

# Information Manipulation and Web Credibility

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**Abstract.** Fake information, news, and reviews are overloaded in the era of big data. We use an agent-based model to simulate social interaction between information producers and consumers. Whether the information producers manipulate true or fake information depends on individual consumers attitude to truth or presentation of information. Consumers adapt themselves to accept or reject information and may evolve or learn socially from the others. Honest and dishonest producers select production strategies and also evolve from the same type of producers. We unexpectedly find that dishonest producers may produce true information because consumers co-evolve with producers by raising their standard on truth of information. To prevent fake information diffusion, let consumers take social responsibility by raising standard on truth of information improving social welfare and web credibility in the era of information overload.

**Keywords:** Information manipulation · Web credibility · Fake information

## 1 Introduction

Web content has become essential for many users in making decision for shopping, employment, education, health, finance, and investment. In the era of big data, surfing on the internet may deteriorate the information overload instead of solving or mitigating it. Social media not only makes information overload more prevalent, but also fake information, news, and reviews overload becomes more serious. A lot of fake information, news, and reviews has been surfed and diffused on the internet. For example, Facebook users complained that fake news had influenced the U.S. presidential election. The reviews made on trip site are deceiving because fake comments are posted without verification.

Online reviews influence opinions and change business trends, while firms adopt comments to create value for customers. Nonetheless, information overload deters consumers to receive true information when making a decision [2, 4].

Internet has become an important source of information that significantly affects people social, economic and political life. The content availability on web is the basis for the operation of digital economy. However, fake information is more powerful and devastating than negative information. Thus, Wierzbicki et al. (2014) classify information to true or false properties [8].

The effects of online review to restaurant and trip are the focus of Anderson and Magruder (2012) [1] and Mayzlin et al. (2014) [6], respectively. Although the effects of fake or positive reviews on consumer and producer choice are discussed in [7, 9, 10], how to prevent fake information diffusing is important but less studied. Let us focus on the issue of preventing fake news. By considering behavioral explanations and preference for punishing selfish, the rejection of trading information lessens the consumers gain but lessens the producers gain even more [3]. Even if there are laws that prohibit misleading information, revealing fake reviews is complicated [5].

We use an agent based model to simulate social interaction between information producers and consumers and express the dynamics whether the information producers manipulate true or fake information depending on individual consumers attitude to truth or presentation of information. Therefore, we rationalize and refine the model of Wierzbicki et al. (2014) which is overlooked. The contributions is summarized as follows. First, the good presentation of information has its value on consumers and results in those dishonest producers may produce true information as honest producer. Second, fake information but accepted by consumer has disutility. Under this circumstance, the honest and dishonest producers almost simultaneously choose good and truth strategy in the beginning. Third, punishment mechanism is social costly. Let consumers acknowledge that accepting fake information is deleterious and take their social responsibility to prevent fake information by raising signal-threshold. Dishonest producers voluntarily and eventually adopt good and true strategy. Consumer side approach benefits our society in the era of big data.

Section 2 provides the baseline model. Section 3 provides the refined model and simulation. Section 4 concludes.

## 2 The Baseline Model

The baseline model follows Wierzbicki et al. (2014). There are 100 producers and each one produce a piece of information. This information has two features or attributions: its content could be true or fake and its presentation could be good or bad. According to information attribution, producers are classified into two types. The first type is honest producers who intend to produce true information. The second one is dishonest producers who tell lies and intend to produce fake information. Accordingly, each type producer has four possible strategies as {GT, BT, GF, BF}, which represents Good and Truth (yellow), Bad but Truth (red), Good but Fake (green), and Bad and Fake (Blue) strategy, respectively. Consumers then consume this information and accept or reject it depending on a signal-threshold on their mind which is comprised by truth or fake content,

and good or bad presentation. Once consumers read, listen, or watch this information, they compare it with signal-threshold. If consumers feel this information beyond their threshold, consumers accept it which is true information and thus gain positive utility +2. Otherwise, consumers accept it which is fake information and gain negative utility -2. Once consumers reject information, they get zero payoffs. Figure 1 shows payoffs of consumers.

Agents	Information is <b>accepted</b> by consumer				Information is <b>rejected</b> by consumer			
	GT (yellow)	BT (Red)	GF (green)	BF (blue)	GT (yellow)	BT (Red)	GF (green)	BF (blue)
Consumer	2	2	-2	-2	0	0	0	0
<b>Honest</b> Producer	4	5	1	2	-1	0	-3	-2
<b>Dishonest</b> Producer	1	2	4	5	-1	0	-3	-2

**Fig. 1.** Payoffs of consumer and producer

The payoff of information producer is denoted as

$$U(P) = S(TF) + C(TF, L)$$

S: the gain of content producer.

C: The costs function of information production.

The surplus of the content producer is represented as

$$S(TF) = \theta TF + \phi.$$

$\theta$ :  $\theta > 0$  represents an honest producer and  $\theta < 0$  represents a dishonest producer.

The cost function of the content producer is given by

$$C(TF, L) = \lambda TF + \mu L + \tau$$

$\lambda$ :  $\lambda < 0$  implies that increasing the fake of the produced information raises the cost of its production because the costs is measured by mental and physical effort for manufacturing or manipulating fake information.

$\mu$ :  $\mu > 0$  denotes that changing the presentation of information from bad to good looking increases the cost.

$\tau$ :  $\tau > 0$  denotes a fixed cost.

TF: TF = 1 (0) denotes the true (fake) information. L: L = 1 (0) denotes the presentation of information is good (bad).

Given their sign remained the same and specific values of these previous parameters, producers payoff is also provided in Fig. 1.

Now, we explain consumer behavior by introducing the signaling game. In the signaling game consumers can not observe producers type. The signal is randomly chosen from a normal distribution because we assume that individual consumer is heterogeneous and has different preference about the truth or fake content and good or bad presentation of consuming information.

$$Mean = w_{TF} \times TF + w_L \times L$$

$$\text{Standard deviation} = \sigma$$

$w_{TF}, w_L$ : are weights of the True/Fake and Good/Bad properties of the produced information.  $w_{TF} + w_L = 1$

$\sigma$ :  $\sigma$  is a constant which implies the degree or level of distraction in the era of information overloading. The higher  $\sigma$  it is, the more distractive of a consumer it is when the reviewer consecutively consumes a piece of information. Given  $\sigma = 2/3$ , we call them as distractive consumers whereas  $\sigma = 0.05$  represents consumers are not distractive. Denote  $\epsilon$  as the ratio of distractive consumer. There are distractive consumers if  $\epsilon = 1$  and there are no distractive consumers if  $\epsilon = 0$ .

In each generation or 20 times, both producer and consumer have 1% chance to evolve or learn from each other. Producer randomly chooses one producer and compares its payoff with selected-producer payoff. Producer imitates or copies selected-producer strategy if the selected-producer payoff is larger than itself. Consumers evolve in the same way by adjusting their acceptance signal-thresholds.

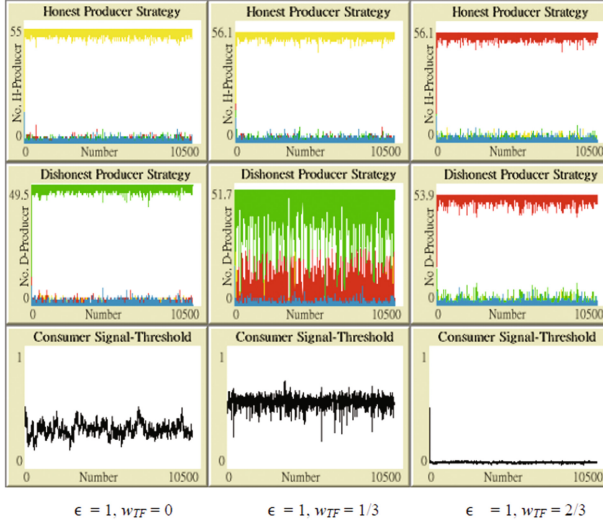
### 3 The Refined Model and Simulation

We rationalize and refine the model of Wierzbicki et al. (2014). New insights are uncovered in Sect. 3.1. In Sect. 3.2, some unexpected results are revealed in the refined models.

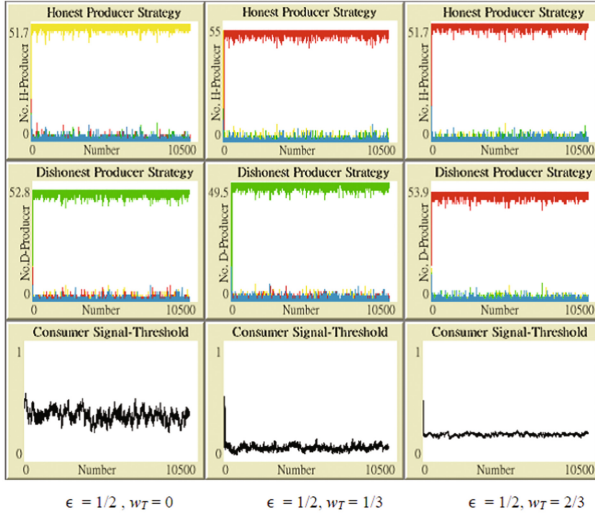
#### 3.1 Dishonest Producers Change Their Strategy Slowly to Tell Truth

Given different combinations of the ratio of distraction consumer  $\epsilon$  and weights of the True/Fake properties  $w_{TF}$ , we simulate the producers strategy evolution and consumers threshold evolutionary dynamics. Each simulation runs 10,000 times as a round and 10 rounds are done. We select the classical ones which prevails the similar patterns and are showed as Figs. 2, 3 and 4.

The honest producers change its strategy from {GT}(yellow) to {BT}(red) at a relative low weight,  $w_{TF} = 1/3$ . On contrast, the dishonest producers strategy is changed from {GF}(green) to {BT} at a relative high weight,  $w_{TF} = 2/3$ . These dynamics are more prevalent when more consumers concentrate on the truthfulness of information or more consumers are less distractive. In other

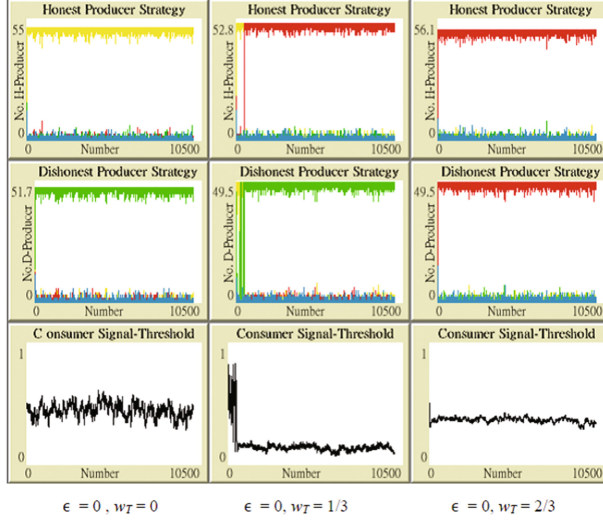


**Fig. 2.** Evolutions of producers strategy and consumers signal-threshold ( $\epsilon = 1$ )



**Fig. 3.** Evolutions of producers strategy and consumers signal-threshold ( $\epsilon = 1/2$ )

words, honest producers change their strategy more quickly than that of dishonest producers. From the view point of honest producer, they would like to choose {GT} because all the consumers judge the information by presentation or appearance. When consumers reduce the weight on appearance and increase more weight on truth, producers find that the {GT} is no longer a prevailing strategy and it is replaced by {BT} to save the presenting cost when  $w_{TF} = 1/3$ .



**Fig. 4.** Evolutions of producers strategy and consumers signal-threshold ( $\epsilon = 0$ )

The honest producers still adopt  $\{BT\}$  strategy when consumers continue to reduce the weight on appearance. On the other side, dishonest producers still adopt  $\{GF\}$  strategy to cheat the consumers when the truth weight is one third. Eventually, the dishonest producers change their strategy from  $\{GF\}$  to  $\{BT\}$  when consumers put more weight on truth,  $w_{TF} = 2/3$ . Comparing their strategies, we find honest producers change their prevalent strategy more quickly than dishonest producers. These results are true when there are little distraction consumer,  $\epsilon = 0.5$  or  $\epsilon = 0$ . Because dishonest producers earn additional gain  $+2$ , they should be accompanied with consumers taking the truth of information more seriously. Furthermore, honest producers just can earn additional gain  $+1$ , they don't need that consumers take the truth of information so seriously.

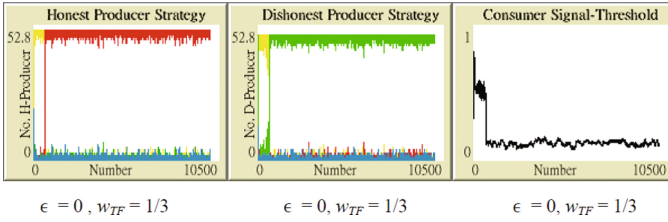
Now, we are going to discuss the evolution of consumers, which are showed by signal-threshold. A trend is revealed in Fig. 2, 3 and 4 except for  $\epsilon = 1$  and  $w_{TF} = 1/3$ . Given the same weights of true, the less of the distractive consumers it has, the higher the signal-threshold it is. When consumers concentrate on the truth of information, they have more confidence on their decision of acceptance which results in a high signal-threshold.

### 3.2 Dishonest Producers May Produce True Information

In this section, we refine the baseline model in different ways. First, we argue that the good presentation of information has its value on consumers and producers which dishonest producers may produce true information as honest producer. The second argument is that fake information but accepted by consumer has disutility. Third, truth information but rejected by consumer also has disutility.

Finally, a way from consumers side that let the dishonest producers tell the truth is compared with punishment mechanism on producer.

**The Good Presentation of Information Has Its Value.** When a piece of information is presented well and accepted by consumer, consumers pay-offs should become larger than that the situation of the baseline model. It is equivalent that we change the consumers payoff from  $\{GT, BT, GF, BF\} = \{2, 2, -2, -2\}$  to  $\{3, 2, -1, -2\}$ . The interesting cases and regimes change are easily happened in the situation of  $w_{TF} = 1/3$ . In the beginning, honest and dishonest producers randomly choose their strategies. Consumers make decisions and evolve through social learning. Consumers then co-evolve their signal-threshold with producers. Honest producers revolution and dishonest producers revolution may emerge a situation that they both use  $\{GT\}$  or yellow strategy and a classical case is showed in Fig. 5.

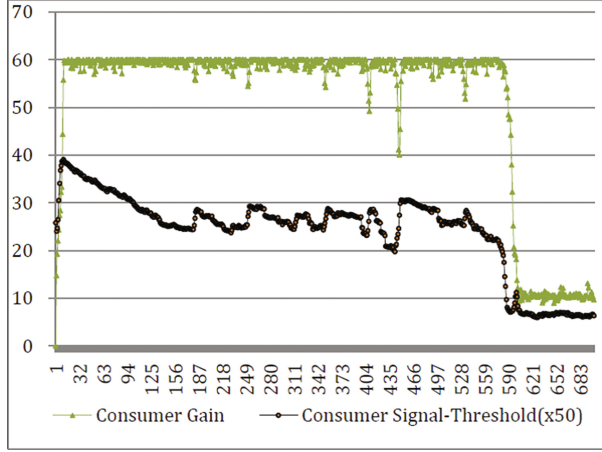


**Fig. 5.** Dishonest producers may produce true information

Now, we discuss the relation between consumer gain and signal-threshold. Figure 6 shows the detail of relation between consumer gain and signal-threshold. The consumer gain is measured for each generation. To maximize utility, consumers adjust their threshold at relative high level in the beginning because we randomly give producers strategy. It is unexpected that dishonesty producers also tell the truth facing high signal-threshold. It means that dishonest producers take high signal into account and tell the truth. As a result, we believe that the good presentation of information has its value on consumers and producers which dishonest producers may produce true information in the beginning as honest producer. However, the dishonest producers also evolve by social learning and produce fake news eventually. Consumers accept the fake information and get its zero expected utility by reducing signal-threshold.

### **Fake Information but Accepted by Consumer Has High Disutility.**

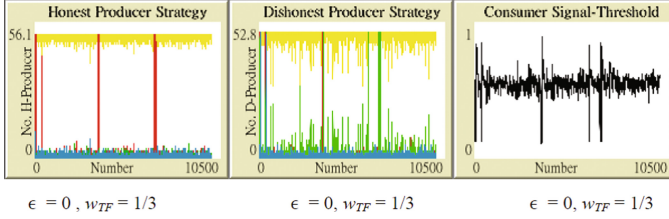
When fake information is accepted by consumer, its payoff should be worse because the consumer is cheated by producers. If we change the payoff  $\{GT, BT, GF, BF\} = \{2, 2, -2, -2\}$  to  $\{3, 2, -2, -3\}$ , the regimes change also happen easily in the situation of  $w_{TF} = 1/3$ . Under this circumstance, the honest and dishonest producers almost simultaneously choose  $\{GT\}$  in the beginning of each round which is similar to Fig. 5.



**Fig. 6.** Relation between consumer average gain and signal-threshold

**Truth Information but Rejected by Consumer Also Has Disutility.** A lot of fake information, news, and reviews spread out on the internet. Consumers often mislead by fake information without attention. Some of consumers may be aloof and refuse to accept true information. When true information is rejected by consumer, its payoff should be worse. Thus, we change the payoff  $\{GT, BT, GF, BF\} = \{0, 0, 0, 0\}$  to  $\{-2, -2, 0, 0\}$ . Under this circumstance, the honest and dishonest producers would not like to choose  $\{GT\}$  in the beginning of each round. The intuition is straightforward. As consumers reject and generate disutility on true information, dishonest producers do not have incentive to produce true information.

**Two Approaches to Prevent Diffusion of Fake Information.** Punishment on rejected cases is an effective way to prevent the diffusion of fake information but it is costly. For example, Facebook provides their user a tool or button to raise a flag and implies the consumed information could be fake. Then, Facebook will ask the objective third party to verify whether this ostensible and flagged information is fake. If it were fake, Facebook reduces this information ranking on the site, which reduces information producers gain. We simulate the practical punishment mechanism as real world. Allowing sufficient high probability to check fake information on producer, we find that punishment is effective when consumers are easy to distraction. In contrast, punishment is less effective when consumers are less distractive. It requires  $1/2$  probability to check the rejected or flagged information in this simulation. As a result, consumers reduce the signal-threshold and accept all the information. No matter it is true or not. Although punishment is effective, this kind of mechanism is costly from the view point of social welfare.



**Fig. 7.** Dishonest producers produce true information eventually

Another positive way is originated from consumer. We may provide some training to teach consumers how to identify the fake information through education, for example. Let consumers acknowledge that accepting fake information is deleterious. It is equivalent that we change the consumers payoff from  $\{GT, BT, GF, BF\} = \{2, 2, -2, -2\}$  to  $\{3, 2, -3, -4\}$ . We find not only dishonest producers tell the truth but also consumers raise their signal-threshold which is showed as Fig. 7. It implies that consumers take their social responsibility to prevent fake information by raising signal-threshold and let dishonest producers voluntarily adopt good and true strategy. This approach edifies us and benefits our society in the era of big data.

## 4 Conclusion

We rationalize and refine the model of Wierzbicki et al. (2014). New insights are uncovered. First, the good presentation of information has its value on consumers and results in those dishonest producers may produce true information as honest producers. Second, fake information but accepted by consumer has disutility. Under this circumstance, the honest and dishonest producers almost simultaneously choose good and truth strategy in the beginning. Finally, the way from consumers side that let the dishonest producers tell the truth is compared with punishment mechanism on producers. Punishment requires high probability to check the flagged information. No matter it is true or not, consumers reduce the signal-threshold and accept all the information. Therefore, punishment mechanism is social costly. Another positive way is originated from consumer. Let consumers acknowledge that accepting fake information is destructive and take their social responsibility to prevent fake information by raising signal-threshold. We find that dishonest producers voluntarily and eventually adopt good and true strategy. This approach improves our social welfare as well as web credibility in the era of big data.

Future work will discuss the strategic matching and ranking behavior of platforms. How negative reviews strategy is used in the framework of duopoly is also worth more in-depth research.

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