

## Research Article

# Value of Mass Media in Food Safety Information Disclosure from the Perspective of Big Data

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The advent of *big data infrastructure* has promoted the development of media forms and content. Food safety information disclosure (FSID) is an effective solution to regulate food safety issues. The mass media, government regulatory agencies, and food companies jointly participate in the disclosure of food safety information. Due to social responsibilities and common interests, a tripartite game relationship is formed. After an evolutionary game model was established with China as an example, the mass media's participation in food safety information disclosure can affect the public's decision-making, and true disclosure can promote the process and effectiveness; however, false disclosure will have adverse effects on all three parties. The application of big data technology doubles the positive and negative effects. Therefore, the government needs to strengthen the supervision of the mass media's participation, and food companies need to actively provide correct disclosure information. The media should strengthen their management and use big data rationally, formulate corresponding disclosure strategies, and coordinate the three parties to promote food safety information disclosure.

## 1. Introduction

Food is an important basis for human survival. With the development of social economy and the improvement of people's living standards, people's demand for food has changed from quantity to quality, and food safety has been paid more attention. However, at present, the outbreak of incidents in food safety and the quality of food and food safety are current concerns. Because of the asymmetry in information, consumers often cannot always identify some of the inherent attributes of food: whether they contain harmful additives or if the source of food is contaminated. In the long run, this will not only erode consumer trust in the food industry but also raise questions about the credibility of the government as a regulator [1, 2]. For example, the “Sanlu

melamine milk powder incident” in 2008, which killed six children and sickened about 300,000 in January 2009, not only led to the bankruptcy of the Sanlu group, but also eventually made China's dairy industry suffer a major blow. Numerous dairy farmers went bankrupt. Therefore, improving the food safety supervision system, strengthening food safety management, and reestablishing consumer confidence in food safety are the focus of the current food safety work.

The system of disclosing food safety information is an effective way to solve the problem of asymmetric food safety information and an outlet for solving food safety problems. Some developed countries, such as the United States, the European Union, and Japan, have achieved solid results in this regard [3]. For consumers, disclosing food safety

information helps to trace the source of food production, so as to ensure the safety of the food purchased. It is conducive to building a good market for producers and avoiding the “lemon market” caused by frequent food safety incidents [4]. For the government departments as the supervisor, the food safety information disclosure is conducive to improving the level of food safety management, forming strong supervision, reducing the occurrence of food safety incidents, and avoiding the adverse impact on the credibility of the government. In the process, mass media, government supervision departments, and food enterprises constitute the main body of information disclosure. Among them, the government has a dominant position in the information disclosure process because of its administrative powers. It provides the most powerful administration for information disclosure by formulating laws and regulations on food safety information disclosure [5]. Food companies occupied a relatively active position in this process. They fully grasp the content of the information disclosed and can determine the content and degree of disclosure of food safety information. However, there are some problems in both of the above; although under the constraints of relevant laws and regulations food companies have to disclose food information [6], they will selectively disclose information that is beneficial to them and hide unfavorable information, and the government may change and conceal the content of disclosure due to an unclear division of responsibilities or because of excessive protection of their own interests. The reliability is difficult to guarantee [7]. Therefore, the involvement of the mass media as a third-party entity can not only supervise the disclosure behavior of government departments and food companies, but also serve as an important tool for information disclosure in the process of food safety [8].

Mass media spreads information to the masses via newspapers, magazines, radio, television, movies, books, and the Internet [9]. The advent of the big data era has brought new opportunities and challenges to the mass media. First of all, cloud computing and the Internet of Things have made large-scale data production, storage, and processing a reality. The media content is constantly enriched, and the transmission speed is getting faster and faster, which increases the audience’s demand for communication [10]. In addition, the types of media continue to develop and merge, and the emergence of interactive media platforms enhances the willingness of the audience to engage. Today, there are more than 10 million photo updates and 3 billion clicks on Facebook every day; Google processes more than 24PT data every day, and more than 400 million micro blog posts appear on Twitter every day. In the era of big data, the communication power of the media cannot be ignored, and it will play a better role in the disclosure of food safety information.

Big data needs to be effectively used with the help of new technological means to reflect its own stronger decision-making power, observational powers, and integration of large-scale, fast-growing, and diversified assets [11, 12]. It is not a single technology presentation but a technology group composed of a variety of different forms,

different functions, and different architectures, including data collection and storage, data screening and processing, data analysis and prediction, data mining and integration, and data results display [13]. It analyzes massive amounts of data to obtain products and services with great value and deep insights [14]. Big data has four characteristics: super large data scale, fast data flow, diverse data types, and low value density [15]. Based on these characteristics, big data will have new advantages when participating in the operation of the media in food safety information disclosure. First of all, big data promotes the innovation of media types, promotes media integration, and jointly completes the dissemination of the disclosure content through all media in the food safety information disclosure. In the era of big data, the boundaries of media types are increasingly blurred, and they are integrated with each other to form an all-media communication method. Media content can be freely converted between multiple media, which provides a more flexible medium for food safety information disclosure. Second, big data has promoted the innovation of media content and changed the way that mass media content is constructed. In the era of big data, the media can use a variety of technical means to capture user information such as identification number (ID), password, web pages browsed, and stay time and then through a large number of users across platforms, devices, and applications. The integration of data behavior is through dynamic tracking and correlation analysis, the analysis and comparison of these information, the audience’s natural attributes (demographic characteristics, region, and time) and social attributes (hobbies, consumption habits, and interpersonal relationships), and the behavior preferences of the audience when receiving media information [16]. In this way, big data can help the mass media to realize the intelligent matching of the audience’s needs, complete the precise positioning of the audience, and, by choosing appropriate communication methods, construct a reasonable and appropriate communication content, realize the accurate communication of food safety information disclosure, and enhance the mass media’s communication effectiveness. Moreover, in the process of FSID (food safety information disclosure), the use of data to analyze and demonstrate food safety information and food safety incidents, instead of just relying on superficial occurrences, can increase the credibility of the media and enable the audience to trust more in food safety [17]. Third, big data technology facilitates the collection and analysis of audience feedback, which is conducive to better play the role of mass media supervision.

Based on the technical background of big data, this article focuses on the communication effectiveness and authenticity of the mass media and, based on this, builds an evolutionary game theory model, analyzes the interaction mechanism of the tripartite game between the media, government supervision departments, and food companies in the process of food safety information disclosure, demonstrates the value of media participation in FSID, and explores how to use big data to make media accurately reach more audiences.

## 2. Multiagent Evolutionary Game Construction of Food Safety Information Disclosure in the Era of Big Data

*2.1. Model Description.* In the era of big data, the communication power of the media has been continuously strengthened and is more precise, and the role of the mass media in the disclosure of food safety information has become increasingly apparent. Based on the role of the mass media as a “watchkeeper” and considering the authenticity and accuracy of information disseminated by the mass media in the context of big data, this paper takes China as an example to construct an evolutionary game model for stakeholders in food safety information disclosure. The three-party game relationship is shown in Figure 1.

As shown in Figure 1, food safety information disclosure involves four main stakeholders: the government, the food companies, the public, and the mass media. The media, government departments, and food companies constitute the main body of information disclosure, and the public is the audience of food safety information disclosure. Therefore, this model mainly considers the interaction mechanism of the government, food companies, and mass media. The public is limited by their own ability to entrust the right to supervise food safety to relevant government departments. Through the use of administrative power, the government regularly discloses food safety information to the society to maintain market order. However, due to the complexity of “unified” supervision, it is difficult for relevant government departments to disclose food safety information in a timely and effective manner. With the development of big data technology, the disclosure of food safety information by the mass media has become an effective supplement to government disclosure. The mass media uses big data to collect information about food safety in a professional way and discloses it to consumers objectively. To a certain extent, it can alleviate the information asymmetry in the food trading market, supervise the supervision of government departments, and affect public purchases. Decisions, in turn, affect the market share and profits of food companies. However, in the face of the massive information brought by the era of big data, the mass media is affected by factors such as their own interests, and exaggerated and inaccurate reports are not uncommon. Exaggerated and inaccurate reports can lead to misleading the public and food companies. Thus, the food industry will have a bad influence, and the mass media will also face the risk of losing credibility. Therefore, the government needs to regulate and guide the mass media, improve the authenticity and accuracy of information disclosed, and reduce social costs.

*2.2. Model Symbol Description.* Based on the above-mentioned tripartite evolutionary game relationship diagram, this paper sets the strategic space of relevant government regulatory agencies as {supervision, no supervision}, in which the proportion of selected supervision is

$x$  ( $0 \leq x \leq 1$ ); the strategic space of the food business group is set as {true disclosure, false disclosure}, where the proportion of food companies that choose true disclosure is  $y$  ( $0 \leq y \leq 1$ ); the strategic space of the mass media group is set to {accurate and realistic reports, exaggerated and inaccurate reports}, of which the proportion of the mass media groups who choose to report in reality is  $z$  ( $0 \leq z \leq 1$ ). Through the analysis of the game focus, the main parameters involved in the evolutionary game of the three subjects in the food safety information disclosure are shown in Table 1.

### 2.3. Model Assumptions

*Hypothesis 1.* The government supervision department groups, food company groups, and mass media groups participating in the game are all rationally bounded. They learn and imitate continuously in the dynamic game process and finally reach a stable state. It should be noted that the behavioral norms of the participating subjects are affected by many factors such as social systems and culture. This article takes the subjects involved in food safety information disclosure under the national conditions in China as the research object. It studies the interactive mechanism of the participating subjects in information disclosure.

*Hypothesis 2.* This article assumes that all food companies will actively disclose food safety information to the society. Companies that produce high-quality food will truly disclose food safety information, while companies that produce low-quality food will hide unfavorable information and disclose false food safety information to the public. Because of the particularity of food, it is difficult for the public to identify some internal attributes that are invisible to the naked eye, such as whether it contains harmful additives and whether the source of the food is contaminated. Therefore, food companies that falsely disclose due to poor quality production are not exposed. The former and the real disclosure of high-quality production of food companies have the same income. Because the true disclosure of food safety information requires companies to pay more effort and cost, it is shown as  $C_{f_1} > C_{f_2}$ .

*Hypothesis 3.* Food safety issues are the focus of social attention. It is assumed that the mass media will spontaneously increase their attention to food safety issues and disclose food safety information of inferior manufacturers to the public [18]. Because the mass media with exaggerated and inaccurate reports failed to conduct thorough investigations, their reporting costs are lower than the reporting costs of the mass media when they report accurately, which is  $C_{m_1} > C_{m_2}$ . In addition, because exaggerated and inaccurate public reports can attract the public’s attention and generate more clicks, the income of the mass media’s accurate and true disclosure of food information is lower than the income of exaggerated and inaccurate disclosure of food safety information, which is  $R_{m_1} > R_{m_2}$ . However, the be-

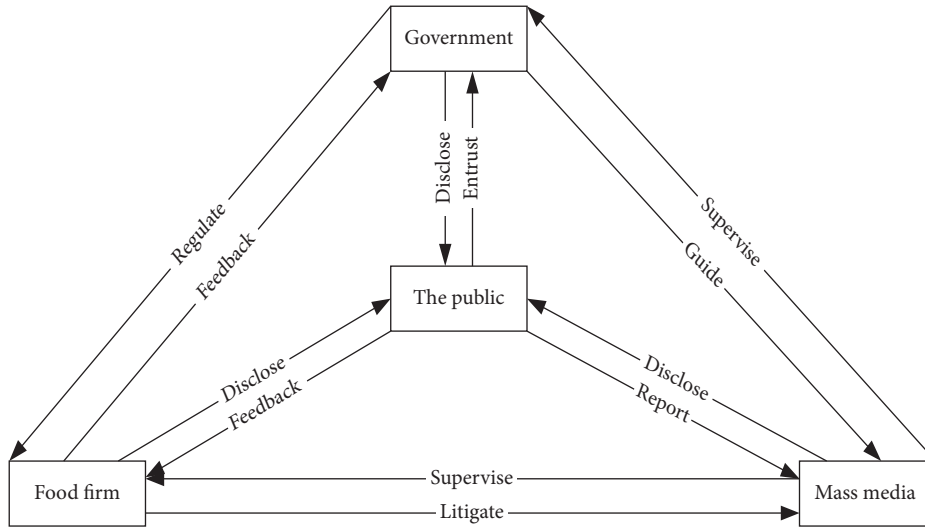


FIGURE 1: Tripartite evolutionary game diagram.

TABLE 1: Symbols and meanings.

Symbols	Symbol meaning and description
$x$	Based on the probability of serious supervision by government regulators; $1 - x$ is the probability of nonfalse disclosure regulation.
$y$	Based on the probability of true disclosure among food enterprise groups; $1 - y$ is the probability of false disclosure.
$z$	The probability of accurate and realistic coverage by mass media groups; $1 - z$ is the probability of exaggerated and inaccurate reporting.
$R_g$	The reputation gain is dependent on the government carefully supervising the timely and correct disclosure of food safety information.
$C_g$	The government does not supervise the timely and correct disclosure of food safety information; reputational damage arises from food safety issues.
$C'_g$	Because of mass media reports, the exaggerated and inaccurate safety information disclosure of high-quality produced food caused reputational damage to the government.
$C_{g_1}$	Because of the exaggerated and inaccurate reports by the mass media, the rumors cause damage to the government.
$R_{f_0}$	The profit depends on the food enterprises when the quality production is truly disclosed.
$C_f$	Food enterprises make false disclosure because of inferior production; reputation loss when food safety information is exposed by the media (decline in brand influence).
$C'_f$	When the quality production of food enterprises is truly disclosed, the reputation of the enterprises will be damaged due to the rumors generated by the exaggerated and inaccurate reports of mass media.
$C_{f_1}$	The cost is dependent on the true disclosure of high-quality products produced by food enterprises.
$C_{f_2}$	The cost is dependent on the false disclosure when a food company produces inferior products.
$C_{f_3}$	The economic loss of food enterprises is dependent on when food insecurity information is exposed (sales to reduce, consumer claim, losses from product recalls).
$P_f$	A fine paid by a food enterprise to the regulatory authorities is dependent on after its false disclosure of food safety information was exposed by the media.
$R_{m_1}$	The profit of accurate food safety information reporting is dependent on the mass media.
$R_{m_2}$	The benefit of exaggerated and inaccurate reporting of food safety information is dependent on the mass media.
$C_{m_1}$	The cost of accurately reporting food safety information is dependent on the mass media.
$C_{m_2}$	The cost of exaggerated and inaccurate reporting of food safety information is dependent on mass media.
$R_m$	Reputation gain is dependent on when the mass media accurately and faithfully reports the food safety information of inferior production.
$C_m$	Reputation loss is dependent on when mass media exaggerates and misreports food safety information of poor quality production.
$P_m$	A fine paid by the government is dependent on when an exaggerated or inaccurate report is reported by the mass media.
$\alpha$	Reputational impact factor is dependent on the attention of event due to the application of big data (the reputation of all parties changes in the impact).

havior of the mass media to exaggerate and misrepresent food safety information may expose them to the risk of being eliminated by the market. Therefore, the reputation loss of exaggerated and misrepresented food safety information is not less than the reputation benefit of true and accurate disclosure, which is  $R_m - C_m \leq 0$ . At the same time, the Chinese government, as a service-oriented government, aims to maximize social welfare and will resolutely perform its duties. Assuming that the government's food regulatory agency fulfills the regulatory responsibilities, it can always disclose food safety information in a timely and correct manner and punish problem companies, which will increase government credibility; if the government does not carefully supervise the information and the problematic food safety information is reported by the mass media, it will have a negative impact on the government's credibility. The government will then penalize the problematic enterprises in order to make up for the fault.

*Hypothesis 4.* Due to consumer misreporting or unfair competition in the same industry, the mass media may disclose relevant issues out of a sense of social responsibility and may make exaggerated and false reports on the safety information of high-quality produced food that is truly disclosed. At this time, the exaggeration is false. The impact of reports on the reputation of the mass media is negligible. The mass media needs a strong sense of social responsibility and scientific literacy in order to report accurately and truthfully on food safety issues [19]. Therefore, this article assumes that the mass media's accurate disclosure of poor-quality food safety information will affect the public's judgment on the media's reputation. Exaggerated and false reports of truly disclosed high-quality production food safety information will have negative reputational effects on

the government and enterprises,  $C'_g$  and  $C'_f$ , respectively, and at this time, the reputation impact on the two parties is less than the reputation loss caused by the government's nonregulation and the company's poor quality production, which are  $C'_g < C_g$  and  $C'_f < C_f$ .

*Hypothesis 5.* The application of big data is becoming more and more extensive. With the help of big data to realize the personalized customization of user news content and news feed form, this will undoubtedly increase the public's attention to news events. The higher the attention of news events, the greater the impact on the reputation changes of all parties. Therefore, this article mainly uses the influence factor  $\alpha$  for the reputation of all parties to reflect the impact of the authenticity and accuracy of mass media food safety information disclosure in the context of big data. It assumes the reputation impact factor in the context of big data as  $\alpha > 1$ .

*2.4. Establishment of Multiagent Game Model.* Based on the game relationship diagram of government regulatory agencies, food companies, and mass media and the above basic assumptions, it is concluded that the mass media in the food safety information disclosure in the era of big data chooses accurate and practical strategies and exaggerated and inaccurate strategies. The income matrix is shown in Tables 2 and 3.

From the above income matrix, we can see the expected income of the government by choosing the regulatory strategy  $U_{g_1}$ . The expected income of choosing the non-regulatory strategy  $U_{g_2}$  and the expected income  $U_g$  of the government group are

$$\begin{aligned} U_{g_1} &= U_{g_1}(\alpha R_g - C_{g_1}) + y(1-z)(\alpha R_g - C_{g_1} - \alpha C'_g + P_m) + y(1-y)(\alpha R_g - C_{g_1} + P_f) + (1-y)(1-z)(\alpha R_g - C_{g_1} + P_f + P_m) \\ &= \alpha R_g - C_{g_1} + P_f + P_m - y\alpha C'_g - yP_f + yz\alpha C'_g - zP_m, \end{aligned} \quad (1)$$

$$\begin{aligned} U_{g_2} &= y(1-z)(-\alpha C'_g) + (1-y)z(-\alpha C_g + P_f) + y(1-y)(1-z)(-\alpha C_g) \\ &= -\alpha C_g + y\alpha C_g - y\alpha C'_g + yz\alpha C'_g - yzP_f + zP_f, \end{aligned} \quad (2)$$

$$U_g = xU_{g_1} + (1-x)U_{g_2}. \quad (3)$$



TABLE 2: The income matrix under the mass media's selection of accurate and practical reporting strategies ( $z$ ).

Government	Food company	
	True disclosure ( $y$ )	False disclosure ( $1 - y$ )
Supervision ( $x$ )	$(\alpha R_g - C_{g_1}; R_{f_0} - C_{f_1}; R_{m_1} - C_{m_1})$	$(\alpha R_g - C_{g_1} + P_f; R_{f_0} - C_{f_2} - \alpha C_f - C_{f_3} - P_f; R_{m_1} - C_{m_1} + \alpha R_m)$
Not regulated ( $1 - x$ )	$(0; R_{f_0} - C_{f_1}; R_{m_1} - C_{m_1})$	$(-\alpha C_g + P_f; R_{f_0} - C_{f_2} - \alpha C_f - C_{f_3} - P_f; R_{m_1} - C_{m_1} + \alpha R_m)$

The expected benefits of food companies choosing the true disclosure strategies are  $U_{f_1}$ . The expected benefits of choosing false disclosure strategies  $U_{f_2}$  and the expected benefits  $U_f$  of food business groups are

$$\begin{aligned}
U_{f_1} &= xz(R_{f_0} - C_{f_1}) + x(1 - z)(R_{f_0} - C_{f_1} - \alpha C_f') + (1 - x)z(R_{f_0} - C_{f_1}) + (1 - x)(1 - z)(R_{f_0} - C_{f_1} - \alpha C_f') \\
&= R_{f_0} - C_{f_1} - \alpha C_f' + z\alpha C_f', \\
U_{f_2} &= xz(R_{f_0} - C_{f_2} - \alpha C_f - C_{f_3} - P_f) + x(1 - z)(R_{f_0} - C_{f_2} - \alpha C_f - C_{f_3} - P_f) \\
&\quad + (1 - x)z(R_{f_0} - C_{f_2} - \alpha C_f - C_{f_3} - P_f) + (1 - x)(1 - z)(R_{f_0} - C_{f_2}) \\
&= R_{f_0} - C_{f_2} - x(\alpha C_f - C_{f_3} - P_f) - (1 - x)z(\alpha C_f + C_{f_3} + P_f), \\
U_f &= yU_{f_1} + (1 - y)U_{f_2}.
\end{aligned} \tag{4}$$

The expected benefits of food companies choosing true disclosure strategies are  $U_{m_1}$ , the expected benefits of

choosing false disclosure strategies are  $U_{m_2}$ , and the expected benefits  $U_m$  of food business groups are

$$\begin{aligned}
U_{m_1} &= xy(R_{m_1} - C_{m_1}) + x(1 - y)(R_{m_1} - C_{m_1} + \alpha R_m) + (1 - x)y(R_{m_0} - C_{m_1}) + (1 - x)(1 - y)(R_{m_0} - C_{m_1} + \alpha R_m) \\
&= R_{m_1} - C_{m_1} + \alpha R_m - y\alpha R_m, \\
U_{m_2} &= xy(R_{m_2} - C_{m_2} - P_m) + x(1 - y)(R_{m_2} - C_{m_2} - \alpha C_m - P_m) + (1 - x)y(R_{m_2} - C_{m_2}) + (1 - x)(1 - y)(R_{m_2} - C_{m_2} + \alpha R_m) \\
&= R_{m_2} - C_{m_2} - \alpha C_m - xP_m + y\alpha C_m, \\
U_m &= zU_{m_1} + (1 - z)U_{m_2}.
\end{aligned} \tag{5}$$

According to the evolutionary game replication dynamic equation method, formulae (1) and (2) can be combined to

obtain the replication dynamic equation selected by the government supervision strategy:

$$F_g(x) = \frac{dx}{dt} = x(1 - x) [\alpha R_g + \alpha C_g - C_{g_1} + P_f + P_m - y(P_f + \alpha C_g) - z(P_f - yP_f + P_m)]. \tag{6}$$

Similarly, the dynamic equations for the selection of food safety information disclosure strategies of food companies

and the selection of mass media reporting strategies are as follows:

$$F_f(y) = \frac{dy}{dt} = y(1 - y) [C_{f_2} - C_{f_1} + \alpha C_f' + x(\alpha C_f + C_{f_3} + P_f) + (1 - x)z(\alpha C_f + C_{f_3} + P_f) + z\alpha C_f'], \tag{7}$$

$$F_m(z) = \frac{dz}{dt} = z(1 - z) [R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + \alpha(R_m + C_m) + xP_m - y\alpha(R_m + C_m)]. \tag{8}$$

TABLE 3: The income matrix under the mass media's choice of exaggerated and inaccurate reporting strategies (1 - z).

Government	Food company	
	True disclosure (y)	False disclosure (1 - y)
Supervision (x)	$(\alpha R_g - C_{g1} - \alpha C_g' + P_m; R_{f0} - C_{f1} - \alpha C_f'; R_{m2} - C_{m2} - P_m)$	$(\alpha R_g - C_{g1} + P_f + P_m; R_{f0} - C_{f2} - \alpha C_f - C_{f3} - P_f; R_{m2} - C_{m2} + \alpha C_m - P_m)$
Not regulated (1 - x)	$(-\alpha C_g'; R_{f0} - C_{f1} - \alpha C_f'; R_{m2} - C_{m2})$	$(-\alpha C_g'; R_{f0} - C_{f2}; R_{m2} - C_{m2} - \alpha C_m)$

### 3. Evolutionary Game Analysis

3.1. *Analysis of the Evolution Stability of Government Strategy.* According to the stability theorem of the differential equation, when the government selects a strategy that satisfies  $F_g(x) = 0$ , and its first derivative is less than 0

$$F'_m(x) = (1 - 2x) [\alpha R_g + \alpha C_g - C_{g1} + P_f + P_m - y(P_f + \alpha C_g) - z(P_f - yP_f + P_m)]. \quad (9)$$

Based on different value ranges, we will analyze the stability of government supervision strategies.

To facilitate analysis, assume  $z_0 = (\alpha R_g + \alpha C_g - C_{g1} + P_f + P_m - y(P_f + \alpha C_g)) / (P_f + P_m - yP_f)$ .

- (1) When  $z = z_0$ ,  $\forall x \in [0, 1]$ , there is  $F_g(x) = 0$ , that is, any proportions of behavioral strategies in the government group are stable strategies. At this time, the government's choice of the supervision strategy will not change over time.
- (2) When  $z \neq z_0$ , then  $x = 0$  and  $x = 1$  are two possible evolutionary stable equilibrium points.

If  $z_0 < 0$ , then  $\alpha R_g - C_{g1} + (1 - y)P_f + P_m < -\alpha C_g + y\alpha C_g$ , there are always  $z > z_0$ ,  $F'_g(0) < 0$ , and  $F'_g(1) > 0$ , and  $x = 0$  is an evolutionary stable strategy by copying the stability theorem of the dynamic equation, that is, when the net income of the government choosing supervision is lower than the net income of nonregulation, the bounded rational government supervision department will choose not to supervise the strategy.

If  $z_0 > 1$ , then  $\alpha R_g + \alpha C_g - C_{g1} + P_f + P_m - y(P_f + \alpha C_g) > P_f + P_m - yP_f$ , that is,  $\alpha R_g + \alpha C_g - C_{g1} - y\alpha C_g > 0$ , and there will always be  $z < z_0$ . Since  $F'_g(0) > 0$ ,  $F'_g(1) < 0$ , and  $x = 1$  are an evolutionary stable strategy, at this time, the net income of serious supervision by the government is greater than the net income of nonregulation, and the government's penalties for problematic food companies and the mass media for exaggerated and false reports are not considered. When the net income is still greater than the unregulated net income, bounded rational government regulatory agencies will choose a regulatory strategy.

( $F'_g(x) < 0$ ), the strategy is an evolutionary stable strategy of the government.

To the government's replicated dynamic equation (6), the first derivative with respect to  $x$  is

When  $0 < z_0 < 1$ , there are two situations. First, when it is  $0 < z_0 < z < 1$ , after long-term evolution, the government tends to adopt a nonregulatory strategy. Second, as the reputation of government supervision increases, the cost of supervision decreases, the penalties for the mass media for falsely disclosing food companies and exaggerated and inaccurate reports increase, and the negative impact of nonregulation of food safety issues on government credibility increases. Then, it will be  $0 < z < z_0 < 1$  situations when the government group strategy changes from nonregulation to regulation.

It can be seen that the choice of government supervision strategy is not only affected by the strategy of food companies and mass media, but also by the reputation gained by government supervision, reputation loss after nonregulation of food safety issues, and supervision costs, and the risk of false disclosure of food companies and exaggerated and false reports are influenced by factors such as the punishment of the mass media. It is worth noting that the application of big data has increased the degree of attention to food safety incidents, which in turn affected the government's strategic choices for food safety information disclosure and promoted the transformation of the government to a service-oriented government.

3.2. *Analysis of the Evolution Stability of Food Companies.* In the same way, to the food companies' replicated dynamic equation (7), the first derivative with respect to  $y$  is

$$F'_f(y) = (1 - 2y) [C_{f2} - C_{f1} + \alpha C'_f + x(\alpha C_f + C_{f3} + P_f) + (1 - x)z(\alpha C_f + C_{f3} + P_f) + z\alpha C'_f]. \quad (10)$$

Based on different range values, the evolutionary stability analysis of the recycling processor strategy is now performed.

Assuming

$x_0 = (C_{f2} - C_{f1} + \alpha C'_f - z(\alpha C_f + C_{f3} + P_f) + z\alpha C'_f) / (\alpha C_f + C_{f3} + P_f - z(\alpha C_f + C_{f3} + P_f))$  and guarantee the existence of  $x_0$ .

- (1) At  $x = x_0$ ,  $\forall y \in [0, 1]$ , there are  $F_f(y) = 0$ , that is, the behavioral strategies of any proportion of the food company group are stable strategies. In this

case, the food safety information disclosure strategy selection of the food company will not change over time.

- (2) When  $x \neq x_0$ , then  $y = 0$  and  $y = 1$  are two possible evolutionary stable equilibrium points.

If  $x_0 < 0$ ,  $C_{f1} - C_{f2} + \alpha C'_f - z\alpha C'_f < z(\alpha C_f + C_{f3} + P_f)$ , always have  $x > x_0$ . Because of  $F'_f(0) > 0$  and  $F'_f(1) < 0$ , at this time,  $y = 1$  is an evolutionary stable strategy. When the sum of the cost saved by the false disclosure of food



companies and the reputation risk cost of high-quality food companies due to media exaggerated and inaccurate reports is lower than the risk of exposure due to false disclosure of food information and due to the production of low-quality food, food companies will choose to increase production quality and then choose the true disclosure of food safety information. Through the above formula, it is not difficult to find that whether the mass media choosing accurate and realistic reports has an important influence on the strategic choices of food companies and the application of big data technology in news reports deepens this influence.

If  $x_0 > 1$ , then  $C_{f_1} - C_{f_2} + \alpha C_{f_1}' - z\alpha C_{f_1}' > z(\alpha C_{f_1} + C_{f_3} + P_f)$  and  $C_{f_1} - C_{f_2} + \alpha C_{f_1}' - z\alpha C_{f_1}' > \alpha C_{f_1} + C_{f_3} + P_f$ , there is always  $x < x_0$ . Because  $F_f'(0) < 0$  and  $F_f'(1) > 0$ , so  $y = 0$  are evolutionary stable strategies. That is to say, the cost saved by the false disclosure of information by food companies is greater than the loss caused by the exposure of false disclosure of food information due to the production low quality, so food companies will choose false disclosure strategies.

If  $0 < x_0 < 1$ , it can be divided into two situations. First, when  $0 < x < x_0 < 1$ , after a long period of evolution, food companies tend to adopt false disclosure strategies; second, with the reduction in cost savings of food companies' false disclosure of food safety information, the reduction in the loss of reputation caused by the mass media's exaggerated and inaccurate reports on food companies that truly disclose food companies, and the increase in the loss of companies'

false disclosures, the probability of food companies choosing true disclosure strategies increases. When  $0 < x < x_0 < 1$ , the behavioral strategy of food companies will shift from false disclosure to true disclosure, thereby promoting the healthy development of the food safety market.

Therefore, the strategic choices of food companies are not only affected by government and mass media strategies, but also by the cost savings of falsely disclosing food safety information, the reputation loss caused by exaggerated and inaccurate reports to true disclosure companies, and the impact of false disclosure of food safety information on production due to poor quality production. Through the above analysis, it can be found that the choice of mass media reporting strategies has an important impact on the choice of food companies' strategies, and the duality of the application of big data to the supervision of corporate food safety information disclosure can also be verified in the above discussion; that is, it has increased accurate and effective reporting which affects the reputation of those falsely disclosing companies and expands the negative impact of exaggerated and false reports on those companies that truly disclose.

**3.3. Analysis of the Evolution Stability of Mass Media.** In the same way, to the mass media' replicated dynamic equation (8), the first derivative with respect to  $z$  is

$$F_m'(z) = (1 - 2z)[R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + \alpha(R_m + C_m) + xP_m - y\alpha(R_m + C_m)]. \quad (11)$$

Now, according to different value ranges, the stability analysis of the mass media evolution strategy is carried out.

Assume  $y_0 = (R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + \alpha(R_m + C_m) + xP_m) / (\alpha(R_m + C_m))$ .

- (1) When  $y = y_0, \forall z \in [0, 1]$ , there are  $F_m(z) = 0$ , that is, any proportions of behavioral strategies in the mass media group are stable strategies. At this time, the strategic choice of the mass media will not change over time.
- (2) When  $y \neq y_0$ , then  $z = 0$  and  $z = 1$  are two possible evolutionary stable equilibrium points.

If  $y_0 < 0$ , then  $R_{m_1} - C_{m_1} + \alpha R_m < R_{m_2} - C_{m_2} - \alpha C_m - xP_m$ , there is always  $y > y_0$ . Because of  $F_m'(0) < 0$  and  $F_m'(1) > 0$ , at this time,  $z = 0$  is an evolutionary stable strategy. When the mass media accurately and effectively reports that the net income of companies that falsely disclose food safety information is lower than the net income of exaggerated and misrepresented food safety information

companies, the mass media groups will choose the strategy of exaggerated and misreported reports.

If  $y_0 > 1$ , then  $R_{m_1} - C_{m_1} + \alpha R_m > R_{m_2} - C_{m_2} - \alpha C_m - xP_m$  and  $R_{m_1} - C_{m_1} > R_{m_2} - C_{m_2} - xP_m$ , there is always  $y < y_0$ . At this time,  $F_m'(0) > 0$  and  $F_m'(1) < 0$ , so  $z = 1$  are evolutionary stable strategies. That is to say, when the net income of the mass media from accurately and realistically reporting food safety information is higher than the net income from exaggerating and inaccurate reporting of food safety information, the mass media groups will choose accurate and practical reporting strategies.

If  $0 < y_0 < 1$ , it can be divided into two situations. First, when  $0 < y_0 < y < 1$ , after long-term evolution, the mass media tends to exaggerate and misrepresent reporting strategies; second, with the increase in the net income of the mass media's accurate and effective reporting, the decrease in the net income of exaggerated and inaccurate reporting, the increase in reputation gains/losses due to accurate/exaggerated and false reporting, the increase in government supervision, and the mass media's choice of exaggeration, the probability of misreporting

strategies is reduced; when  $0 < y < y_0 < 1$ , the behavioral strategies of the mass media will change from exaggerated and inaccurate reports to realistic and accurate reports.

The choice of the mass media strategy is not only affected by government strategies and food business strategies, but also by factors such as the cost/benefit of accurate and realistic/exaggerated false reports, the profit/cost of accurate and realistic/exaggerated false reports, and government penalties. The positive effect of big data application in regulating the behavior of mass media is reflected in the above analysis, that is, it not only increases the reputation

benefits of accurate and realistic reporting of enterprises, but also increases the reputation cost of exaggerated and false reports by mass media. The application of big data can improve the social responsibility of the mass media and regulate the development of the industry.

### 3.4. Stability Analysis of System Evolution Strategy.

Combining equations (6)–(8) together, the three-dimensional copying power system of the government, food companies, and mass media can be obtained as

$$\begin{cases} F_g(x) = x(1-x)[\alpha R_g + \alpha C_g - C_{g1} + P_f + P_m - y(P_f + \alpha C_g) - z(P_f - yP_f + P_m)], \\ F_f(y) = y(1-y)[C_{f2} - C_{f1} - \alpha C_f' + x(\alpha C_f + C_{f3} + P_f) + (1-x)z(\alpha C_f + C_{f3} + P_f) + z\alpha C_f'], \\ F_m(z) = z(1-z)[R_{m1} - R_{m2} + C_{m2} - C_{m1} + \alpha(R_m + C_m) + xP_m - y\alpha(R_m + C_m)]. \end{cases} \quad (12)$$

Let in formula (12),  $F_g(x) = F_f(y) = F_m(z) = 0$ , and it is easy to get 8 pure strategy partial equilibrium points  $E_1(0, 0, 0)$ ,  $E_2(1, 0, 0)$ ,  $E_3(0, 1, 0)$ ,  $E_4(0, 0, 1)$ ,  $E_5(1, 1, 0)$ ,  $E_6(1, 0, 1)$ ,  $E_7(0, 1, 1)$ , and  $E_8(1, 1, 1)$  and 1 mixed strategy stable equilibrium point  $E_9 = (x^*, y^*, z^*)$ . For  $E_9 = (x^*, y^*, z^*)$ , it is established true if and only if  $0 \leq x^*, y^*, z^* \leq 1$ , among them:

$$\begin{cases} x^* = \frac{C_{f1} - C_{f2} + \alpha C_f' - z^*(\alpha C_f + C_{f3} + P_f) - z^* \alpha C_f'}{\alpha C_f + C_{f3} + P_f - z^*(\alpha C_f + C_{f3} + P_f)}, \\ y^* = \frac{R_{m1} - C_{m2} + C_{m2} - C_{m1} + \alpha(R_m + C_m) + x^* P_m}{\alpha(R_m + C_m)}, \\ z^* = \frac{\alpha R_g + \alpha C_g - C_{g1} + P_f + P_m - y^*(P_f + \alpha C_g)}{P_f + P_m - y^* P_f}. \end{cases} \quad (13)$$

According to research by Ritzberger and Weibull [20], three-party evolutionary game analysis only needs to analyze the stability of the above eight equilibrium points. Following Friedman's method, the Jacobian matrix is used to perform local stability analysis on 8 stable points to obtain the evolutionary stability strategy, and the Jacobian matrix of the system is

$$J = \begin{bmatrix} \frac{\partial F_g(x)}{\partial x} & \frac{\partial F_g(x)}{\partial y} & \frac{\partial F_g(x)}{\partial z} \\ \frac{\partial F_f(y)}{\partial x} & \frac{\partial F_f(y)}{\partial y} & \frac{\partial F_f(y)}{\partial z} \\ \frac{\partial F_m(z)}{\partial x} & \frac{\partial F_m(z)}{\partial y} & \frac{\partial F_m(z)}{\partial z} \end{bmatrix} = \begin{bmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ J_{31} & J_{32} & J_{33} \end{bmatrix}. \quad (14)$$

Substituting the eight equilibrium points into the Jacobian matrix (14), the eigenvalues of the Jacobian matrix corresponding to the equilibrium points can be obtained as shown in Table 4.

According to the judgment method of the evolutionary stable strategy, when the Jacobian matrix eigenvalues of a certain equilibrium point are all nonpositive, the strategy is an evolutionary stable strategy.

According to Hypothesis 2, there is a difference between the cost of truly disclosing food safety information and false disclosure of food safety information by food companies, that is,  $C_{f1} > C_{f2}$ , so  $-(C_{f2} - C_{f1} - \alpha C_f') > 0$ ; therefore,  $E_3(0, 1, 0)$  cannot be an evolutionary strategy. According to the different levels of perfection of the food safety information disclosure mechanism in the market, this paper divides it into two different development stages: development stage  $E_2(1, 0, 0)$  and mature stage  $E_8(1, 1, 1)$ . The following two stages will analyze the levels separately.

In the development stage, it must be satisfied that  $\lambda_1^{E_2}, \lambda_2^{E_2}$ , and  $\lambda_3^{E_2}$  are all nonpositive, which is satisfied  $\alpha R_g - C_{g1} + P_f + P_m > \alpha C_g$ ,  $C_{f2} + \alpha C_f + C_{f3} + P_f < C_{f1} + \alpha C_f'$ , and  $R_{m1} - C_{m1} + \alpha R_m < R_{m2} - C_{m2} - \alpha C_m - P_m$ . At this time, the total benefits of government supervision of falsely disclosing companies and cracking down on the mass media of exaggerated and inaccurate reports are greater than the total benefits of nonregulation of food safety issues; the sum of the cost of food companies' false food safety disclosure and the food companies' losses after exposure is lower than the sum of the company's true disclosure of food safety information costs, and the sum of the reputation losses caused by media is exaggerated and misrepresented reports; in addition, in the face of problem companies, the total revenue of accurate and realistic reports by the mass media is less than the total revenue of exaggerated and false reports. Therefore, as the leader of the food safety information disclosure mechanism, the government will actively supervise the food safety market. However, based on the principle of maximizing their own interests, food companies and mass media groups, respectively, choose to falsely

TABLE 4: Jacobian matrix eigenvalues.

Equilibrium point	Eigenvalues $\lambda_1$	Eigenvalues $\lambda_2$	Eigenvalues $\lambda_3$
$E_1(0, 0, 0)$	$\alpha R_g + \alpha C_g - C_{g_1} + P_f + P_m$	$C_{f_2} - C_{f_1} - \alpha C'_f$	$R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + \alpha(R_m + C_m)$
$E_2(1, 0, 0)$	$-(\alpha R_g + \alpha C_g - C_{g_1} + P_f + P_m)$	$C_{f_2} - C_{f_1} - \alpha(C_f - C'_f) + C_{f_3} + P_f$	$R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + \alpha(R_m + C_m) + P_m$
$E_3(0, 1, 0)$	$\alpha R_g - C_{g_1} + P_m$	$-(C_{f_2} - C_{f_1} - \alpha C'_f)$	$R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1}$
$E_4(0, 0, 1)$	$\alpha R_g + \alpha C_g - C_{g_1}$	$C_{f_2} - C_{f_1} + \alpha C'_f + C_{f_3} + P_f$	$-[R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + \alpha(R_m + C_m)]$
$E_5(1, 1, 0)$	$-(\alpha R_g - C_{g_1} + P_m)$	$-(C_{f_2} - C_{f_1} - \alpha C'_f + \alpha C'_f + C_{f_3} + P_f)$	$R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + P_m$
$E_6(1, 0, 1)$	$-(\alpha R_g - \alpha C_g - C_{g_1})$	$C_{f_2} - C_{f_1} + \alpha C'_f + C_{f_3} + P_f$	$-[R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + \alpha(R_m + C_m) + P_m]$
$E_7(0, 1, 1)$	$\alpha R_g - C_{g_1}$	$-(C_{f_2} - C_{f_1} + \alpha C'_f + C_{f_3} + P_f)$	$-(R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1})$
$E_8(1, 1, 1)$	$-(\alpha R_g - C_{g_1})$	$-(C_{f_2} - C_{f_1} + \alpha C'_f + C_{f_3} + P_f)$	$-(R_{m_1} - R_{m_2} + C_{m_2} - C_{m_1} + P_m)$

disclose food safety information and exaggerate and misrepresent food safety issues.

In addition, it can be seen from the above analysis that the application of big data has different effects on different subjects. For the government, big data plays a positive role in promoting the government’s fulfillment of its regulatory responsibilities; for food companies, the application of big data has two sides. It will not only increase the supervision of problem companies, but also increase the degree of harm to “injure” companies. For the mass media, big data has a positive effect on improving the accuracy and authenticity of reports.

With the enhancement of government supervision, the proportion of food companies choosing to truly disclose food information continues to increase, and mass media groups are gradually increasing the proportion of accurate and practical reports under government regulations. The food safety information disclosure mechanism continues to improve to a mature stage  $E_8(1, 1, 1)$ , satisfying  $\alpha R_g > C_{g_1}$ ,  $C_{f_2} + \alpha C_f + C_{f_3} + P_f > C_{f_1}$ , and  $R_{m_1} - C_{m_1} > R_{m_2} - C_{m_2} - P_m$ . That is, when the reputation benefits obtained by government supervision are higher than the cost of government supervision, the sum of the cost of food companies’ false disclosure of food safety information and the loss after being exposed by the media is higher than the cost of companies’ true disclosure of safety information; and in the face of truly disclosed food companies, when the net income of the mass media’s true reports is higher than the net income of false reports, the government will play its leading role in food safety information disclosure and choose to supervise the food market. Food companies will choose to improve food quality based on their own interests and then truly disclose food safety information. The mass media will play their complementary role in food safety disclosure and choose accurate and practical reporting strategies. It is worth noting that in the mature stage of the food safety information disclosure mechanism, the negative impact of the application of big data on food companies disappears. Through the analysis of the two stages, it can be seen that the choice of the mass media reporting strategy mainly depends on the level of net income of different strategies. This conclusion can be fully proved by the comparative analysis of  $E_5(1, 1, 0)$  and  $E_8(1, 1, 1)$ . Therefore, in order to give full play to the role of the mass media as a “watchkeeper,” it is necessary to increase the net income of accurate and realistic reports by the mass media and at the same time reduce the

net income of exaggerated and inaccurate reports through government regulations and guidance measures.

#### 4. Conclusions and Recommendations

The above research shows that mass media plays an important role in the disclosure of food safety information and influences the strategic choice of government regulators and food enterprises. Both in line with their own interests, maximization principle, and mass media social responsibility, positive real information disclosure will be beneficial to food safety supervision and management. To participate in the game of government regulators, food companies and media have a positive development; on the other hand, false information disclosure can make the three parties lose the trust of the audience and have loss of economic benefits and their reputation. Therefore, starting from the Chinese nation, the government should strengthen the supervision of the mass media to avoid false information; food enterprises should actively cooperate with the mass media to improve the strength and scope of information disclosure; the mass media itself should strengthen media literacy where true information shall be disclosed to put an end to false information. Although disparate countries will affect the government’s regulatory actions and efforts due to their different political systems, the participation of big data in media communication will enhance the effectiveness of the mass media’s participation in food safety information disclosure. In this case, both positive and negative effects will be amplified. Therefore, rationally and maximally playing the positive role of big data in mass media can double the value of mass media in food safety information disclosure, bringing maximum benefits to the three parties in the game and also ensuring food safety to the maximum extent.

First: using big data to segment the audience to achieve accurate communication. Accurate communication requires mass media to carefully divide audiences into different groups according to their psychological characteristics, interest preferences, and psychological preferences and output different communication contents for different groups. The segmentation of audience needs to rely on big data for user research, such as searching and browsing traces of Internet users or viewing data on video platforms. In the process of food safety information disclosure, the accurate push of different disclosure content according to different user needs can increase the public’s interest in reading and improve the

reading rate of the disclosed contents, and at the same time, different push times can be set for different audiences. All these measures can improve the efficiency of food safety information disclosure.

Second: choosing the media reasonably. In the era of big data, the media preference of the audiences can be accurately calculated, and mass media that are closer to their reading preferences can be adopted. In addition, the concept of Omnimedia is widely used in the selection of media. Omnimedia can be regarded as a new mode of media operation. It integrates content production and form and is a comprehensive application of traditional media and new media. Any two or more media can freely convert to each other. In the food safety information disclosure, the disclosure can use their data analysis system for food safety information as well as collecting and monitoring public preferences, choosing the reasonable mass media in the production process to push, and later in the use of the Internet platform to accept their reading feedback and use the feedback to adjust disclosure content.

Third: optimizing the communication content. On the premise of audience segmentation, the subject of food safety information disclosure needs to customize differentiated communication content and produce accurate communication content for different audiences. In the process of content production, attention should also be paid to content processing to make the disclosed content more effective and more in line with the audience's aesthetic taste under the guidance of big data. In terms of content expression, it should be designed according to the ideological consciousness, cultural leveling, and cognitive ability of different audiences, so that the disclosure of food safety information can improve the communication efficiency and encourage more people to accept it.

Despite theoretical and managerial contributions of this study, there are still limitations.

In different countries, due to political, historical, cultural, and other factors, the unity of opposition between government supervision, mass media communication, and factory disclosure is complicated and cannot be generalized. In this article, we only adopt a method suitable for China's national conditions to establish an analysis of the model. However, this does not mean that our topic does not have universal value. These elements can still be harmonized with each other to achieve a beneficial state for the proposition of food safety. Therefore, this article can be expanded from the following directions in the future: (1) based on the differences in social environment, studying the role of media in food safety information disclosure in the era of big data under different social environment backgrounds, conducting comparative analysis, proposing strategies more suitable for the development of China, and improving the food safety supervision system and strengthening food safety management. (2) Studying this issue based on the perspective of the global supply chain, enhancing the international influence of Chinese media, and at the same time enhancing the international competitiveness of food companies, and providing the world with effective Chinese solutions.

## Data Availability

No data were used to support this study.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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