



To vaccinate or not to vaccinate? A coevolutionary dilemma

Alessio Cardillo

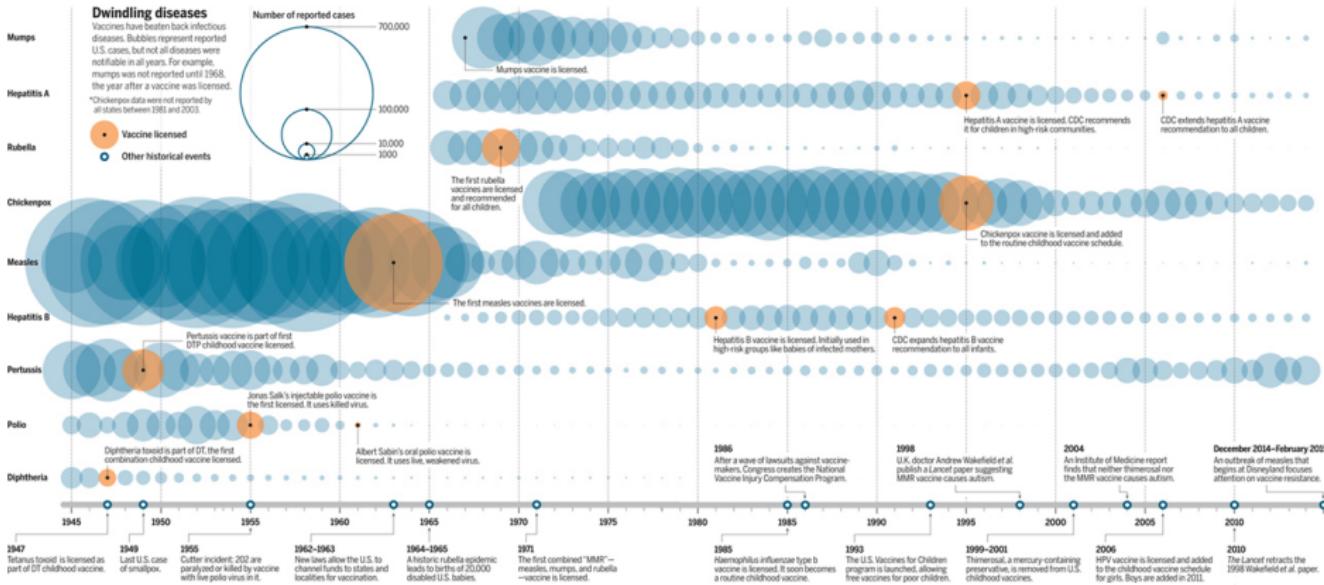
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Tarragona, Spain



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Wadman, M., & You, J. (2017). The vaccine wars. *Science*, **356**(6336), 364–365.

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Altmetric 1,475 DOI: [http://dx.doi.org/10.1016/S0140-6736\(97\)11096-0](http://dx.doi.org/10.1016/S0140-6736(97)11096-0)

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Dr AJ Wakefield, FRCP[✉], FRCPsych, AP Dhillon, MRCGP, MRCP, FRCP

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Some parents are still ignoring the message to immunise their children against measles, an inquiry into the

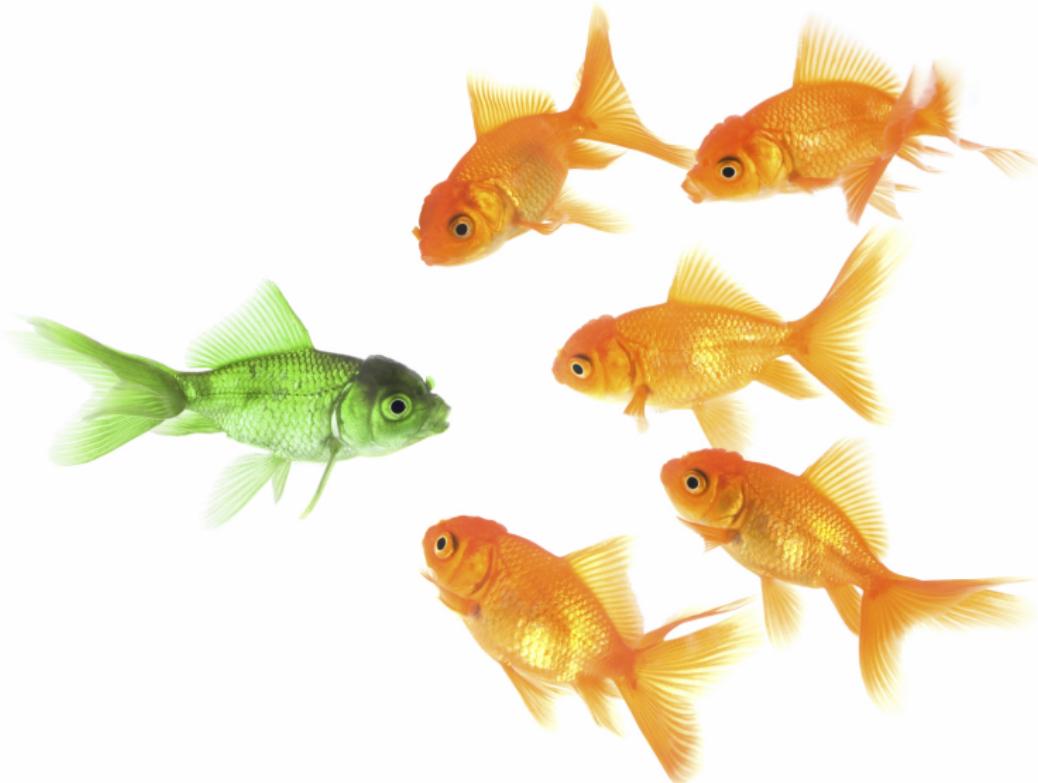
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Vaccination dilemma



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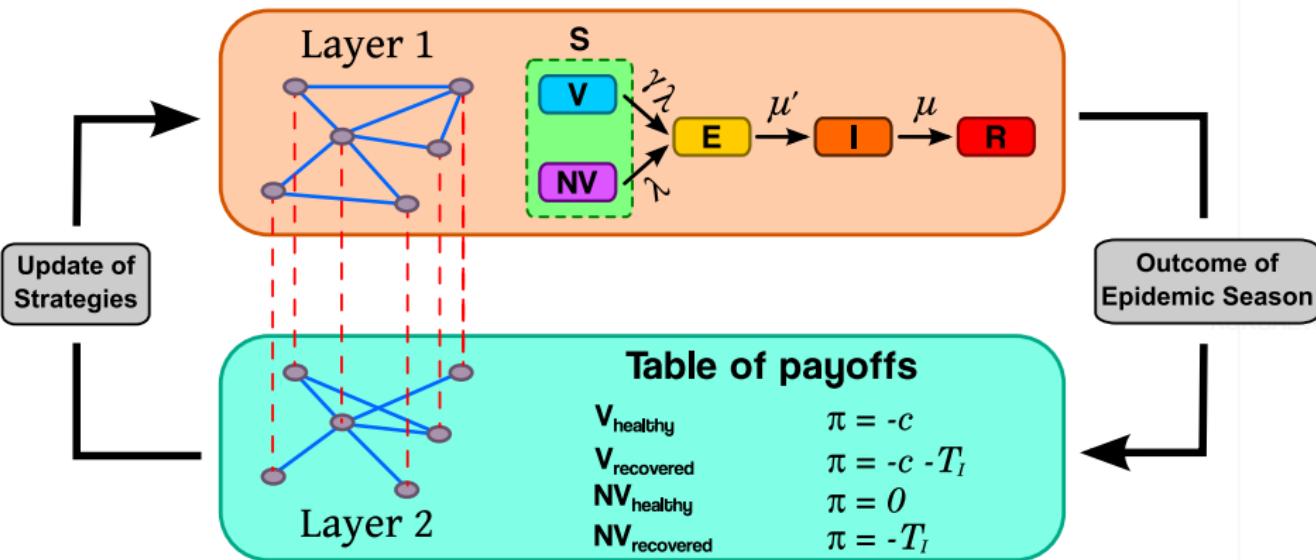
Vaccination dilemma

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Cooperation VS Spreading who will prevail?

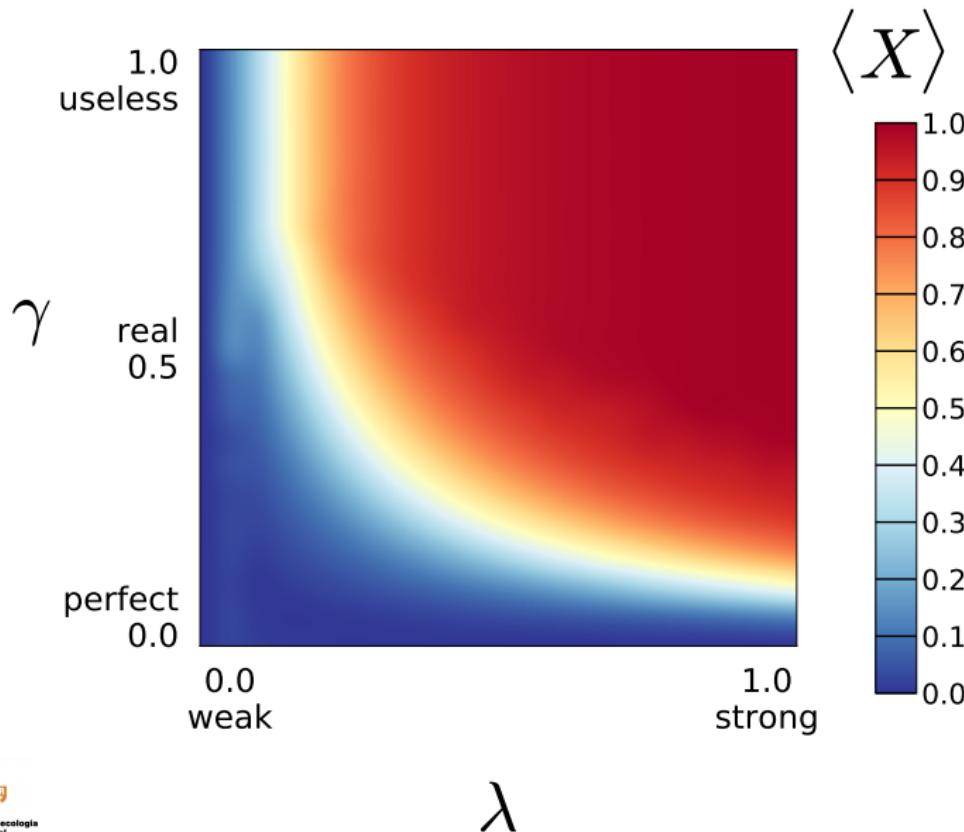
The coevolutionary model



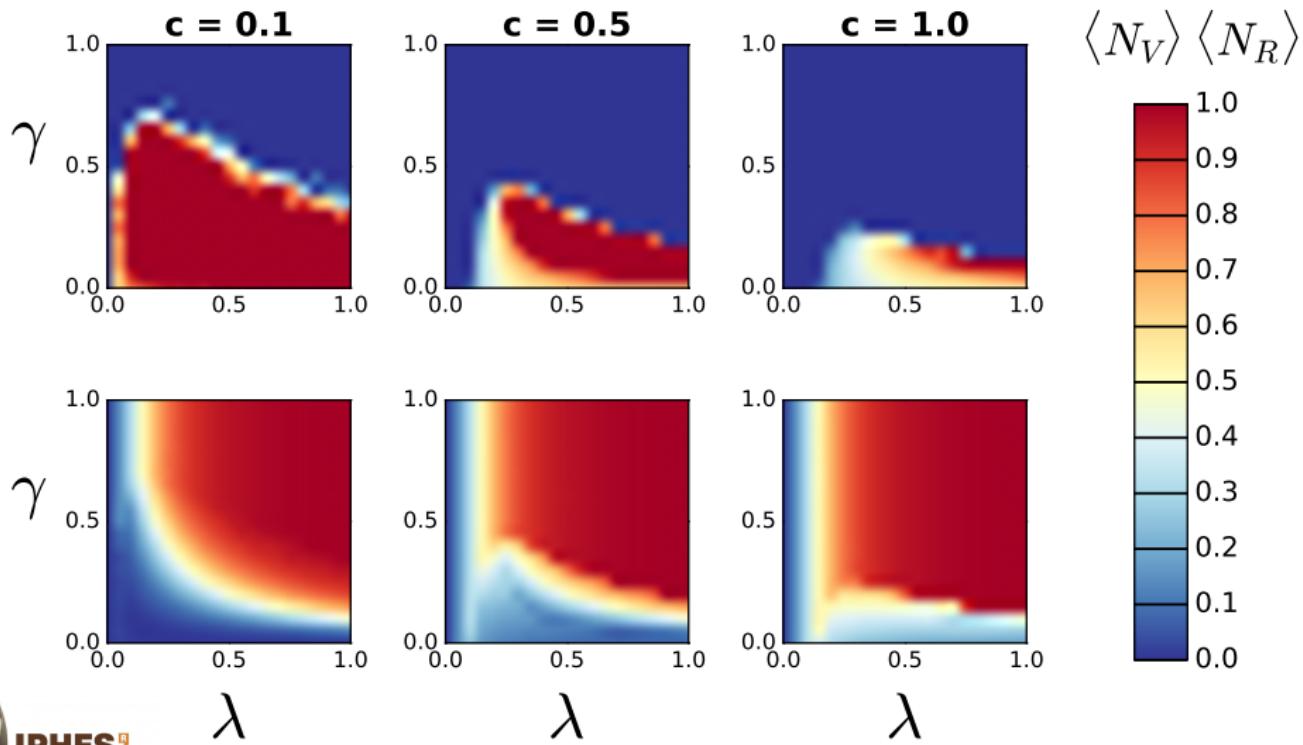
A. Cardillo, et al. "Evolutionary vaccination dilemma in complex networks." Phys. Rev. E, **88**, 032803. (2013).

Results

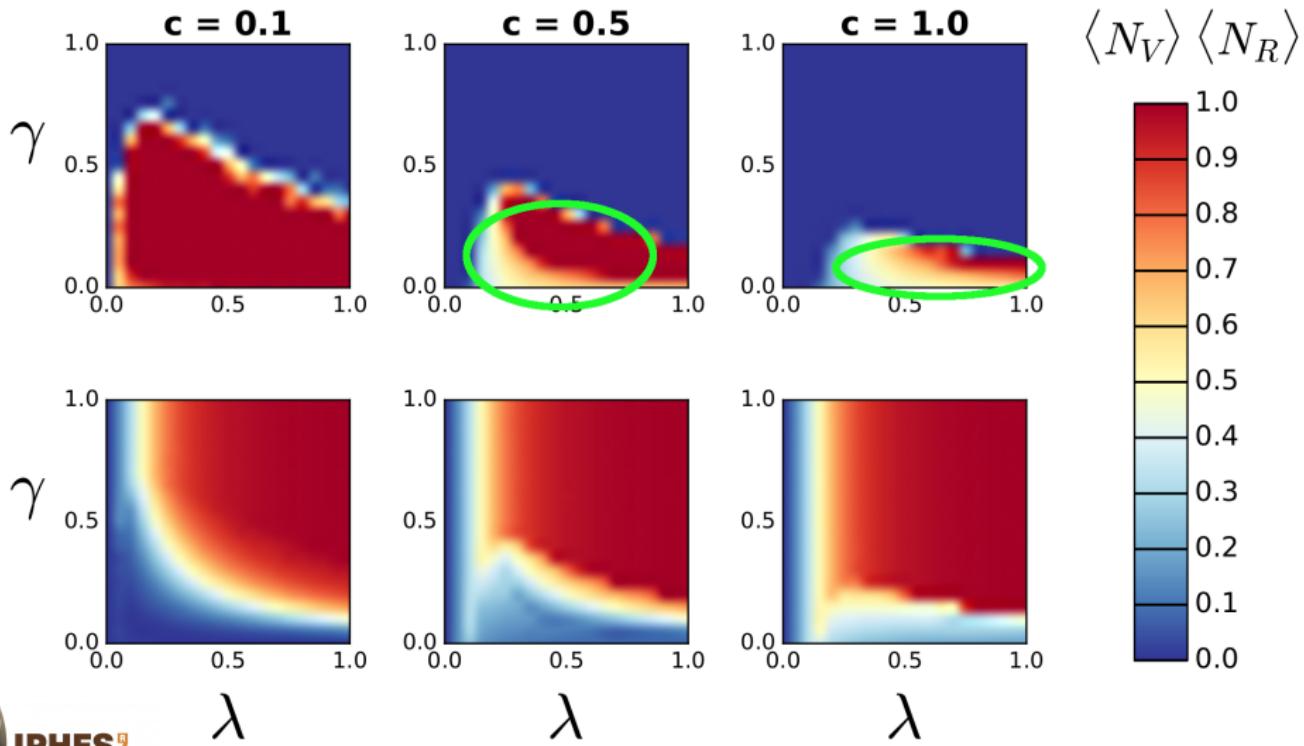
Global behaviour (RGG – SF)



Global behaviour (RGG – SF)

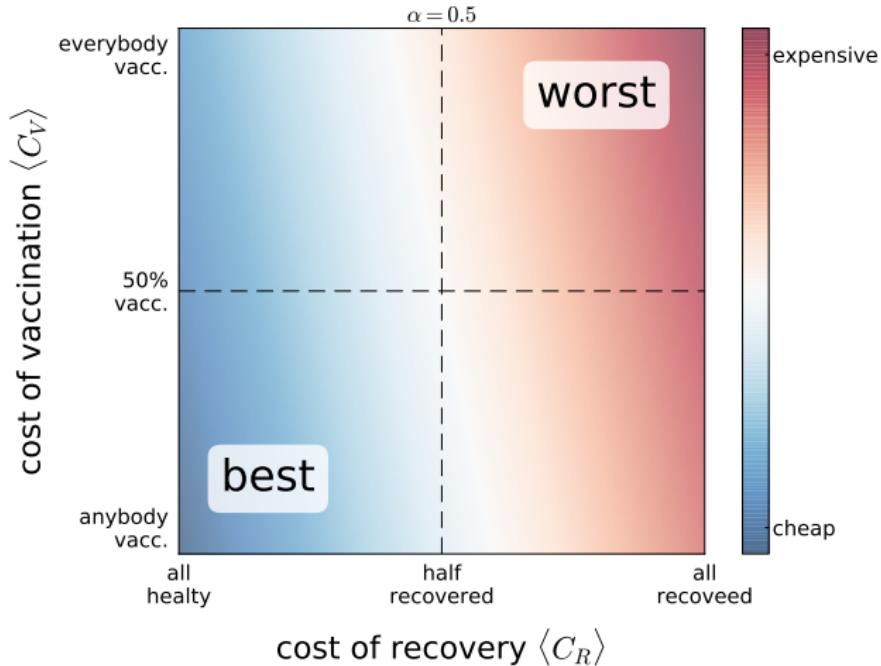


Global behaviour (RGG – SF)



Overall cost

$$\rho = \alpha \langle C_V \rangle + (1 - \alpha) \langle C_R \rangle$$



Zealots

Zealots

“ Between 2005 and 2010, the proportion of French people in favour or very in favour of vaccination dropped from 90% to 60% (2013 INPES Peretti-Watel health barometer). The percentage of French people between the ages of 18 and 75 who are anti-vaccination increased from 8.5% in 2005 to 38.2% in 2010. In 2005, 58% of doctors questioned the usefulness of vaccines administered to children while 31% of doctors were expressing doubts about vaccine safety. These figures must surely have increased since then. (Michèle Rivasi) ”

Zealots

“

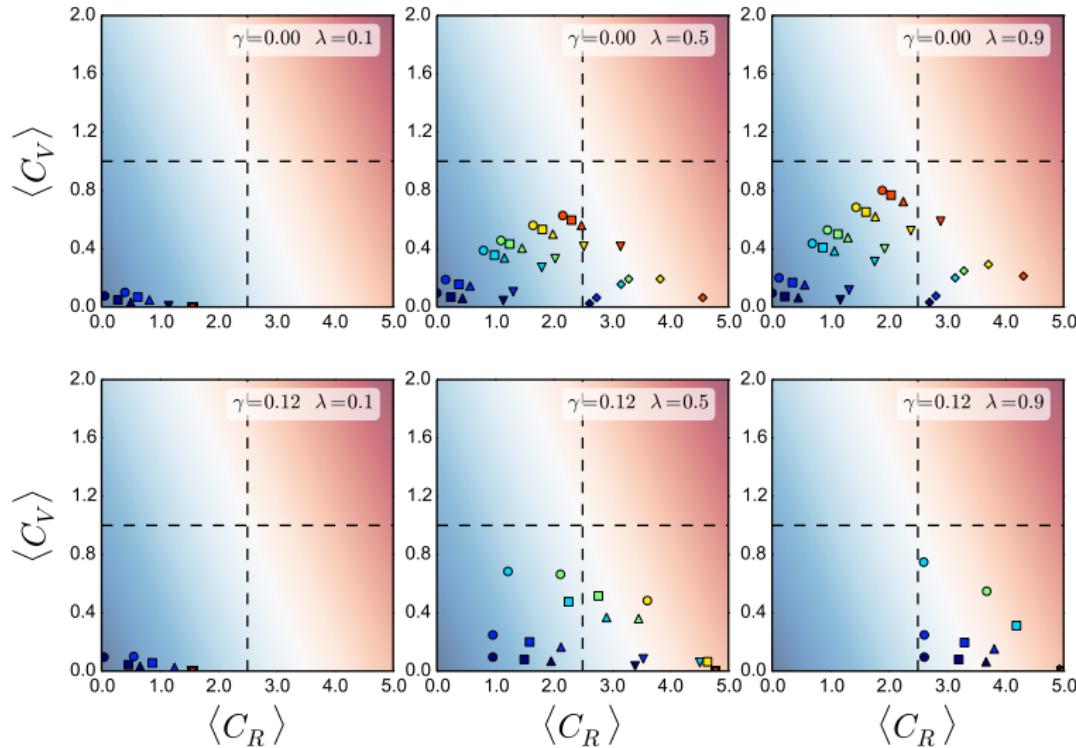
Between 2005 and 2009, the percentage of French children aged between 2 and 11 years old who had not been vaccinated against measles fell from 8.5% in 2005 to 3.5% in 2009.



vaccination
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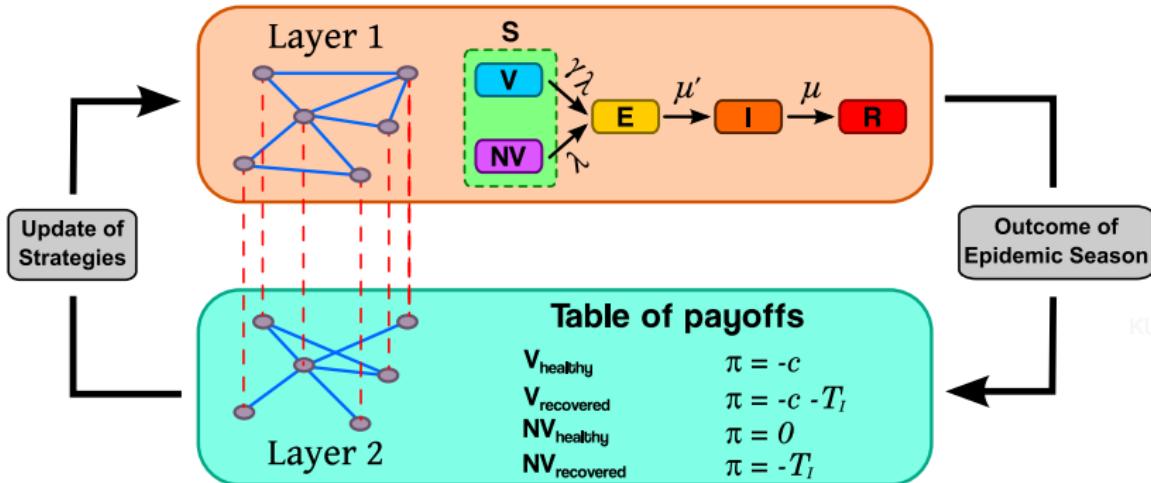
Zealots & overall cost



- $Z=0\%$
- $Z=5\%$
- ▲ $Z=10\%$
- ▼ $Z=25\%$
- ◆ $Z=50\%$

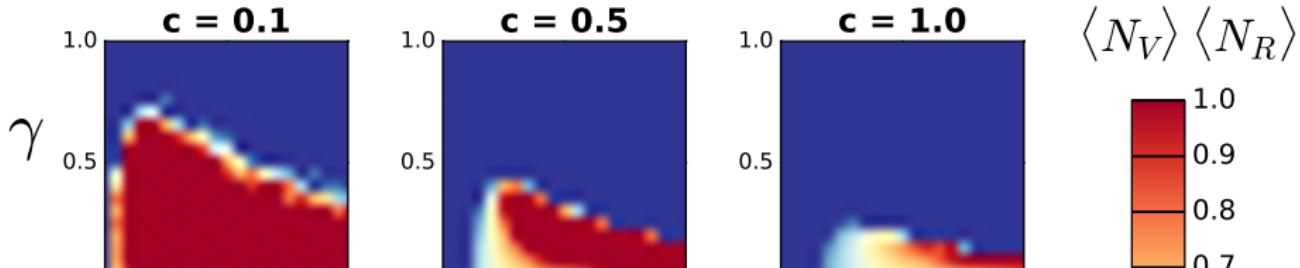
Conclusions

Summing up . . .

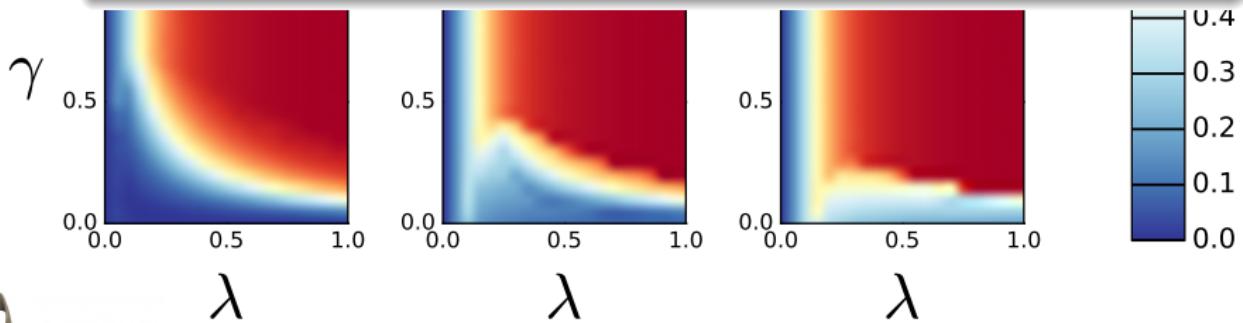


Coevolutionary model based on **epidemic spreading** and **evolutionary game theory** on multiplex networks.

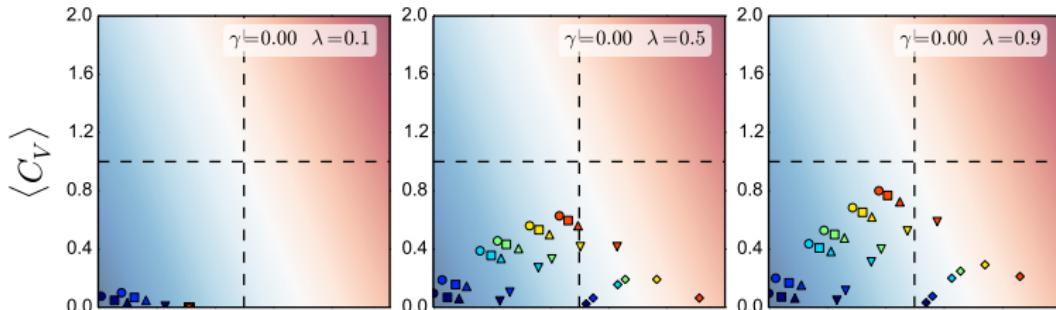
Summing up . . .



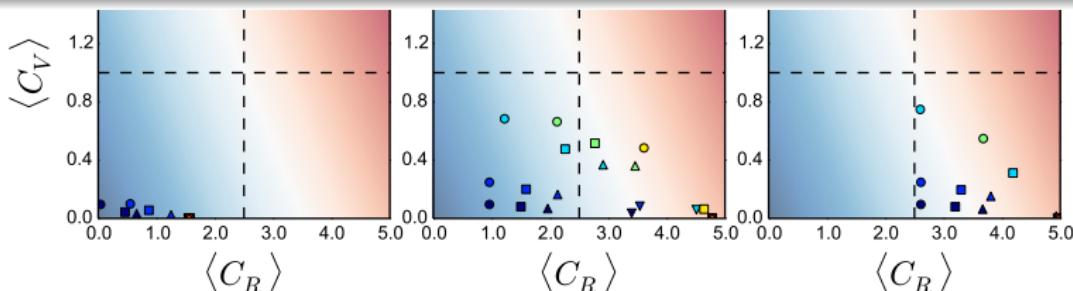
Influence of topology, cost, infection risk and vaccine effectiveness on the global behaviour.



Summing up . . .



Effects of **zealotry** on the overall performances and possible solutions.



- $Z=0\%$
- $Z=5\%$
- ▲ $Z=10\%$
- ▼ $Z=25\%$
- ◆ $Z=50\%$

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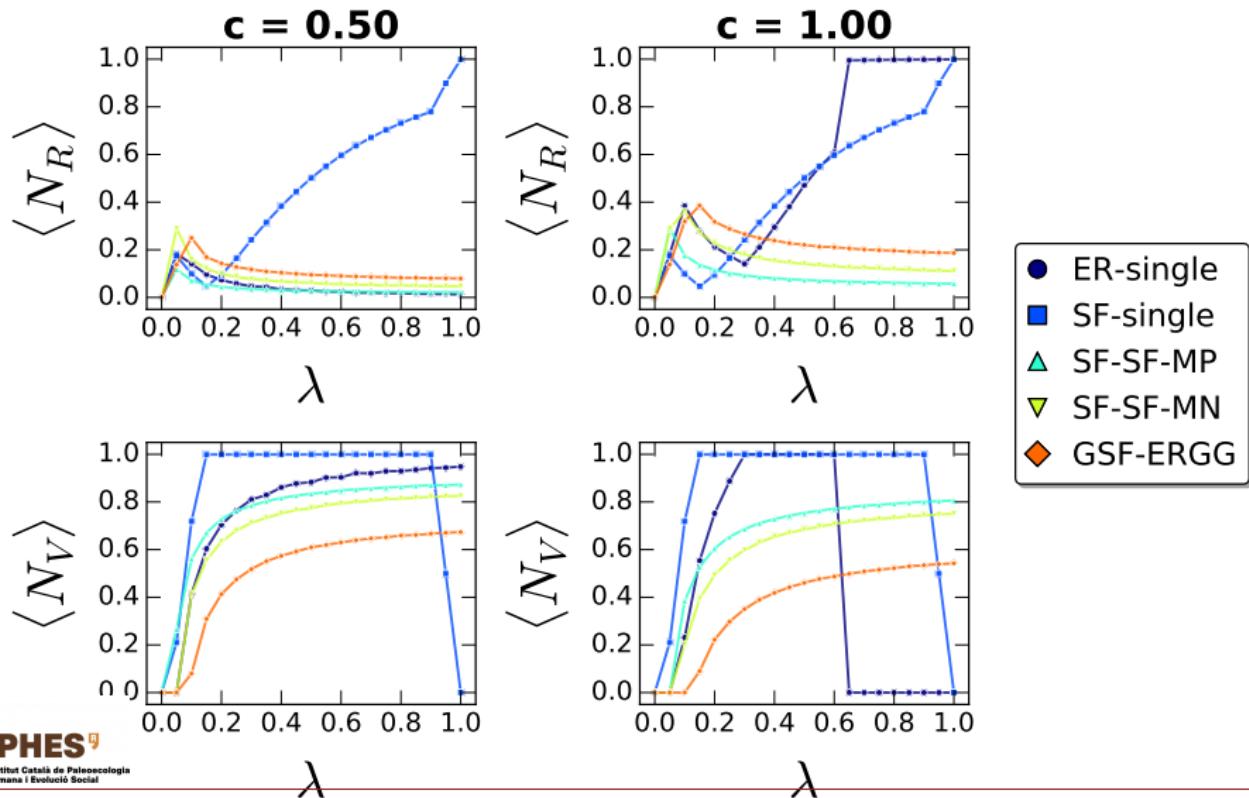
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Part II

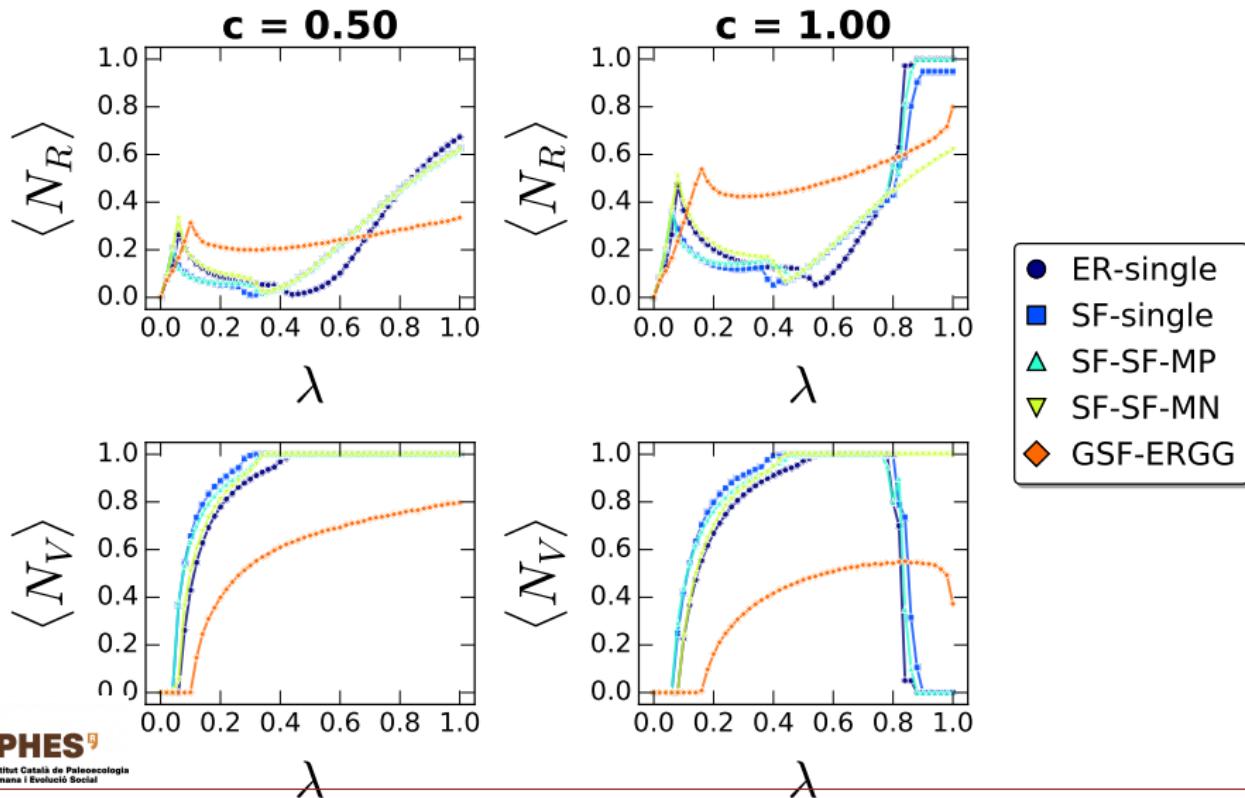
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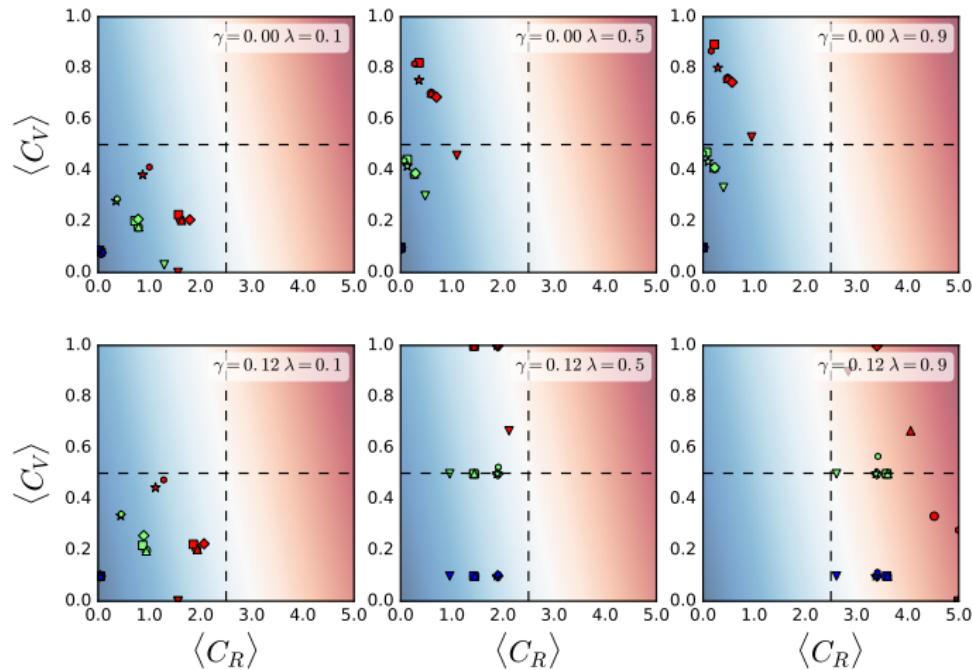
Effect of multiplexity/topology



Effect of multiplexity/topology

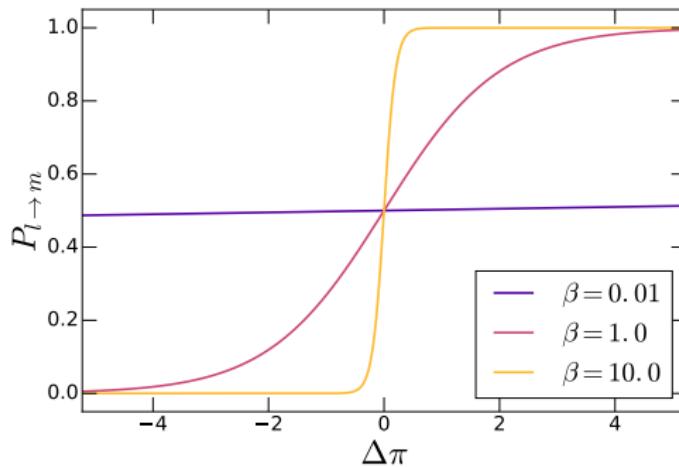


Effect of multiplexity/topology



- ER-single
- SF-single
- ▲ SF-SF-MP
- ▼ SF-SF-MN
- ◆ ER-ER
- ★ GSF-EER
- GSF-ERGG

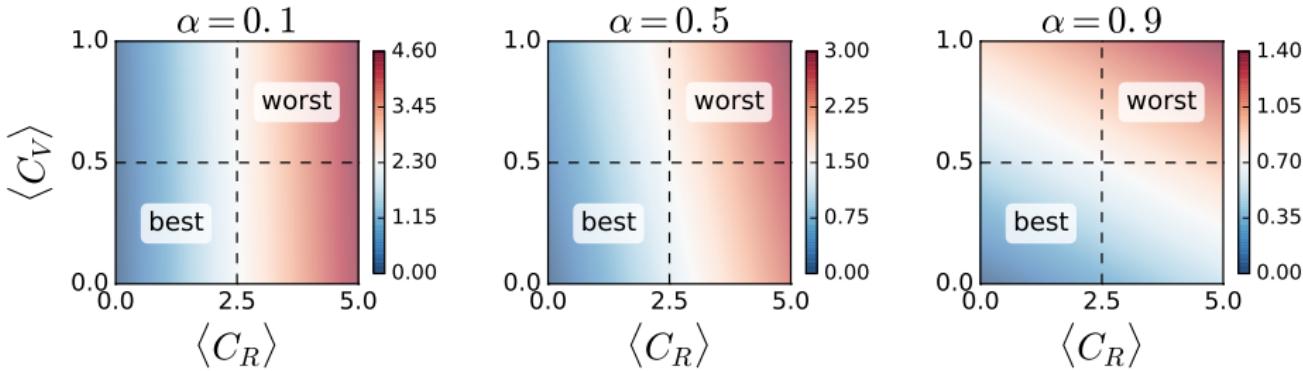
Update of strategy



Fermi's Rule

$$P_{l \rightarrow m} = \frac{1}{1 + e^{-\beta(\pi_m - \pi_l)}}.$$

Relative cost



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-  Wang, Z., *et al.* Phys. Rep., **664**, 1–113 (2016).
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-  [http://www.thevaccinereaction.org/2015/08/
the-french-national-debate-on-vaccine-safety/](http://www.thevaccinereaction.org/2015/08/the-french-national-debate-on-vaccine-safety/)

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