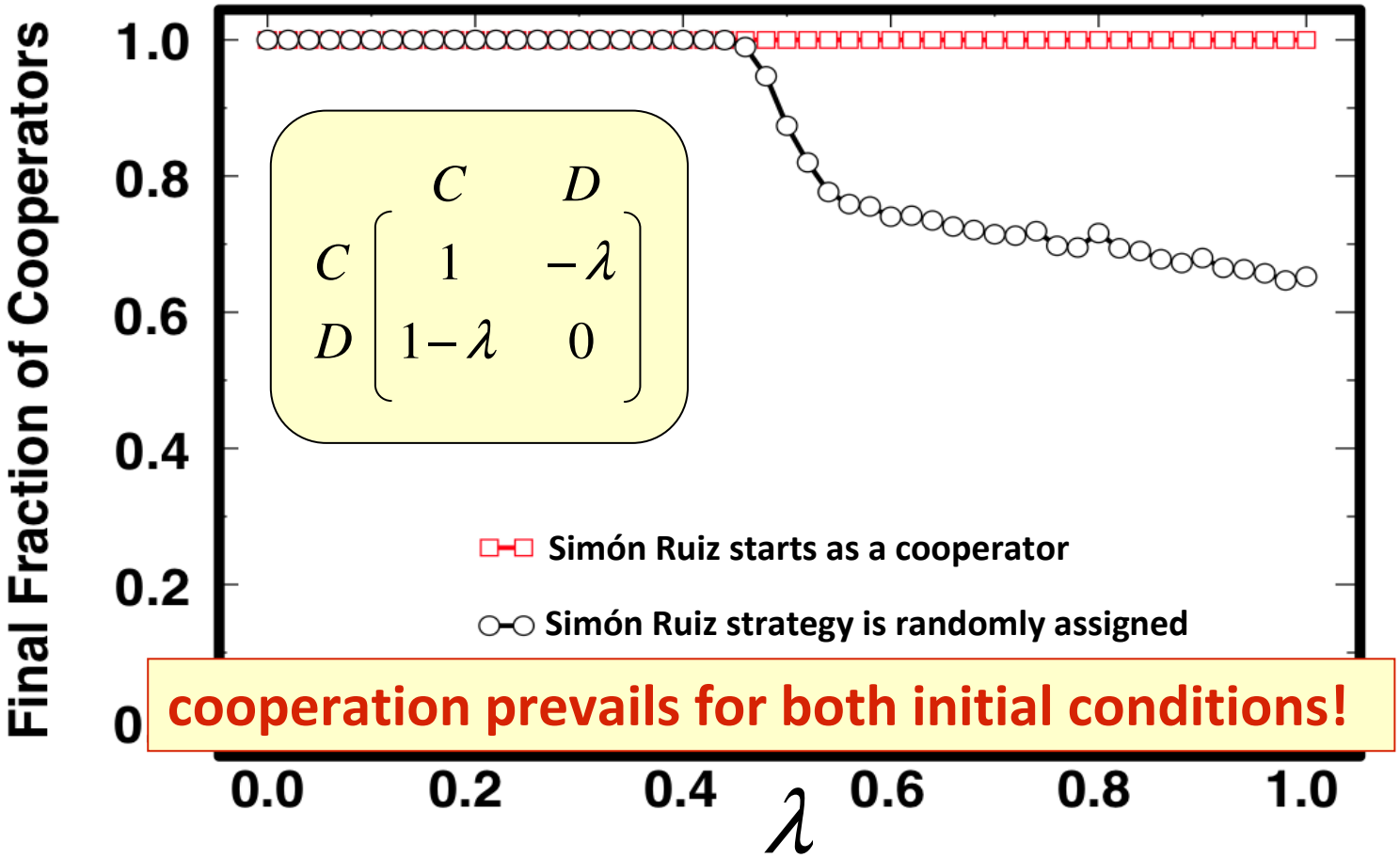

cooperation on SRG

prisoner's dilemma

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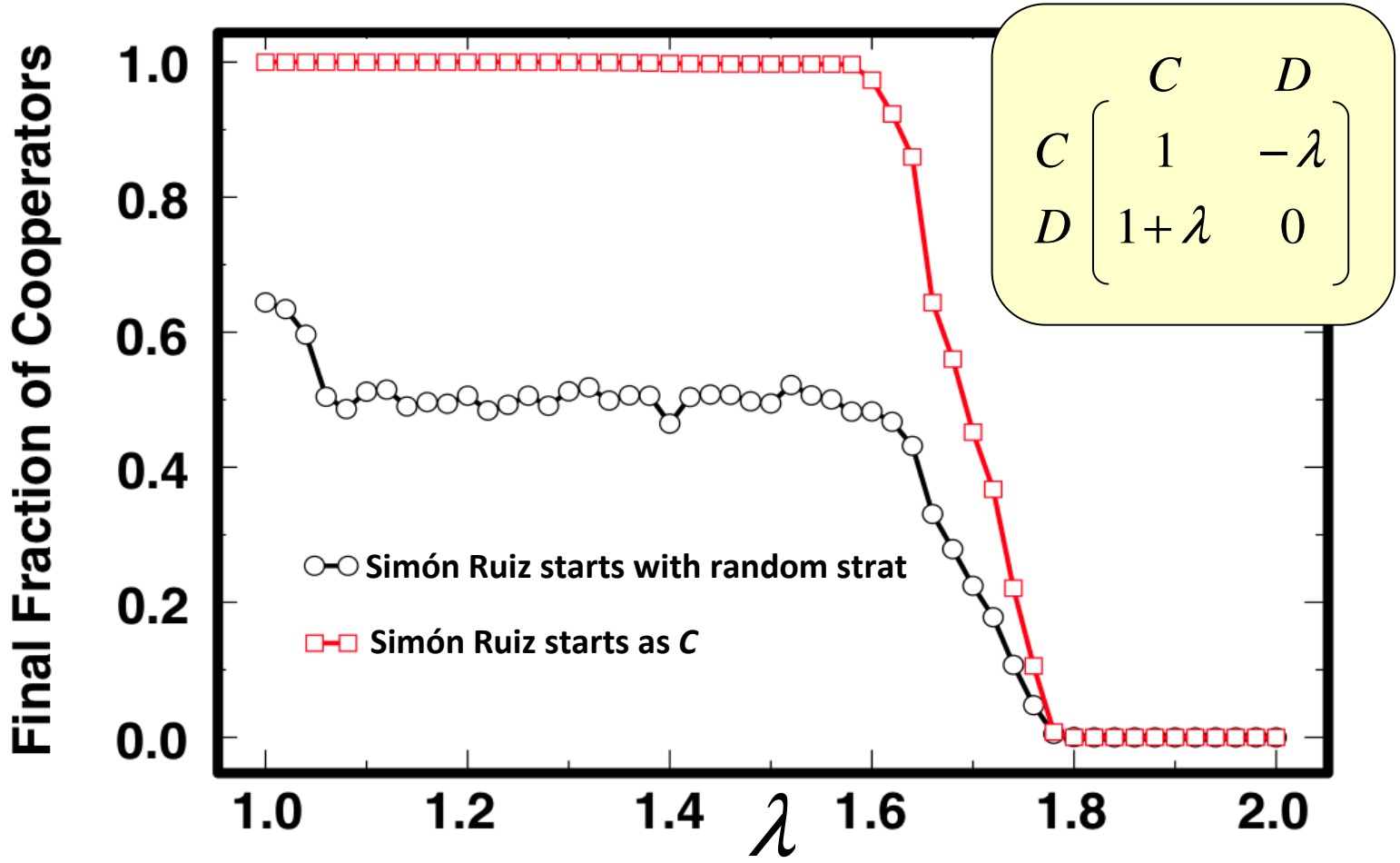

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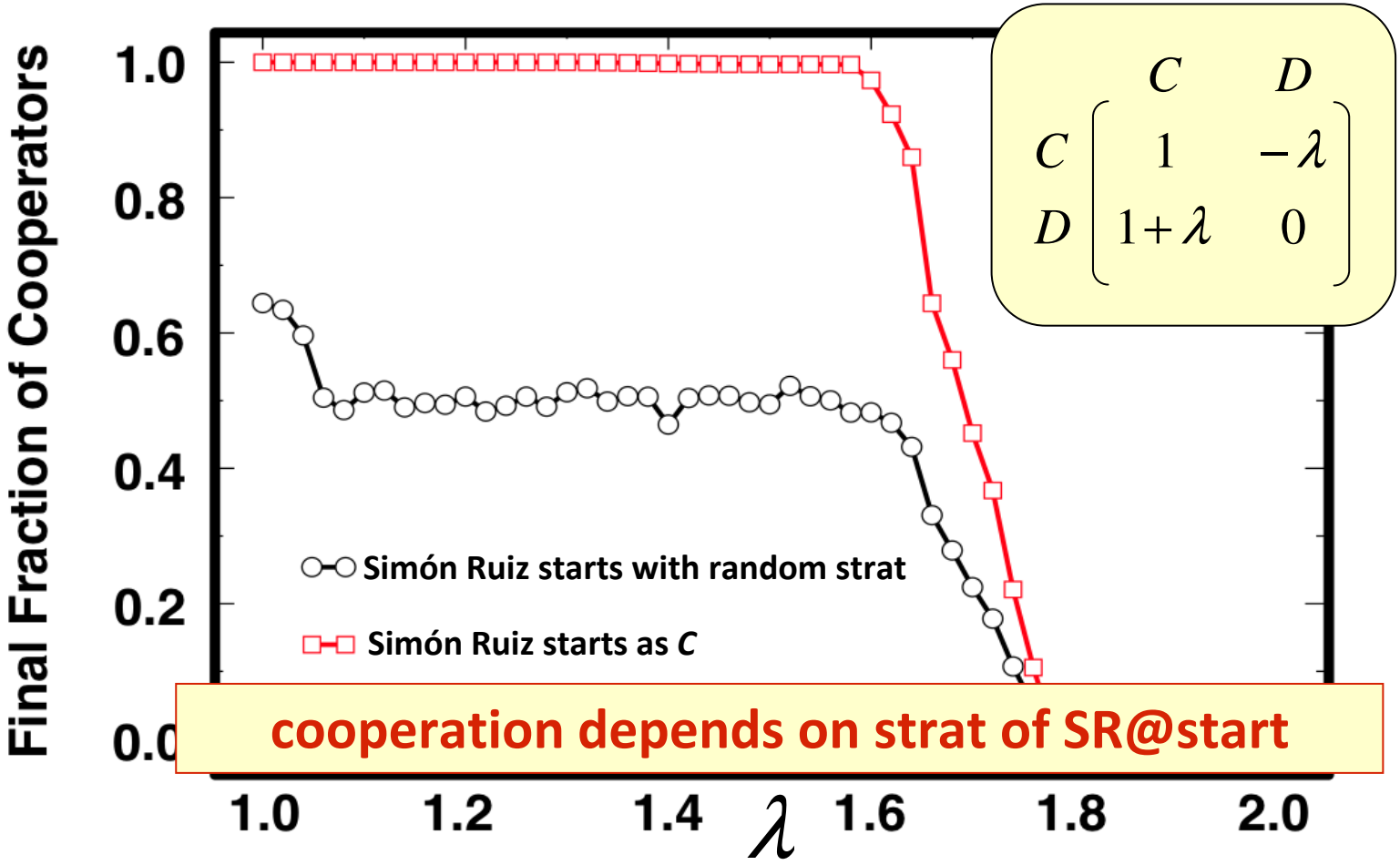
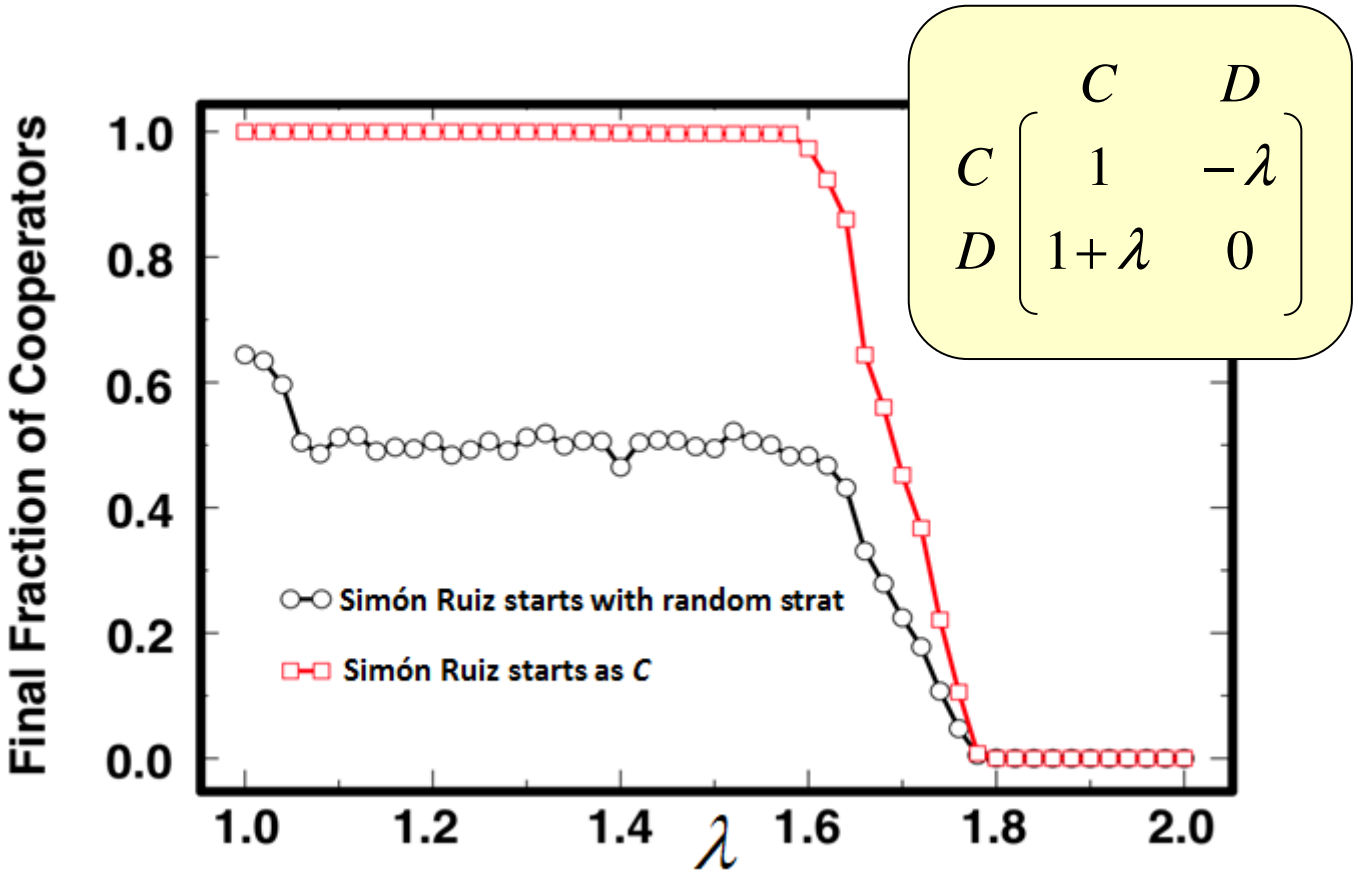


cooperation on SRG

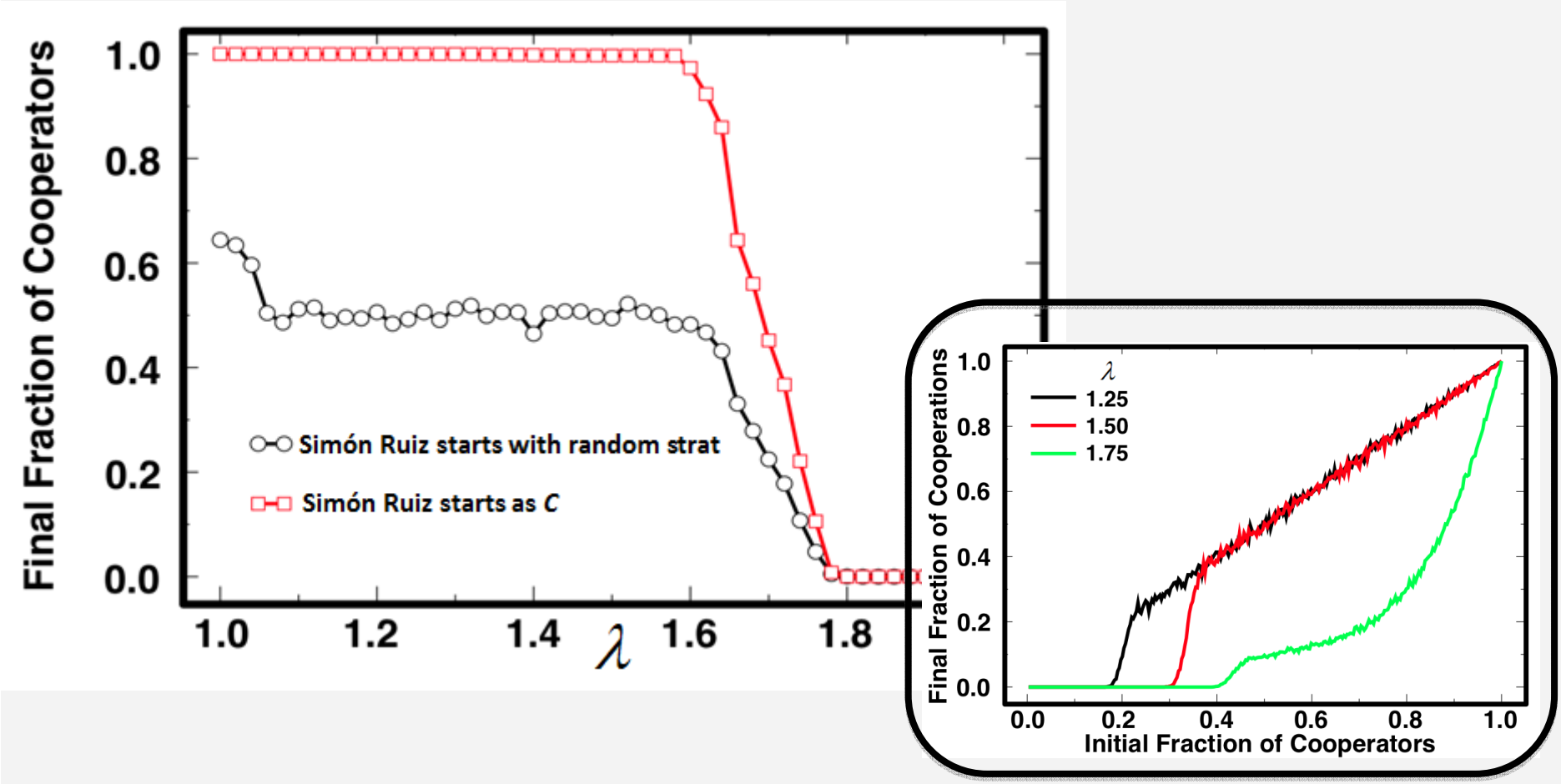
prisoner's dilemma



$$\begin{array}{c} \\ C \\ D \end{array} \begin{array}{c} \begin{array}{cc} C & D \end{array} \\ \begin{pmatrix} 1 & -\lambda \\ 1+\lambda & 0 \end{pmatrix} \end{array}$$

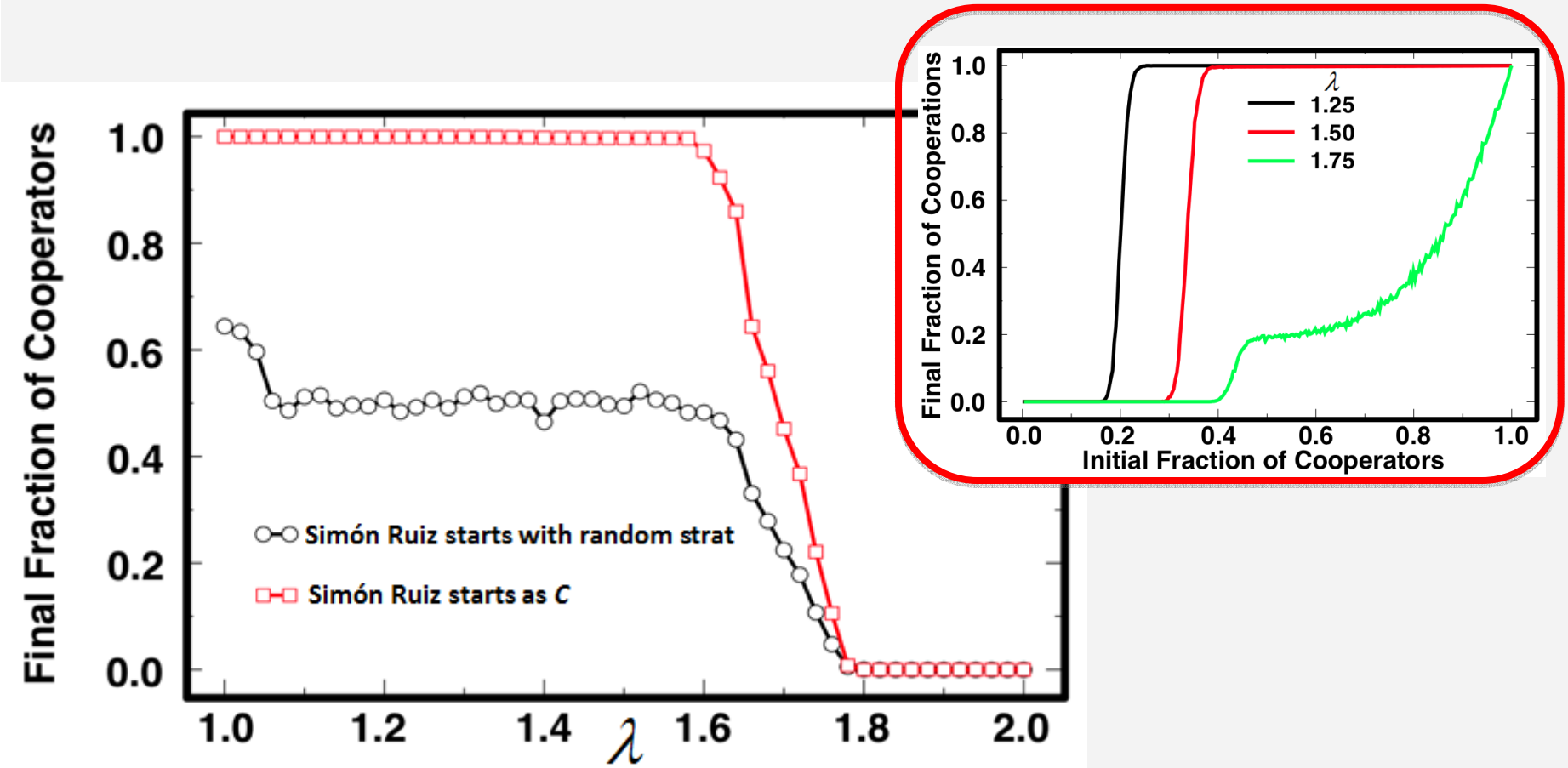
cooperation on SFG

prisoner's dilemma



cooperation on SFG

prisoner's dilemma

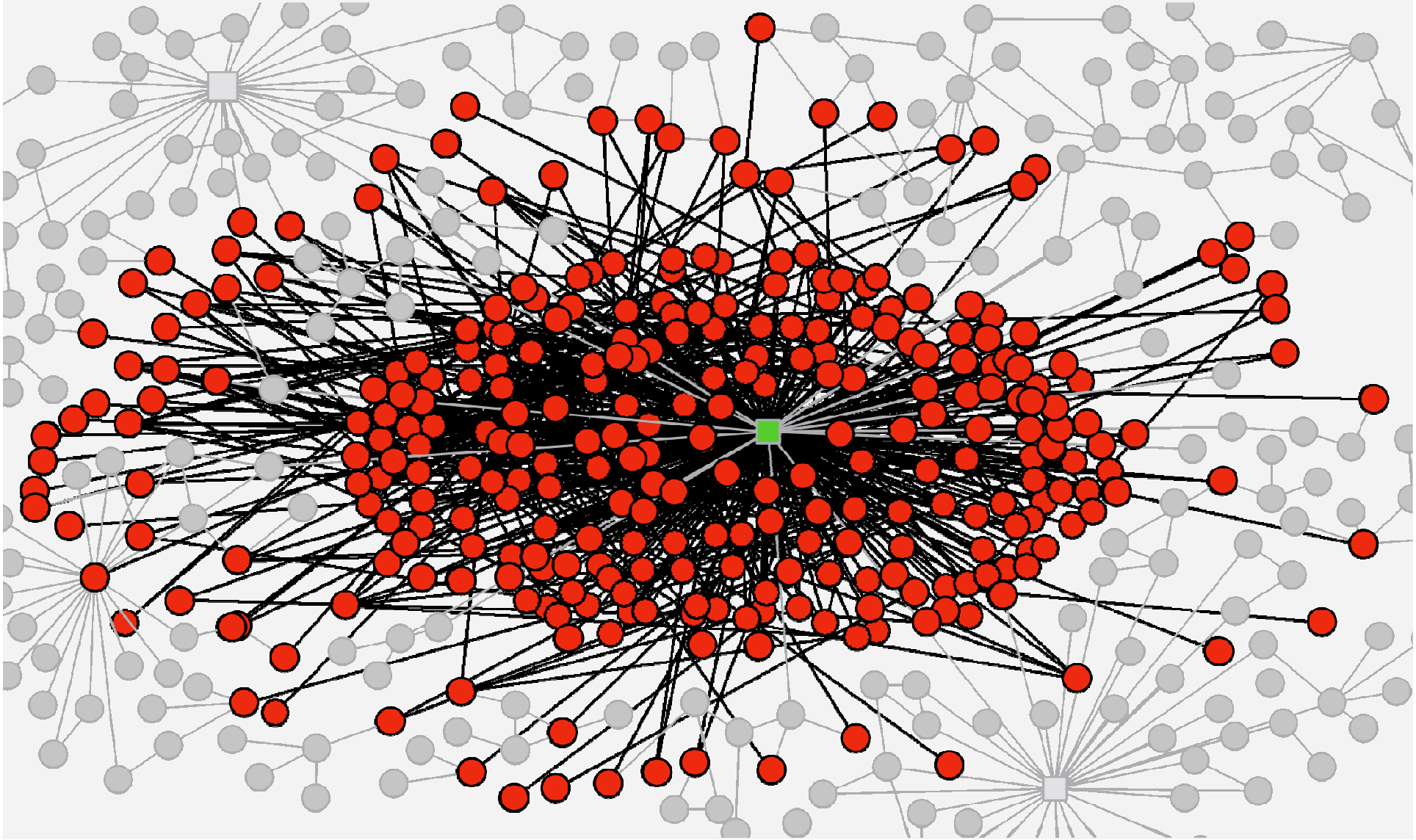


Simón Ruiz Graph (SRG)

can mathematics help history ?

- trade is robust on **SRG**
- cooperation will depend on behaviour of Simón Ruiz

SRG is only a sub-graph of the complex network between merchants in Europe



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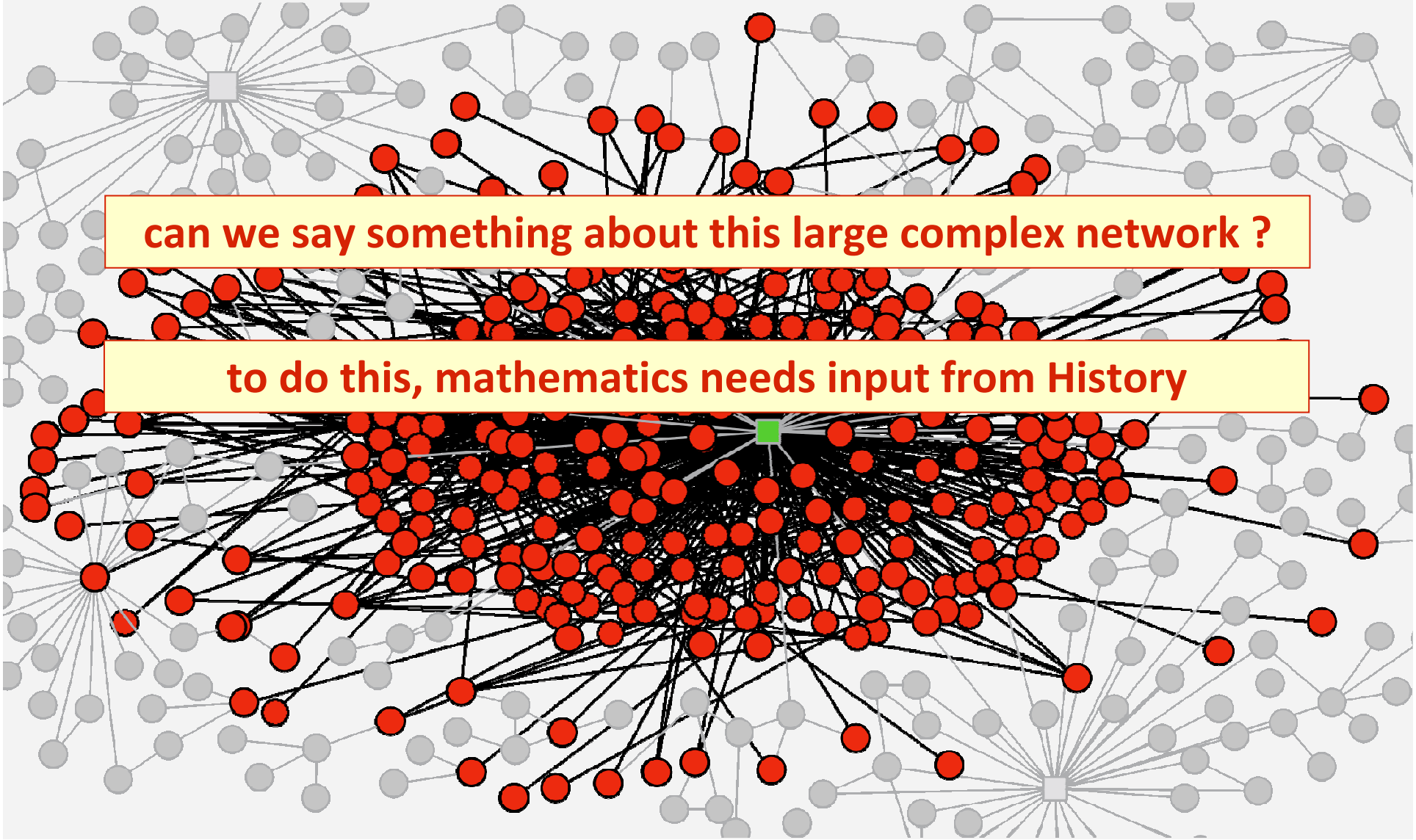

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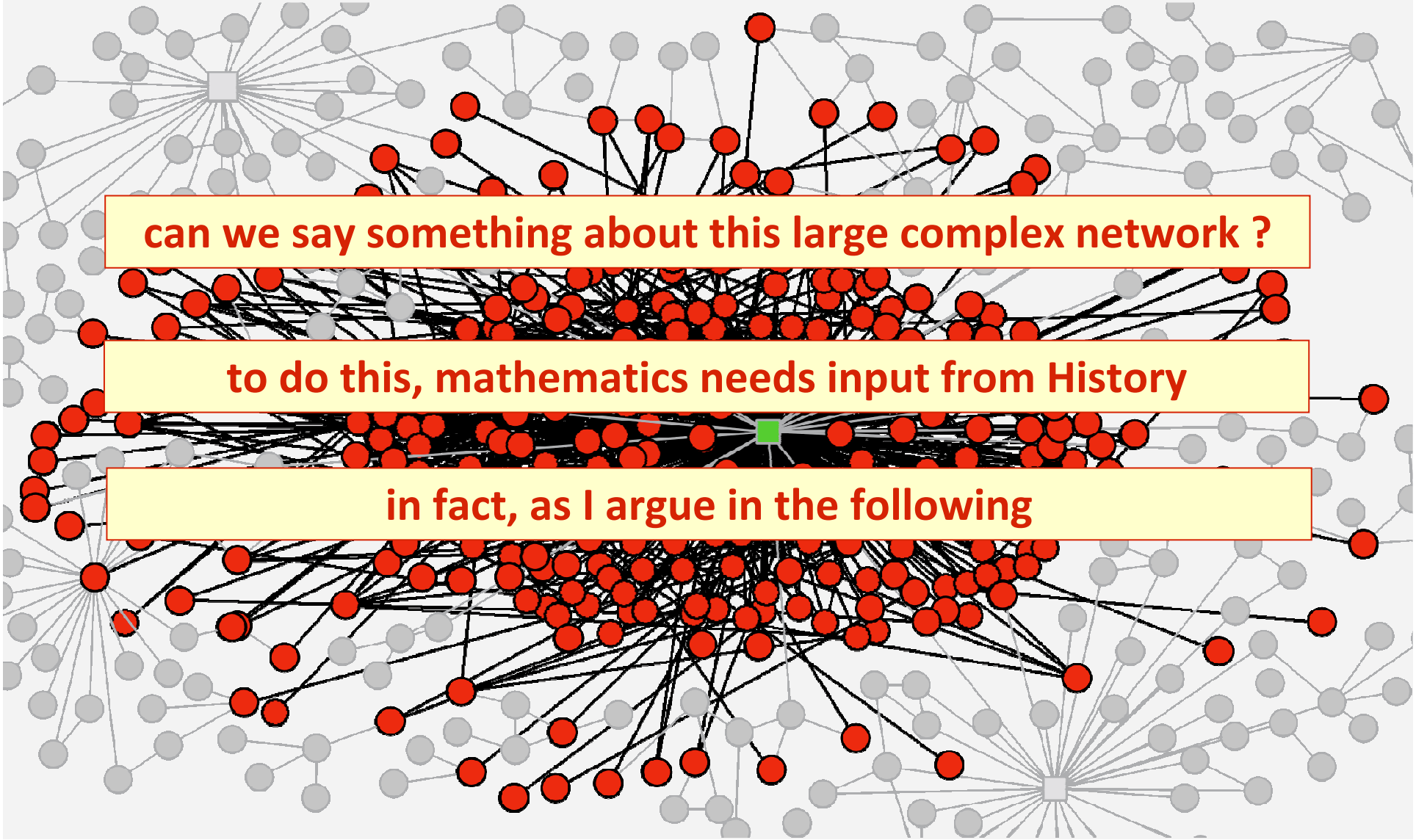
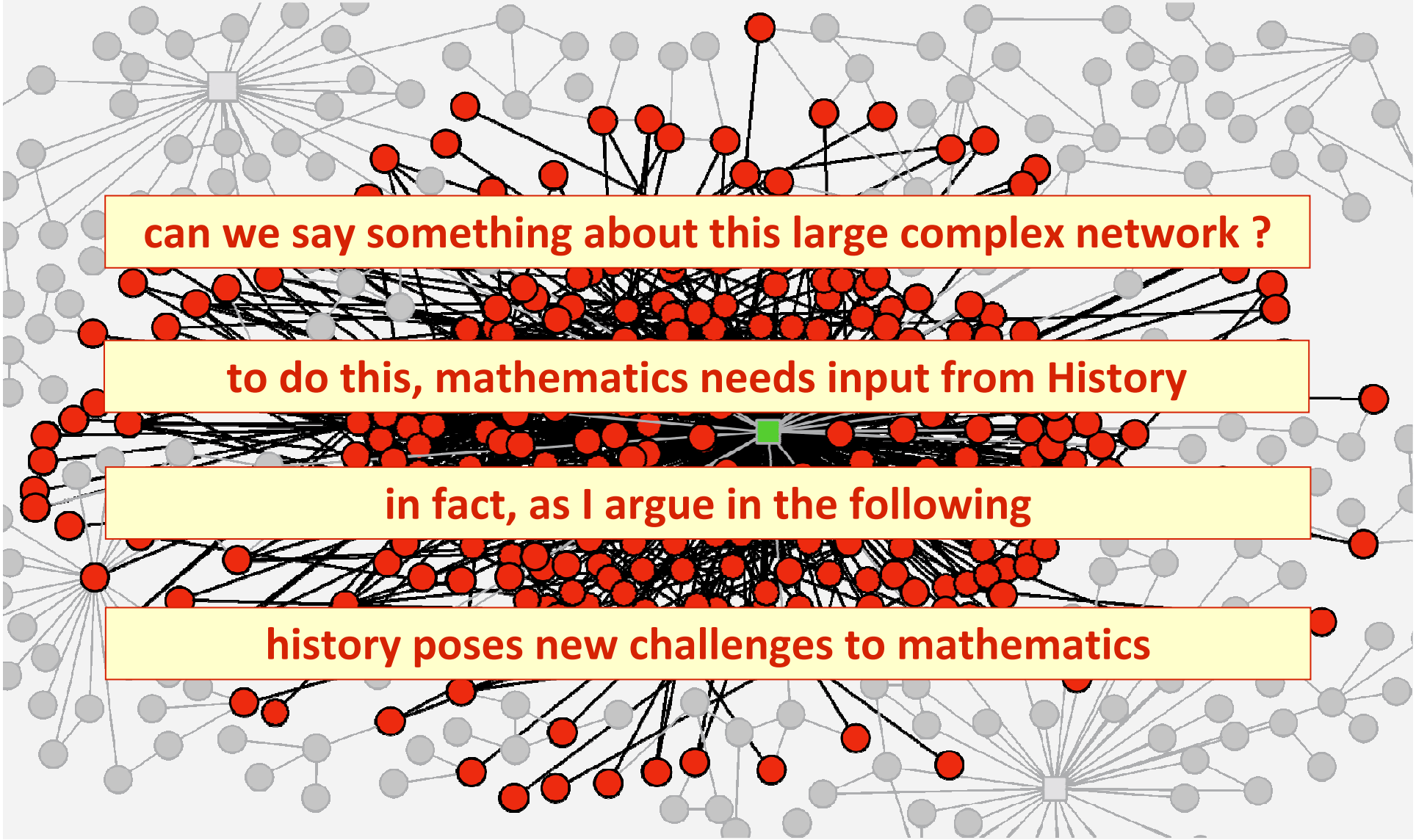


can we say something about this large complex network ?

to do this, mathematics needs input from History

in fact, as I argue in the following

SRG is only a sub-graph of the complex network between merchants in Europe



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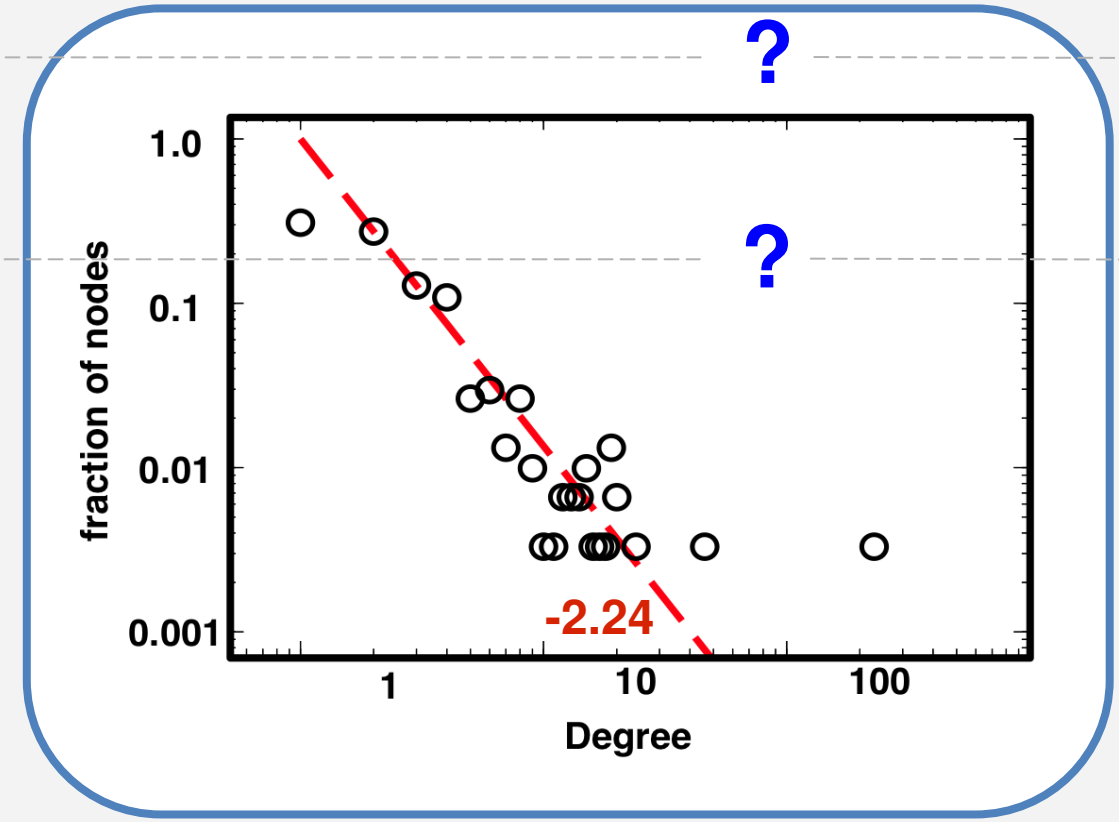
history poses new challenges to mathematics

predicting the past ?

what	full-net	SRG
N	?	304
<k>	?	4.38
γ	?	2.24



predicting the past ?

let us assume

- network is scale-free with $\gamma \rightarrow 3$ (ubiquity)

  (growth & preferential attachment)

- N = ??? > 304 (obvious)
- <k> = ??? > 4.38 (in general)

open questions

- historical data collection → sampling scheme ?
- how does <k> depend on the sampling ?
- . . .
- . . .

predicting the past ?

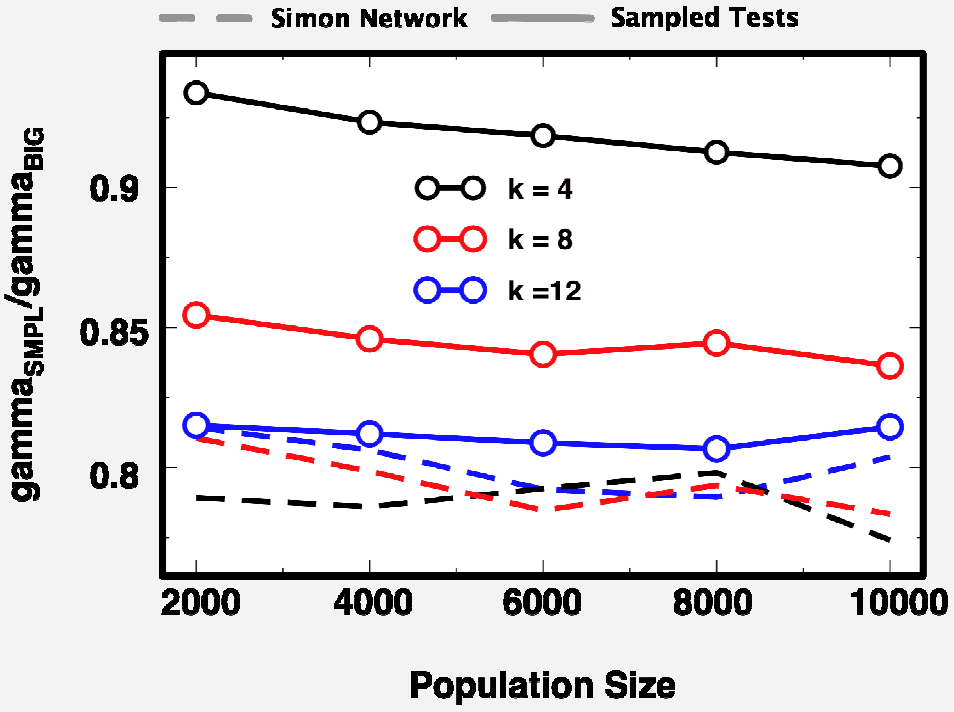
history must help mathematics here…

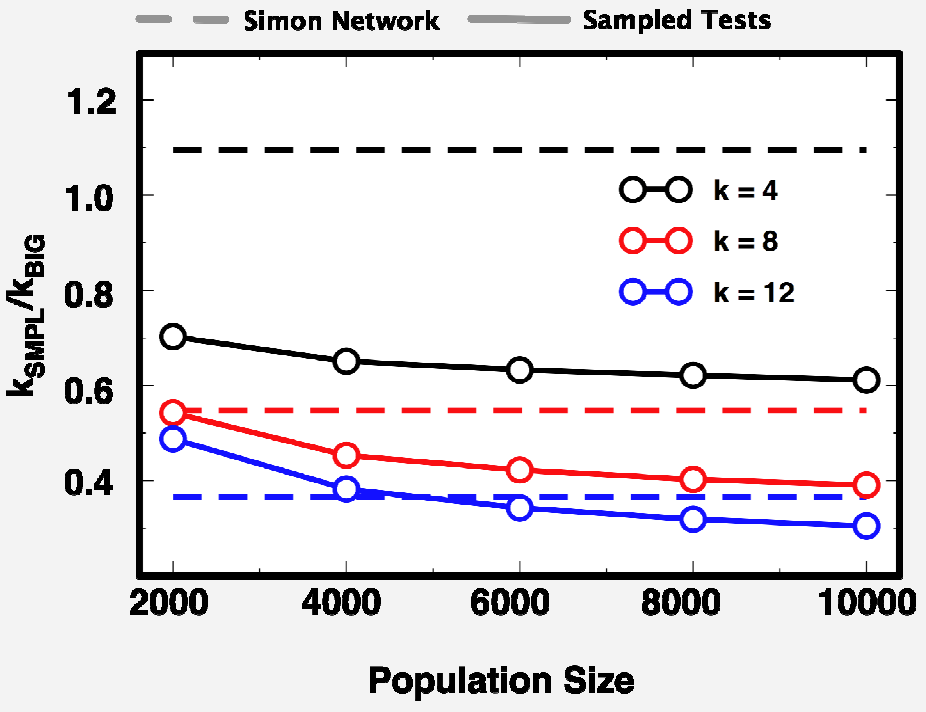
- we assume that nodes show up in the historical record with a probability that is proportional to the connectivity of the node

- (this is only reasonable; history will guide us towards finding a better sampling scheme)

- there are other observables that further constrain the sampled data

predicting the past ?

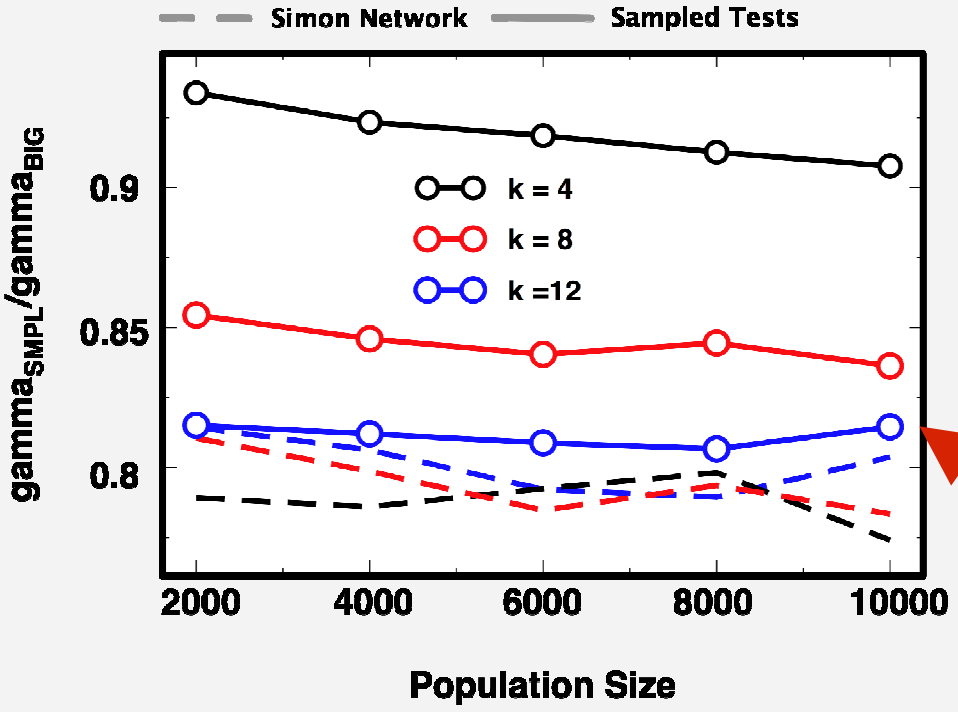


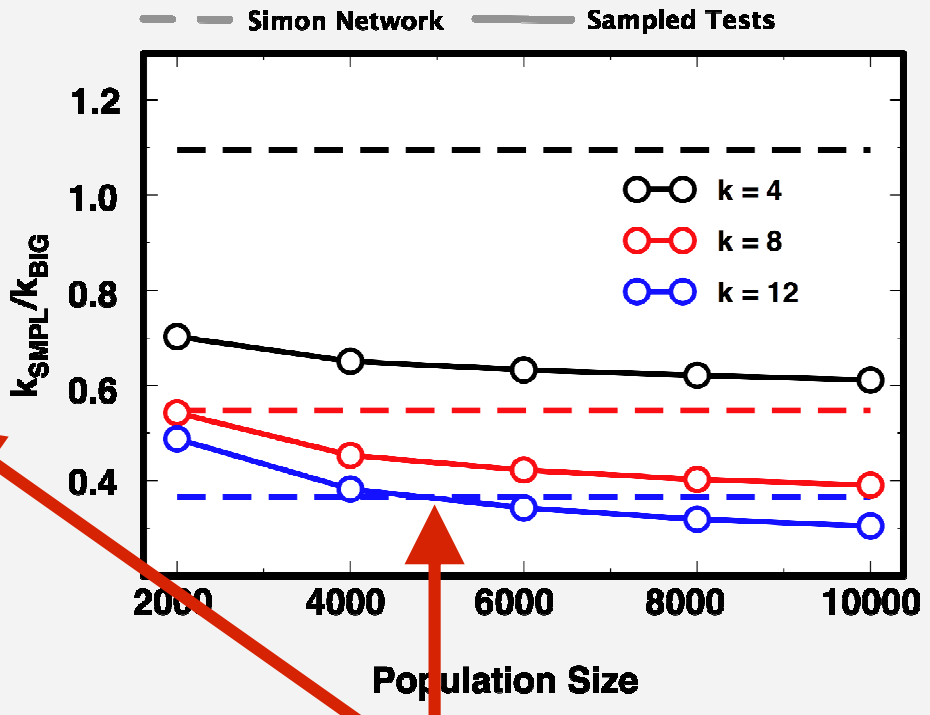


k = 4		k = 8		k = 12	
2000	2.842336	2000	2.767695	2000	2.754446
4000	2.853995	4000	2.808442	4000	2.782286
6000	2.830586	6000	2.858506	6000	2.831582
8000	2.810346	8000	2.826405	8000	2.841478
10 000	2.897996	10 000	2.863270	10 000	2.790844

(work in progress)

predicting the past ?





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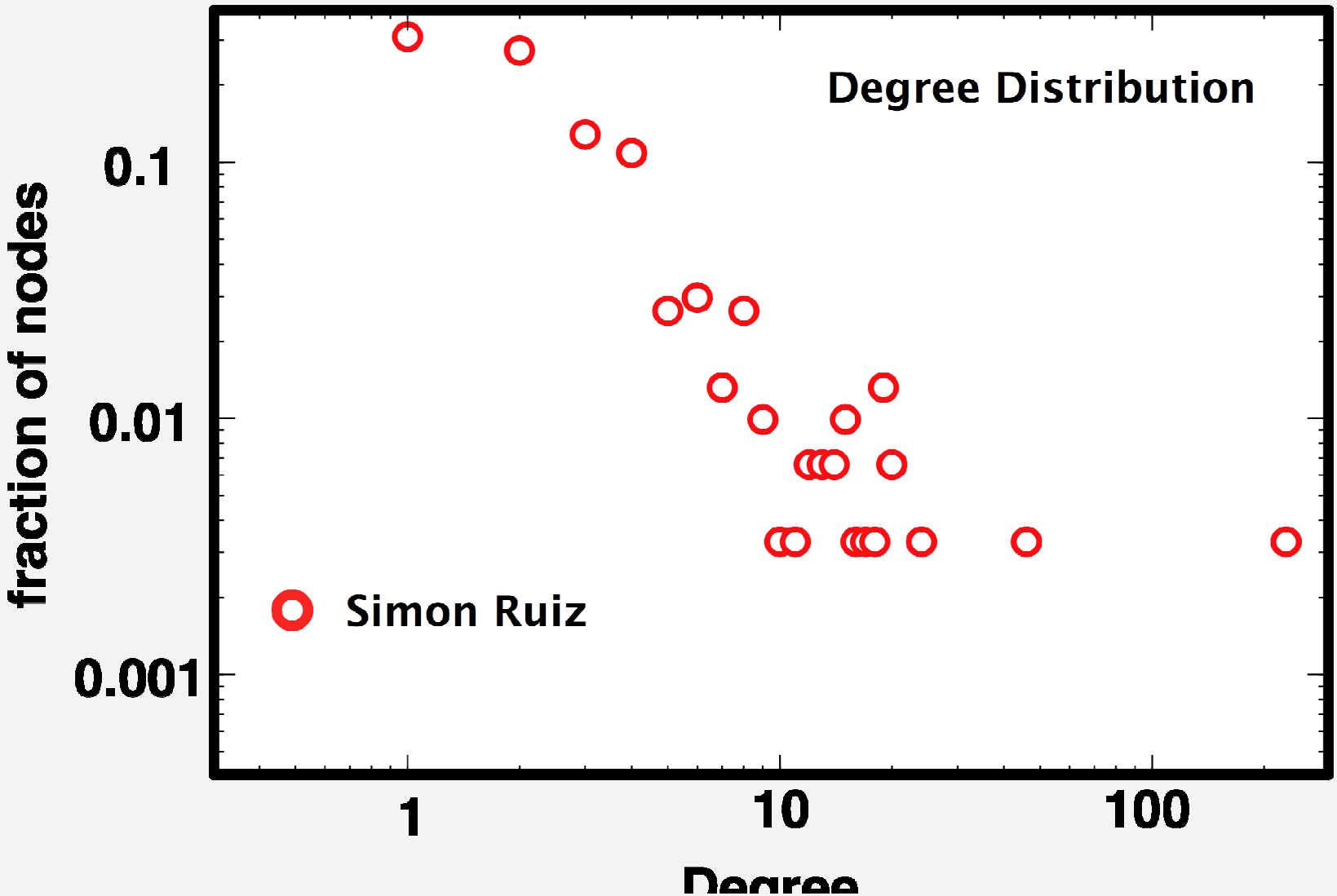

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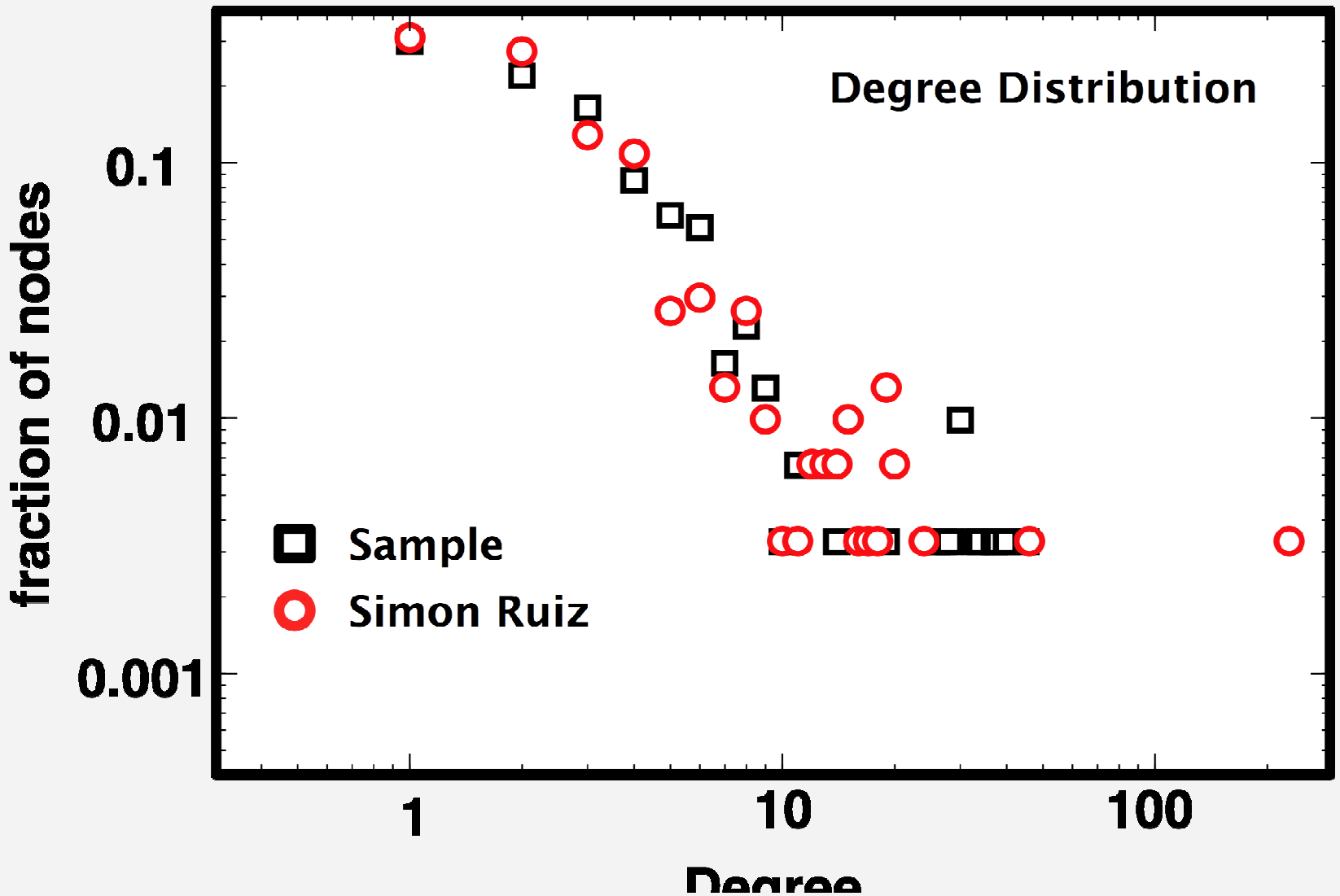

conclusions

- cooperation & trade during the First Global Age is a fascinating interdisciplinary problem

- techniques from network science & graph theory provide a fresh perspective and additional insights to historical data

- historical methods and records setup new challenges, providing important guidelines on how to properly approach the data from a complex systems perspective

- there is plenty of room for improvement !!!