Game-theoretic Models of Web Credibility

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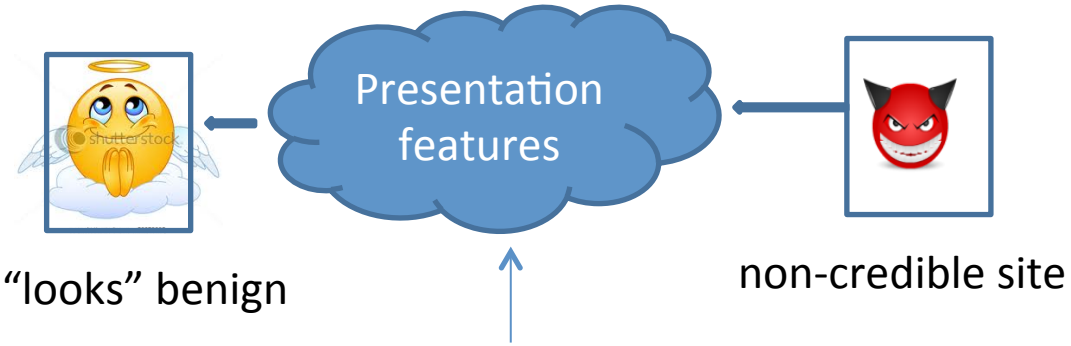
Outline

1. Web Credibility
2. Games
    1. Basic Game
    2. Signaling Game
    3. Consumer Expertise
    4. Producer Utility
3. Simulation Results
4. Conclusions and Future Work

1. Introduction

- Increasingly difficult to assess credibility of Web content
  - Economic incentives to manipulate information
    - Marketing, fraud, political motives, etc.
  - Enormous volume of web information

User: Believe or not ?



Current Approaches

- Empirical studies to elicit behaviors underlying the manipulation of Web content
  - Correlate content features with user evaluation
  - No explanatory power for strategies and their dynamics
- Reputation mechanisms (information asymmetry)
  - History building is non-trivial
    - large number of pages
    - dynamic domain names changes
- Our approach: study Web credibility as a game between rational content producers and consumers
  - No suitable models devised so far (e.g. prisoners dilemma, persuasion games do not capture salient features)

Model of Credibility Evaluation

- Design desiderata
  - Distinguish content producers (CP) and content consumers (CC)
  - Distinguish content quality and presentation
  - Model diverse strategies and competences
    - Honest and dishonest content producers
    - Naive and expert content consumers
    - Economic incentive structure

2.1 The Basic Game

- Content producer
  - Action "truth" TF a choice of information variants
  - Action "looking true" L incurs extra cost
    - F (bad looking false, TF = 0, L = 0),
    - GF (good looking false, TF = 0, L = 1),
    - BT (bad looking true, TF = 1, L = 0),
    - T (good looking true, TF = 1, L = 1)

- Content consumer
  - Actions are binary: Accept (A) or Reject (R)
  - Can observe type of content producer

Basic Game Payoff Matrices

- Different games for high and low quality producer

CP-H \ CC

	A	R
F	2 / -2	-2 / 0
GF	1 / -3	-2 / 0
BT	5 / 0	2 / 0
T	4 / -1	2 / 0

high quality producer vs. consumer
BT is dominant strategy
(BT, A) subgame perfect equilibrium

CP-L \ CC

	A	R
F	5 / -2	-2 / 0
GF	4 / -3	-2 / 0
BT	2 / 0	2 / 0
T	1 / -1	2 / 0

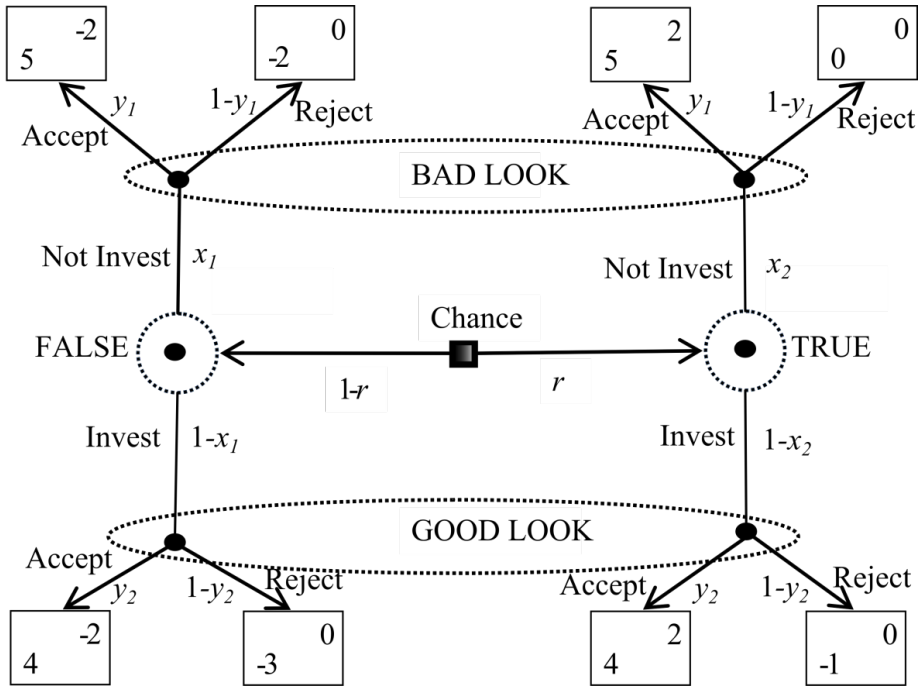
low quality producer vs. consumer
Nash equilibrium is given by
F = BT = 1/2 and A = 2/5
Evolutionary stable strategy

2.2 The Signaling Game

- Content producer
  - Type of content determined by type of producer
    - Honest has only true content
    - Dishonest only false content
  - Invest or Not Invest in presentation
  - Fraction *r* of CP-H in the system

- Content consumer
  - Cannot observe type of content producer!

Signaling Game Strategic Form



Content producer

Investing or not should give same payoff

$$x_2(5y_1 + (1-y_1)0) = (1-x_2)(4y_2 - (1-y_2))$$

$$x_1(5y_1 - (1-y_1)2) = (1-x_1)(4y_2 - 3(1-y_2))$$

Content consumer

Probability to accept proportional to being the good decision

$$y_1 = \frac{x_2 r}{x_2 r + x_1(1-r)}$$

$$y_2 = \frac{(1-x_2)r}{(1-x_2)r + (1-x_1)r}$$

2.3 Consumer Expertise

- Naïve consumer
  - Always Rejects BAD LOOK, always Accepts GOOD LOOK
  - Dominant strategy for both CP-L and CP-H is Invest

- Expert consumer
  - Always Accepts when matched CP-H, always rejects CP-L
  - Dominant strategy for both CP-L and CP-H is Not Invest

- Fraction f of experts
  - CP-H plays Invest if $f < 4/5$, otherwise Not Invest
  - CP-L plays Invest if $f < 6/7$, otherwise Not Invest

2.4 Economic Modeling

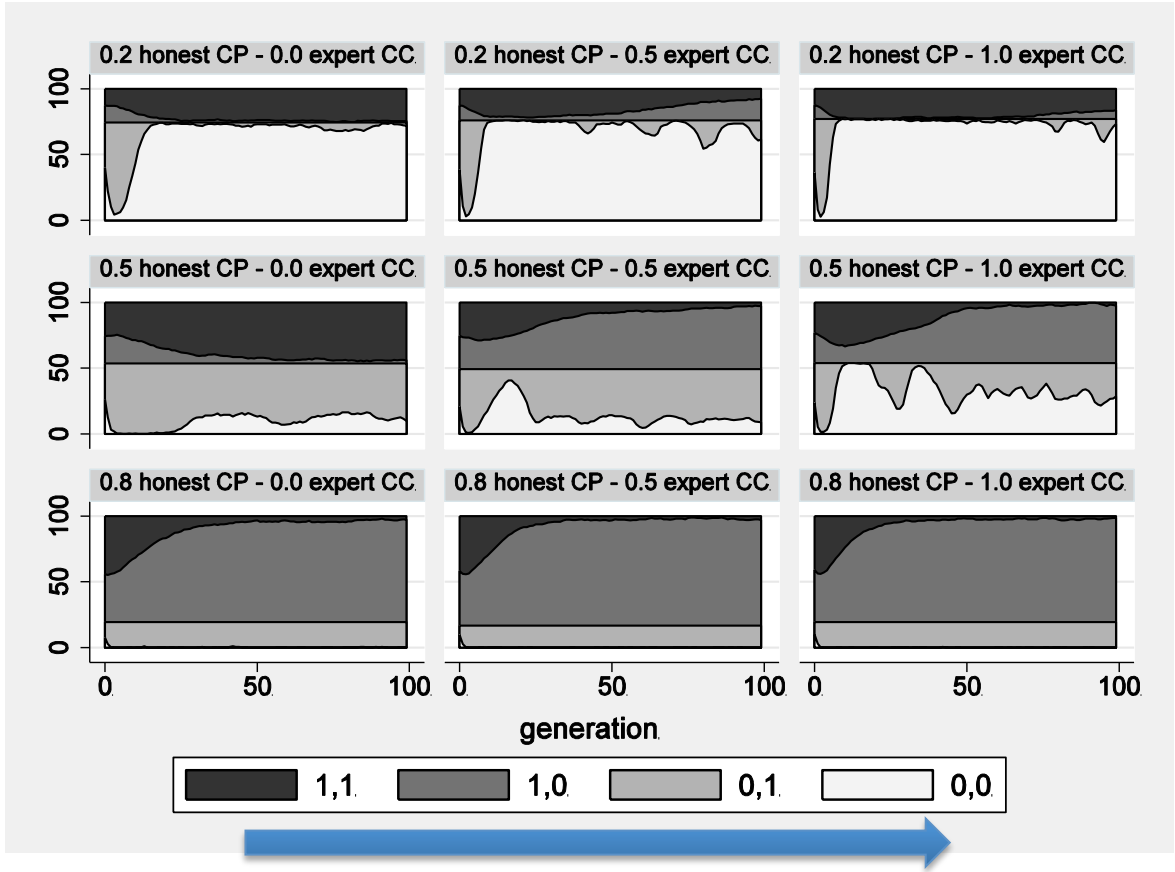
- Content producer
  - Continuous strategy space: TF, L in [0, 1]
  - Utility function: U(TF, L) = k G(TF) – C(TF, L)
    - G(TF) gain from acceptance
    - C(TF, L) cost of production
    - k number of accepting consumers
    - Linear in TF, L

- Example: honest producer
  - G(TF) = α TF + β, C(TF, L) = γ TF + δ L + ε
  - $\alpha > 0$: wishes acceptance
  - $\gamma < 0$: creating a false information is costly
  - $\delta > 0$: making look good is costly

3. Simulation Study

- Evolution simulation
  - 100 producers, 1000 consumers
  - Consumers randomly choose producers per time slot
  - Every 100 rounds offspring is produced proportional to achieved utility (stochastic universal sampling)
  - Random mutations
- Content producers
  - Based on economic model above
- Content consumers
  - Threshold-based decision based on weighted sum of TF and L with noise (reflects level of expertise)

Truthfulness strong signal

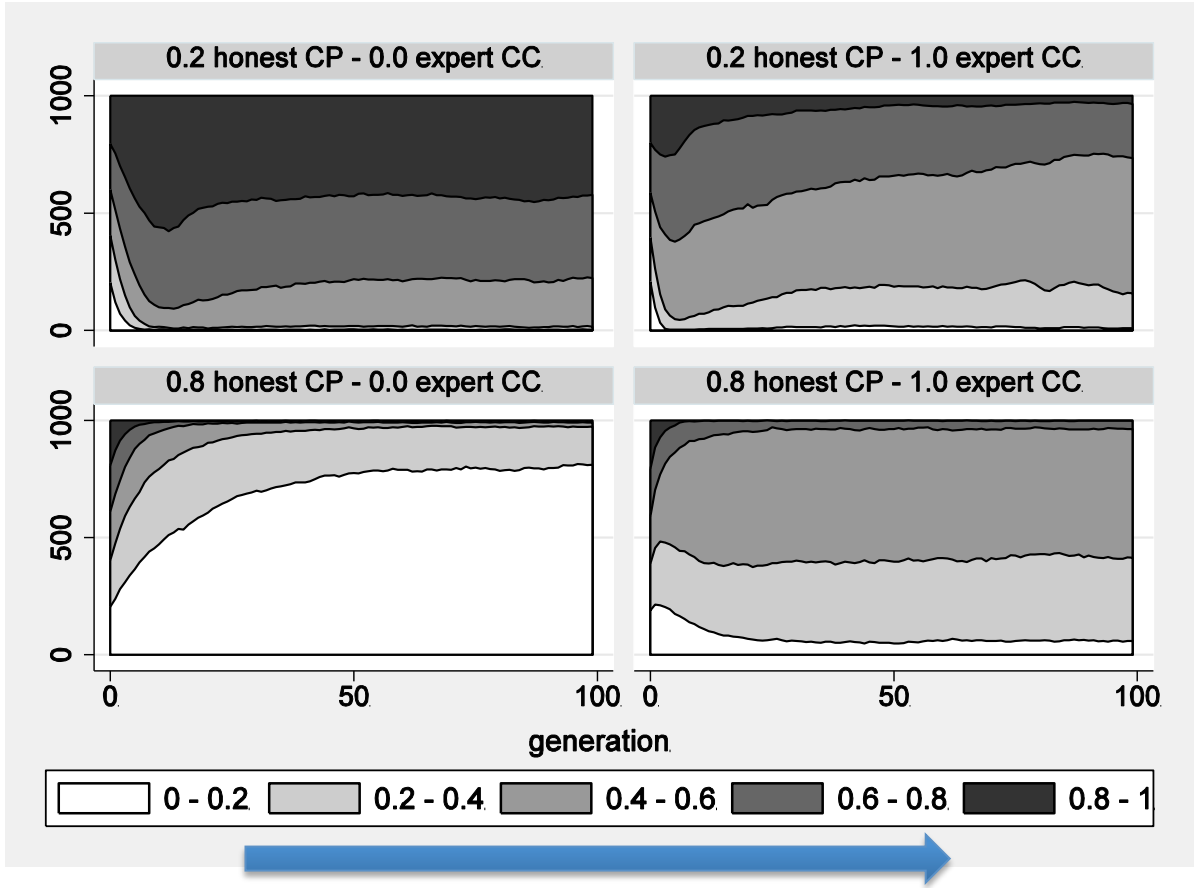


Honest players care about presentation while dishonest don't

Honest players adapt to expertise

Honest player do not care about presentation while dishonest do

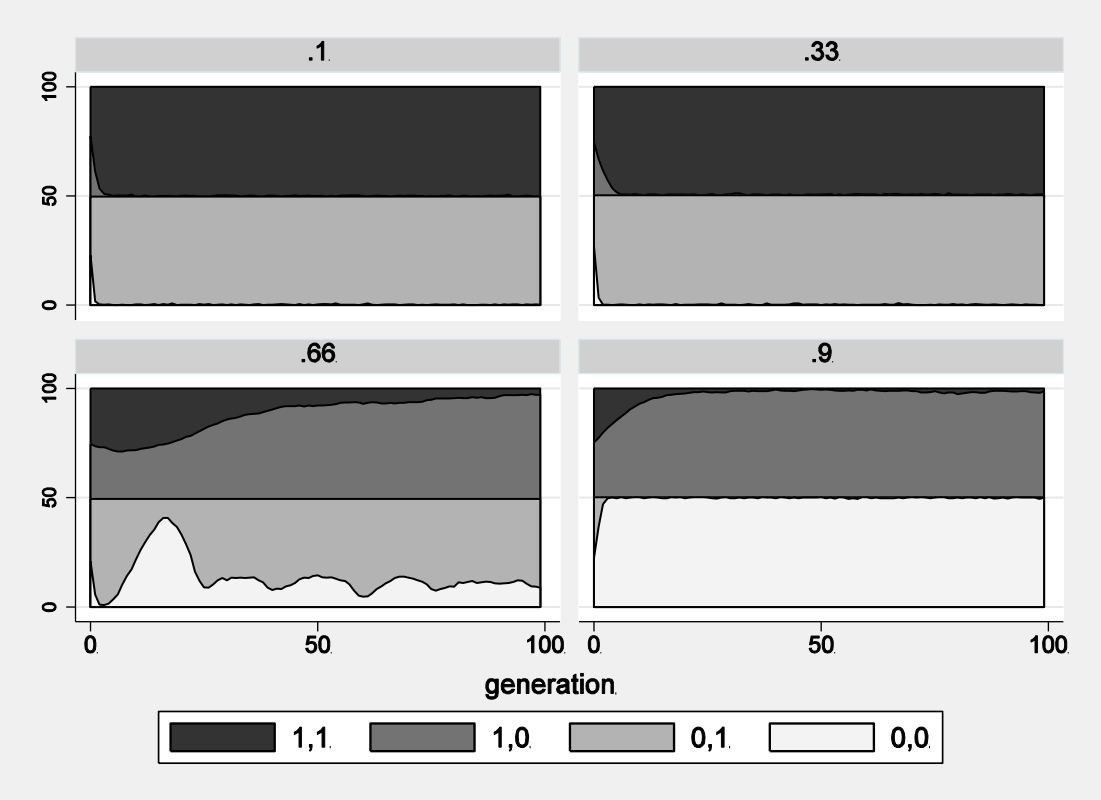
Truthfulness strong signal



Naïve players choose high threshold

Naïve players choose low threshold

Changing weight of Truth



Low weight: invest in presentation

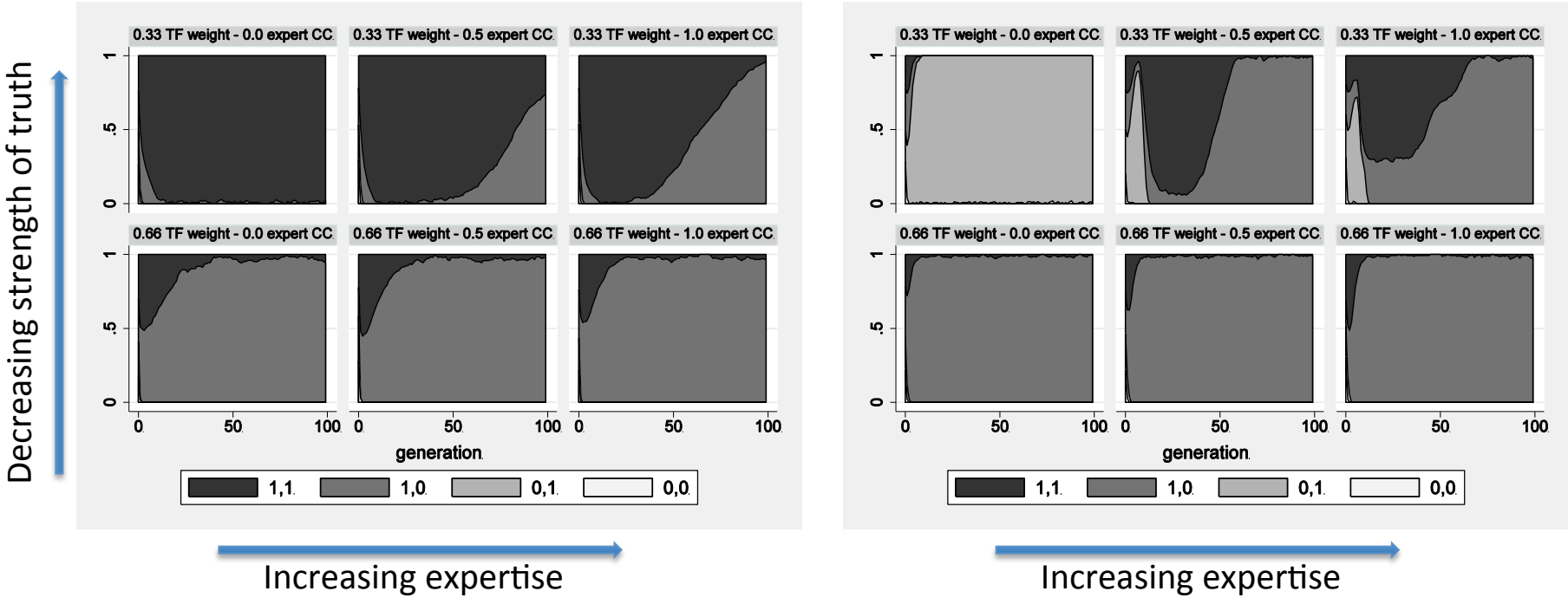
High weight: don't invest in presentation

50% experts

Strategy Evolution

Honest Producers

Dishonest Producers



- When truth signal is weak, producers of both types Invest in presentation quality, while telling truth (honest) or lying (dishonest) against naïve consumers
- As consumer expertise rises or truthfulness signal strength increases, all producers invest less in presentation quality, while dishonest producers become truthful!

4. Conclusions – Future Work

- We proposed flexible game models that facilitate studying incentives and dynamics of Web credibility
  - against various consumer expertise and adversary strategies
- Experimental results verify the theoretical analysis
- Future work
  - More complex features (beyond presentation)
  - More sophisticated adversary strategies
  - Incorporating user feedback on Web credibility

Thank you. Any questions ?

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