Information Dissemination and Control of NIMBY Projects under Stigmatization

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NIMBY (Not in My Backyard) projects are easily stigmatized due to their environmental risk. Stigmatization enlarges residents’ risk perception, urges residents to spread information, and takes actions to resist project implementation, causing environmental mass emergency. Taking paraxylene (PX) project as an example, information dissemination model of NIMBY project under stigmatization based on SEIR model in small world network was established, and the information dissemination process and characteristics of NIMBY project under stigmatization were simulated and analysed. The results show that (1) the public risk perception deviation caused by stigmatization promotes residents to disseminate information; (2) stigmatization has a greater impact on the information dissemination of NIMBY project with low environmental risk; (3) stigmatization accelerates the speed of information dissemination and increases the number of residents participating in information dissemination in different dissemination environment. The contribution of this paper is that SEIR model in small world network is used to verify the role of stigmatization in promoting information dissemination of NIMBY project by comparing the information dissemination before and after stigmatization.

1. Introduction

As people’s well-being continues to improve, NIMBY (Not in My Backyard) projects are more easily being resisted in the quick process of urbanization [1]. NIMBY is frequently used as a pejorative term, while NIMBY projects are regarded as development projects that seem to serve the community needs but are dangerous, annoying, or likely to result in decreased property values [2]. These negative emotions may lead to residents’ opposition to local development of these projects, which are motivated by the potential environment risk from those NIMBY projects [3]. These NIMBY projects do meet the needs for living and economic development that benefit the city.

NIMBY was first put forward by O’Hare in 1977, which presented an attitude of resistance [4]. NIMBY projects could be divided into three categories, that is, pollution-related, risk-clustering, and psychological dismay. Pollution-related NIMBY projects include waste treatment plant, sewage treatment facilities, highway, etc., which are opposed because of their pollution. Risk-clustering projects include public facilities with high risk but low probability of occurrence, such as nuclear power plant and paraxylene project, whose high risk strengthens residents’ perceptual risk resulting in resistance. Psychological dismay projects include mental hospital, funeral parlour, crematorium, public cemetery, etc. [5]. Except psychological dismay projects, the other two NIMBY projects are resisted because of their environmental impact.

The threat of environmental risks brought by NIMBY projects urges local people to reflect on the relationship between economic development and health, well-being, and equity and strongly demand democratic participation in such environmental decision-making and administrative
procedures [6, 7]. With the dissemination of information, environmental risk will be gradually transformed into social risk, which is manifested as environmental mass emergency and leading to the failure or shelve of NIMBY projects [8, 9]. The dissemination process is influenced by many factors, including residents’ risk perception, trust in government, project site selection, population density, public education, residents’ income level, etc. [10–16]. Besides, stigmatization adds fuel to the transformation.

Stigmatization means that a person, product, or technology is given a defective or undesirable mark [17]. Communicators construct stigma through language or symbol, and stigma is strengthened and finally formed in each risk event through the spread of information flow. In the construction process of PX project, nuclear power plant, and other controversial NIMBY projects, stigmatization not only enlarges the public’s risk perception of environmental risks of such projects, but also spreads such social risks to similar projects, and similar projects are labelled [18, 19]. Take PX as an example. According to the list of carcinogens published by International Agency for Research on Cancer (IARC) in 2020, xylene belongs to category 3 carcinogens; that is, it is suspicious for human carcinogenicity, and there is no sufficient human or animal data. However, in the PX incident in Xiamen, PX was labelled as highly toxic product. Residents boycotted the project construction and environmental mass emergency was occurred. However, labels such as “highly toxic” and “carcinogenic” have become an important reason for the public to strongly oppose the construction of PX project in the future. The construction of PX project in Ningbo, Maoming, and other places is suspended or postponed, and the construction of PX project in Jiujiang has experienced twists and turns.

Under the communication advantages of information technology, it is easy to form stigma, but it is difficult to “destigmatize” and reconstruct trust [20, 21]. This paper decomposes the environmental risk structure of NIMBY projects and analyses the mechanism of stigmatization on the information dissemination of NIMBY projects. Taking PX project as an example, the SEIR model is used to simulate the impact of stigmatization on the information dissemination of NIMBY projects and proposes how to control information when considering the impact of stigmatization.

The remainder of this article is organized as follows. In Section 2, mechanism of stigmatization on the information dissemination of NIMBY projects is analysed, and the methodology is introduced. In Section 3, taking PX project as an example, main simulation results about the impact of stigmatization on the information dissemination are analysed. In Section 4, detailed discussion about impact path of stigmatization on information dissemination of NIMBY project is made. Finally, conclusions, policy recommendations, and future research directions are discussed in Section 5.

2. Materials and Methods

2.1. Information Dissemination of NIMBY Project under Stigmatization. The social amplification of risk framework (SARF) is dedicated to answering the question “Why are projects with low risk assessed by experts cause widespread public concern and seriously affect social and economic development?” In SARF, stigmatization is considered as one of the four main reaction mechanisms in the process of social amplification of risk, and the ripple effect caused by stigmatization will have greater social impact [22]. This paper focuses on the impact of stigmatization on the information dissemination in the ripple reaction caused by stigmatization.

Environmental risk of NIMBY project is the basis of information dissemination. Due to its technical and engineering properties, NIMBY projects will produce risks that will not be transferred by will [23]. This kind of risk is the actual tangible and quantifiable hazard [24], which is embodied in the environmental risks such as safety threat, health hazard, environmental pollution, and ecological damage of the project [25–27]. This means that residents do have the probability of getting physical injury. In the risk society, this probability is perceived by residents and magnified sharply and urges residents to spread related information to share their concerns about NIMBY project [28].

Public risk perception distorts the environmental risk of NIMBY projects. Risk includes not only the actual tangible environmental risk, but also the perceived risk constructed by public cognition. There is no significant consistency between the environmental risk of NIMBY project and public risk perception [29]. Risk perception is the public subjective judgment of risk and the basis for the formation of public attitude. It will arouse emotions such as anger, disgust, fear, and opposition and resistance [30, 31]. The public risk perception is easily influenced by the surrounding environment [32]. Site selection of NIMBY project is not only to select the site that can meet the requirements of project construction and operation, but also to choose the group to sense the environmental risk of NIMBY project. Firstly, insufficient professional knowledge, different interest demands, and asymmetric information will cause public panic about NIMBY projects [33–35]. Secondly, the spatial relationship between NIMBY project and the public will affect the public risk perception, and its influence scope and facility distance will stimulate public opposition [36–38]. In the construction of specific projects, rural and urban fringe residents bear more environmental risks than urban residents [39]. In the absence of government, media, and other external interventions, this paper divides public risk perception into humanistic risk perception and spatial relationship perception. Humanistic risk is related to the group characteristics of residents in the construction site of NIMBY project but remains stable during information dissemination, such as the cultural level and affluence degree of residents in the construction site, which is the representation of residents’ acceptance of professional knowledge and interest demands.

Diffusion of individual perceived risk in groups forms social risk. According to the risk constructivism, the risk generated by the risk source is perceived by different individuals through various media. The individual’s risk perception is reflected in the psychological level such as fear.
and the cultural level such as socioeconomic background. After the individual receives the risk event information, the individual risk perception will form dissatisfaction. This negative emotion and attitude urge the individual to spread the risk perception in a larger group and hope to be recognized, thus forming the risk perception of the public group. The public’s risk perception is reflected in the psychological level such as social panic and the cultural level such as “stigmatization.” The common emotion or common cognition of the public plays a key role in the individual participation in mass incidents. When the public perceives that the risk far exceeds the risk return, the perceived risk will form and eventually lead to environmental group events. When the group where the individual is in reaches a certain common feeling, even the indirect stakeholders will also participate in the group event, which is the formation of social risk [40, 41].

Stigmatization strengthens public risk perception on NIMBY projects. Stigmatization includes five interrelated components: labelling, stereotype, cognitive separation, emotional response, and status loss or discrimination [42]. Taking the stigmatization of PX project as an example, derogatory language or symbols, such as “highly toxic” and “carcinogenic,” leave a negative impression on the public through the dissemination of information, which makes the public cognition of PX project deviate from the reality, arousing public disgust, hatred, and other negative emotions. Many times of information dissemination spread this risk perception to a larger social group, deepening the negative impression of public on PX project, which is discriminated against.

The effect of stigmatization on information dissemination on NIMBY project is reflected in two aspects. On the one hand, stigmatization consciously magnifies the defects or frightening attributes of NIMBY projects. For example, PX is stigmatized as highly toxic products; nuclear power project is stigmatized as “high radiation source” and “carcinogenic source.” On the other hand, stigmatization enhances the public risk perception of NIMBY projects and strengthens public fear, disgust, and anger. These emotions stimulate public resistance to NIMBY projects, and the attitude stimulates the audience to spread information again. Social risks spread with the spread of information [43, 44]. The impact path of stigmatization on information dissemination of NIMBY project is shown in Figure 1.

2.2. Model of Information Dissemination of NIMBY Project under Stigmatization

2.2.1. Applicability of Small World Network. Since Watts and Strogatz studied the average path length and agglomeration coefficient of nematode neural network, power grid in western America, and cooperation network among film actors, they found that those networks had the characteristics of small average path length and large agglomeration coefficient and formally proposed the small world network [45]. After long-term development, small world network has been proved to be effective in quantitatively studying the related problems of real complex socioeconomic systems. Many scholars study real interpersonal networks and social networks based on complex networks and found that their topology has the characteristics of small world network [46]. Jun studied the viability of conditional cooperation in a dynamically evolving social network, which possesses the small world property [47]. Zhu studied the influence of human heterogeneity to information dissemination on social networks using small world network [48]. Information of NIMBY project is disseminated on a complex network of multisubject interaction based on real interpersonal network and social network, so small world network is used to study its dissemination process.

The construction algorithm of WS small world network starts with a ring-shaped nearest neighbor coupling network, which contains \( N \) nodes. Each node is connected with its \( K/2 \) adjacent nodes on the left and right sides, and the edges in the network are randomly reconnected with probability \( p \); that is, one endpoint of the edge is kept unchanged, and the other endpoint is renewed to randomly select any node in the network. In this process, it is necessary to ensure that there can only be one edge between any two nodes, and each node has no edge connected to itself. In this way, \( pNK/2 \) edges will be formed to connect a node with a distant node. When \( p = 0 \), the network becomes a completely regular network; when \( p = 1 \), the network becomes a completely random network. With the in-depth study of small world network, Newman and Watts improved the WS small world network by changing the random reconnection into random edge addition; that is, edges are added between a pair of randomly selected nodes in the network with probability \( p \), which also needs to meet the condition that there can only be one edge between any two nodes and each node has no edge connection with itself. This is the NW small world network [49]. Different from regular networks and random networks, small world networks have higher agglomeration coefficient and shorter average distance.

2.2.2. Characteristics of Information Dissemination Network of NIMBY Project

(1) Subjects in Information Dissemination Network of NIMBY Project. In this paper, subjects of information dissemination of NIMBY project are divided into four categories: the ignorant, the silent, the disseminator, and the uninterested. In the information dissemination system of NIMBY project, the ignorant refers to the subjects who do not contact or know the information about NIMBY projects and will not spread the information. The silent refers to those who have known the relevant information about NIMBY project but maintain a wait-and-see attitude at this stage and will not actively participate in information dissemination for the time being due to their low risk perception. The disseminator refers to those who are with high risk perception and resistance to NIMBY projects, so they actively disseminate information for interest demands. The uninterested refers to those who are not interested in NIMBY project and therefore do not participate in the information dissemination (or are immune to the information of NIMBY project).
In the process of information dissemination of NIMBY projects, the ignorant, the silent, the disseminator, and the uninterested interact and influence each other, forming the information dissemination network. The basis for the subjects to receive relevant information about NIMBY project and spread it to others is that there is a certain social connection between them. Therefore, the information dissemination network can be regarded as a directed-unweighted network, where subjects are the nodes and interpersonal relationships are the edges, as shown in Figure 2. When Subject A receives the information about NIMBY project, if he perceives that the project risk is high, negative emotions and attitudes will be produced and promote him to spread the information to Subjects B, C, D, etc. After receiving the information spread by Subject A, Subject B and C may perceive that the project risk is low or not interested in it, so they will not spread again; Subject D may be affected by the information and also perceives that the project risk is high, so negative emotions and attitudes will further promote him to disseminate the project information to subjects associated with him, that is, Subjects A, C, and E.

Specifically, there are four types of subjects: the ignorant, the silent, the disseminator, and the uninterested. The ignorant becomes the silent after learning the information about NIMBY project. Due to difference of risk perception and different concern about the project, some of the silent keep the state of silence, some become disseminators, and some become the uninterested. In the process of information dissemination, due to proper handling by government or their own reasons, some disseminators will become uninterested and will not participate in information dissemination for the time being. With the continuous updating of information about NIMBY project, the uninterested may become the ignorant who do not know the new information.

(3) Media of Information Dissemination of NIMBY Project. The communication media is the carrier of information dissemination. The media of information dissemination of NIMBY project is the relationship network between subjects, including not only traditional media and new media, such as the Internet and newspapers, but also various social relations formed in the region. Through these media, information of
NIMBY projects is spread to a wider range, which has a great impact on project construction and the local.

2.2.3. Model Hypothesis. Owing to the applicability of small world network and epidemic model, information dissemination process of NIMBY project is studied under the topology of small world network. Based on the mean field theory in statistical physics, the influence of node degree is considered in the model, and the mean degree of small world network is introduced into the model. Based on Figure 3, information dissemination rules of NIMBY projects are as follows:

1. The information dissemination scope of NIMBY project is limited to the city where the project is located, so as to ensure that the information dissemination system is a closed system.

2. In this system, there is a probability $\alpha$ for an ignorant person to obtain the information from the disseminator and become a silent person who knows the project information; that is, probability of the ignorant to know the event information is $\alpha$.

3. There is a probability $\beta$ for a silent person to become a disseminator and a probability $\epsilon$ to become an uninterested person directly, and the other silent people may remain silent. In this process, perceived risk is the main reason for the silent to choose to be a disseminator or an uninterested. This is because a silent person may not be interested in the project information and will not pay attention to it after knowing the information, so he will turn into an uninterested person; if he is interested in NIMBY project and his perceived risk is low, he will remain silent and see how the event develops; if he is interested in NIMBY project but his perceived risk is high, he will become a disseminator.

4. There is a probability $\gamma$ that a disseminator will become an uninterested person. Due to some internal or external reasons, such as proper handling by government, some of the disseminators will become satisfied and uninterested in the project.

5. There is a probability $\theta$ that an uninterested person will become an ignorant. As the events continue to ferment, there is a probability that the uninterested person will become an ignorant person of the new information.

2.2.4. Dynamic Model of Information Dissemination of NIMBY Project. Define $I(t)$, $S(t)$, $D(t)$, and $U(t)$ as the proportion of the total number of the ignorant, the silent, the disseminator, and the uninterested, respectively, at $t$ time. According to the assumption that the number of people in the system is constant, $I(t) + S(t) + D(t) + U(t) = 1$. Based on the mean field method in system dynamics, the differential equations model of conflict system is constructed as follows:

\[
\frac{dI}{dt} = -\alpha < k > ID + \theta U, \\
\frac{dS}{dt} = \alpha < k > ID - \beta S - \epsilon S, \\
\frac{dD}{dt} = \beta S - \gamma D, \\
\frac{dU}{dt} = \epsilon S + \gamma D - \theta U.
\]  

In the equation, $dI/dt$, $dS/dt$, $dD/dt$, and $dU/dt$, respectively, represent the number change rate of the ignorant, the silent, the disseminator, and the uninterested, respectively. $\alpha$, $\beta$, $\gamma$, $\epsilon$, and $\theta$ are the conversion rate of the ignorant to the silent, the silent to the disseminator, the disseminator to the uninterested, the silent to the uninterested, and the uninterested to the ignorant, respectively. $k$ represents the average size of the small world network. These coefficients satisfy the following constraints:

\[
\alpha, \beta, \gamma, \epsilon, \theta \in [0, 1]; \quad \beta + \epsilon \in [0, 1].
\]

As $I(t) + S(t) + D(t) + U(t) = 1$, (2) could be transformed into

\[
\frac{dI}{dt} = -\alpha < k > ID + \theta (1 - I - S - D), \\
\frac{dS}{dt} = \alpha < k > ID - \beta S - \epsilon S, \\
\frac{dD}{dt} = \beta S - \gamma D.
\]

2.2.5. Equilibrium Analysis and Stability Analysis. By solving the differential equations, two solutions could be got. They are $P_0(1, 0, 0, 0)$ and $P^*(I^*, S^*, D^*, U^*)$, where

\[
D^* = \frac{\theta (\alpha < k > \beta - (\beta + \epsilon)\gamma)}{\alpha < k > (\beta \beta + (\beta + \epsilon + \theta)\gamma)} = 1 - ((\beta + \epsilon)\gamma/\alpha < k > \beta) \\
S^* = \frac{\gamma D^*}{\beta}, \\
I^* = \frac{(\beta + \epsilon)\gamma}{\alpha < k > \beta}, \\
U^* = 1 - I^* - S^* - D^*.
\]

In a bounded system, $I, S, D, U \geq 0$, and $I + S + U \leq 1$, so when $D > 0$, the system has a unique nonzero-equilibrium point. Let

\[
N_0 = \frac{(\beta + \epsilon)\gamma}{\alpha < k > \beta}
\]
and when $N_0 < 1$, there are zero equilibrium and unique
nonzero equilibrium in the system; and when $N_0 > 1$, there is
only a zero equilibrium.

Solve the characteristic equation of Jacobian matrix in $P^*$
and $P_0$.

When $N_0 < 1$, the Jacobian matrix of (2) at the nonzero
equilibrium point is

$$J^* (I, S, F) = \begin{bmatrix}
-a < k > D^* - \theta & -\theta & -a < k > I^* - \theta \\
\alpha < k > D^* & -\beta - \varepsilon & \alpha < k > I^* \\
0 & \beta & -\gamma
\end{bmatrix}.$$  

(6)

Let the characteristic equation of Jacobian matrix equal 0:

$$a_0 \lambda^3 + a_1 \lambda^2 + a_2 \lambda + a_3 = 0,$$

$$a_0 = 1,$$

$$a_1 = a < k > D^* + \beta + \varepsilon + \theta + \gamma,$$

$$a_2 = (a < k > D^* + \theta) (\beta + \varepsilon + \gamma) + a < k > \theta D^*,$$

$$a_3 = a < k > \gamma D^* (\beta + \varepsilon + \theta) + a < k > \beta \theta D^*.$$

(7)

The coefficient of characteristic equation $a_0, a_1, a_2, a_3 > 0$
and $a_1a_2 - a_0a_3 > 0$. According to the Routh-Hurwitz
riterion, when $N_0 < 1$, the nonzero equilibrium point tends
to be stable, and the system is stable.

When $N_0 > 1$, the Jacobian matrix of equation (2) at the
zero-equilibrium point is

$$J_0 (I, S, F) = \begin{bmatrix}
-\theta & -\theta & -a < k > - \theta \\
0 & -\beta - \varepsilon & a < k > \\
0 & \beta & -\gamma
\end{bmatrix}.$$  

(8)

Let the characteristic equation of Jacobian matrix equal 0:

$$(\lambda + \theta) [\lambda^2 + (\beta + \varepsilon + \gamma) \lambda + (\beta + \varepsilon) - a < k > \beta^*] = 0,$$

$$a_0 \lambda^3 + a_1 \lambda^2 + a_2 \lambda + a_3 = 0,$$

$$a_0 = 1,$$

$$a_1 = \beta + \varepsilon + \theta + \gamma,$$

$$a_2 = (\beta + \varepsilon + \gamma) \theta$$

$$+ (\beta + \varepsilon) \gamma - a < k > \beta,$$

$$a_3 = (\beta + \varepsilon) \gamma - a < k > \beta \theta.$$

(9)

As $N_0 = (\beta + \varepsilon) / a < k > \beta > 1$, $a_0, a_1, a_2, a_3 > 0$, and
$a_1a_2 - a_0a_3 > 0$, the zero-equilibrium point tends to be stable
when $N_0 > 1$ according to the Routh-Hurwitz criterion, and
the system is stable.

2.2.6. Basic Reproduction Number $R_0$. Referring to the re-
search on information dissemination system by Samsuzzoha
[50], there is a basic reproduction number $R_0$ in the system,
which represents the average number of disseminators
among all the ignorants during the information dissemi-
nator. When $R_0 > 1$, the information dissemination con-
tinues and the system tends to be stable; when $R_0 \leq 1$, the
dissemination gradually dies out. $R_0$ is the threshold of
dissemination persistence in the system. In the model, $R_0$
and $N_0$ are the reciprocal relation; that is,

$$R_0 = \frac{1}{N_0}$$

$$= \frac{a < k > \beta}{(\beta + \varepsilon)\gamma}$$

$$= \frac{a < k >}{\gamma (1 + (\varepsilon / \beta))}$$  

(10)

2.2.7. Indicators of Public Risk Perception. As mentioned
above, public risk perception is the decisive factor to pro-
mote residents to spread information and is affected by
project environmental risk, residents’ humanistic charac-
teristics, and other factors.

Spatial relationship represents the distance between the
project and residents, which is an important factor in site
selection of NIMBY projects. Cong et al. found that near
the place of residence was one of the crucial factors that resulted
in site selection failure [7]. Gallo used a discrete optimisation
model and a heuristic algorithm to solve the landfill siting
problem and suggested that landfills should be located in
sparsely populated sites [51]. Sun et al. found that the closer
the distance between waste-to-energy plants and the real
estate, the stronger the negative externality of waste-to-
energy plants [52].

Humanistic risk represents the perception deviation of
residents caused by their education or wealthiness. Devine-
Wright investigated the relationship between sociodemo-
graphic characteristics and NIMBYism in new energy in-
frastructure and results showed that education had
significant effect on it [53]. Liu et al. used a questionnaire
survey to study how to improve local residents’ acceptance
towards waste-to-energy incineration facilities and found
that local residents of lower education levels and other characteristics own a lower level of acceptance [54] while Xu and Lin carried out a random survey in four metropolises in China and found persons with higher education levels or with higher income are willing to pay more to avoid the construction of waste incineration power plants in their surroundings [55].

Environmental risk is the root for residents to disseminate information about NIMBY project. Johnson examined how people respond to potential local health hazards through interview and documentary data from three anti-incinerator campaigns and believed that public health concerns remained central in the three campaigns [2]. Dai et al. believed that NIMBY effect exists in nuclear power due to its threat of releasing harmful radioactive substances and calculated the health risks using a health impact assessment methodology [56]. Cong et al. established an early warning system to determine the NIMBY of heavy pollution projects, which included public security influence, impact of production safety accidents, and different kinds of environmental pollutants [57]. He et al. concluded that chemistry has the characteristics of high environmental and safety impacts and risks and it is easily protested by residents [40]. Botetzagias believed that perceived effect (costs, risks, and benefits associated with the project) and other factors are predictors of individual’s opposition to the siting of NIMBY projects [58].

Therefore, this paper constructs an index system to quantify the risk perception level of residents in the construction site, as shown in Table 1.

On the basis of the index system, the analytic hierarchy process (AHP) is used to determine the weight of each index. The weight is expressed as $\omega = (\omega_1, \omega_2, \ldots, \omega_{10})^T$. The infection rate $\beta$ can be obtained by multiplying and summing the index weight and index layer values:

$$\beta = \sum_{i=1}^{10} A_i \omega_i, i = 1, 2, \ldots, 10,$$

(11)

where $A_i$ represents each indicator, and $\omega_i$ represents the weight of each indicator. Different $\beta$ is obtained before and after stigmatization, and the influence of stigmatization on information dissemination of NIMBY project can be obtained by introducing different $\beta$ into SEIR model for simulation.

3. Results

3.1. Case Study. Information dissemination of PX project is selected as the analysis case. This is mainly because the PX project has some characteristics:

(1) PX project products are mostly strategic goods for social and economic development. The output of PX is a symbolic index reflecting the national chemical level and the main raw material to produce clothing, textiles, plastics, and films.

(2) PX project has a large investment scale. The investment scale of PX project is huge, usually in billion yuan. For example, the total investment of Sinopec Jinling Petrochemical is 3 billion yuan, and the total investment of Fujia Dahua PX project is 9.5 billion yuan.

(3) PX project is a chemical project with certain environmental risks. PX is a flammable liquid, which has the risk of combustion and explosion. Inhalation of a large amount of high concentration xylene vapor for a long time will cause poisoning. For example, among many PX projects, there was an explosion in Gulei PX project in Zhangzhou, Fujian Province.

(4) PX project stigmatization is common. As mentioned before, xylene belongs to category 3 carcinogens. In Xiamen PX incident and Ningbo PX incident, PX was stigmatized as “highly toxic” and “carcinogenic.” Therefore, information about PX was widely spread and PX project was strongly resisted.

3.2. Public Risk Perception on PX Project. In this section, five PX projects in China were selected as case study, including Xiamen PX in 2007, Pengzhou PX in 2008, Ningbo PX in 2012, Jiujiang PX in 2013, and Maoming PX in 2014. In Ningbo PX project, it involved a large number of people, produced many kinds of rumours, and caused a wide range of influence. In Maoming PX project, government came forward to clarify the false information. In Xiamen PX project, SMS against PX project was widely spread. The boycott was not lifted until the government announced that the PX project was completely shut down. The information of these three PX projects spread rapidly, resulting in environmental mass emergencies. As a breakthrough sample of PX project, Jiujiang PX project originally spread information slowly and gently but affected by the Kunming PX project, Jiujiang residents began to spread information to resist construction of the PX project. The data of five PX projects are shown in Table 2.

Experts in the field of NIMBY research were invited to score the indicators of public risk perception on PX project, including 4 professors engaged in NIMBY research, 3 project managers of chemistry project, and 3 regulators responsible for chemistry project approval. Weight of each indicator was calculated by MATLAB. The consistency ratio of comparison matrix $CR = 0.0354 < 0.1$, which passed the test. Indicator weight is shown in Table 3.

According to the processed project data and the weight of each indicator, conversion rate $\beta$ of the silent to the disseminator in the five PX projects was calculated, as shown in Table 4.

According to the data in the table, the conversion rate of Ningbo PX was the largest among the five projects, followed by Maoming PX event and Xiamen PX event, and the conversion rate of Jiujiang PX was the lowest. The calculation results were in good agreement with the fact.

3.3. Impact of Stigmatization on Information Dissemination of PX Project. In order to compare the information dissemination of NIMBY projects before and after stigmatization, other variables unrelated to stigmatization should remain unchanged.
to investigate the effect of stigmatization on NIMBY projects. First, one kind of NIMBY projects was selected, that is, PX project, to make sure that the effect of stigmatization on the selected projects is the same. Besides, weights of indicators were kept unchanged along with the value of indicators not affected by stigmatization, such as education degree, income level, project investment, etc. And only the value of health hazards of PX project was increased from 0.5 to 1 according to the reports that PX was stigmatized as “highly toxic substance.” Based on those analyses, the conversion rate $\beta$ after stigmatization is calculated as shown in Table 5.

It can be seen from the data in Table 5 that stigmatization significantly increased the conversion rate $\beta$ of the silent to the disseminator. In contrast, stigmatization had a greater impact on projects with low environmental risk. For example, the conversion rate of Jiujiang PX project increased by nearly 30%, and the projects that could have been carried out smoothly also experienced twists and turns. In the absence of stigmatization, NIMBY projects with high environmental risk are easily resisted by residents. NIMBY projects with low environmental risk are easy to stigmatize, which is also one of the answers to the question “why do the

### Table 1: Indicators of public risk perception.

<table>
<thead>
<tr>
<th>Target layer</th>
<th>Criterion layer</th>
<th>Index layer</th>
<th>Description</th>
<th>Main reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanistic risk</td>
<td>Construction site $A_1$</td>
<td>Geographical distance between the project construction site and the center of residential area</td>
<td>Cong et al. [8]; Gallo [51]; Sun et al. [52]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Population density $A_2$</td>
<td>The ratio of population per unit area to national average population density</td>
<td>Devine-Wright [53]; Liu et al. [54]; Xu and Lin [55]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Education degree $A_3$</td>
<td>The ratio of proportion of local education funds in financial expenditure to its national level</td>
<td></td>
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<tr>
<td></td>
<td>Income level $A_4$</td>
<td>Ratio of local per capita disposable income to national per capita disposable income</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project investment $A_5$</td>
<td>Total investment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual output $A_6$</td>
<td>The number of products or services per year after the completion of the project</td>
<td></td>
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<tr>
<td></td>
<td>Health hazards $A_7$</td>
<td>According to NFPA 704 identification standard, the health hazards caused by NIMBY project are divided into 0–4 levels; level 4 is the degree of health hazards</td>
<td>Johnson [2]; Dai et al. [56]; Cong et al. [57]; He et al. [40]; Botetzagias et al. [58]</td>
<td></td>
</tr>
<tr>
<td>Environmental risk</td>
<td>Security threats $A_8$</td>
<td>Association (NFPA) 704 identification standard, the flammability and reactivity of the project materials or products are divided into 0–4 grades</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental pollution $A_9$</td>
<td>The pollutants are determined according to the specific project type, and the environmental pollution of the project is divided into four levels according to the relevant national standards. Based on Daily’s research [57], the degree of ecological damage can be divided into four levels. Grades 1–4 represent 3–10 years, 10–20 years, 20–50 years, and more than 50 years of ecological restoration time</td>
<td></td>
<td></td>
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<tr>
<td>Ecological damage $A_{10}$</td>
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</tbody>
</table>

### Table 2: Relevant data of five PX projects.

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial relationship</td>
<td>Construction site $A_1$</td>
<td>1</td>
<td>0.67</td>
<td>0.67</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Population density $A_2$</td>
<td>4.413</td>
<td>4.055</td>
<td>6.541</td>
<td>1.795</td>
</tr>
<tr>
<td>Humanistic risk</td>
<td>Education degree $A_3$</td>
<td>0.951</td>
<td>0.589</td>
<td>0.354</td>
<td>1.220</td>
</tr>
<tr>
<td></td>
<td>Income level $A_4$</td>
<td>1.56</td>
<td>1.098</td>
<td>1.543</td>
<td>0.835</td>
</tr>
<tr>
<td>Environmental risk</td>
<td>Project investment $A_5$</td>
<td>108</td>
<td>400</td>
<td>558.73</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Annual output $A_6$</td>
<td>80</td>
<td>65</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Security threats $A_7$</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Environmental pollution $A_9$</td>
<td>0.375</td>
<td>0.375</td>
<td>0.375</td>
<td>0.375</td>
</tr>
<tr>
<td></td>
<td>Ecological damage $A_{10}$</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Data source: the author calculated according to the statistical yearbook data; part of the data is collected from the Internet.
projects with low risks assessed by experts attract public attention and seriously affect social and economic development?” in SARF.

3.4. Simulation on Information Dissemination Process of PX Project under Stigmatization. Firstly, a WS small world network with a certain number of nodes and an average degree of $k$ was established using MATLAB. The number of nodes indicates the number of subjects in the information dissemination network, and the average degree indicates that each subject in the dissemination network has a direct connection with $k$ individuals on average. The types of nodes in dissemination networks are divided into four categories: the ignorant $I$, the silent $S$, the disseminator $D$, and the uninterested $U$. The small world network with different $k$ values is shown in Figure 5.

Then, based on SEIR model, information dissemination process of PX project was simulated. People who know and spread information are the core of information dissemination system, so the conversion rate from the silent to the disseminator was mainly studied. The information of PX project is widely spread when the incident occurs, and the probability for residents knowing the information is high. In the meanwhile, the construction of PX project is closely related to the interests of residents, so the probability of residents’ spontaneous uninterested to the event is small. With the continuous fermentation of the incident, residents will join a new round of information dissemination process. Therefore, in this paper, the conversion rate $\alpha$ was set as the rate of infected nodes to all nodes in its adjacent nodes, the conversion rates $\gamma$, $\epsilon$, and $\theta$ were set as 0.1, 0.1, and 0.3, respectively, and the initial ratios of the ignorant, the silent, the disseminator, and the uninterested were set as 0.95, 0.02, 0.02, and 0.01, respectively.

3.4.1. Impact of $k$ Value on Information Dissemination of PX Project. The average degree indicates that each subject in the diffusion network has a direct relationship with $k$ individuals on average, showing the closeness of the connection between individuals. Disseminators in small world network with different $k$ values are shown in Figure 5.

It shows when the average degree increased, the numbers of the silent, the disseminator, and the uninterested in the information dissemination system increased while the number of the ignorant decreased, and the speed to stable state shortens, indicating that when closeness of relations between subjects and their connections increases, information of NIMBY project will spread quickly and widely.

3.4.2. Impact of Stigmatization on Information Dissemination of PX Project. Stigmatization had a significant impact on the conversion rate from the silent to the disseminator. Taking Jiujiang PX project as an example, the simulation of information dissemination before and after stigmatization was shown in Figure 6.

From the comparison between Figure 6, after stigmatization, the time for the disseminator to reach the stable state was shorter, the stable value was higher, and the time for the silent to reach the peak value and the stable value was shorter, and the stable value was lower. There was no significant difference between the ignorant and the uninterested. Comparing the information dissemination simulation of 5 PX projects before and after stigmatization, the results were shown in Figure 7.

It can be seen from Figure 7 that, in addition to the proportion of the disseminator in the stable state, stigmatization had a negative effect on the parameters of the system, indicating that stigmatization reduced the number of the ignorant, the silent, and the uninterested in the system.
and increased the number of the disseminators. Stigmatization had the greatest impact on the proportion of the silent and the time when the system tended to be stable and the least effect on the proportion of the uninterested when the system tended to be stable. This shows that stigmatization will accelerate the transformation from the silent to the disseminator and make it difficult for the silent to become the uninterested, thus accelerating the information dissemination of PX project.

To study information dissemination in different dissemination trajectories, comparison between information dissemination of NIMBY project before and after stigmatization in small world network with different \( k \) values is shown in Figure 8.

The number of the disseminator increased and obviously the number of the silent decreased, and the time to stable state and the time to peak shortened in small world network with different \( k \) value. No matter what dissemination trajectories, stigmatization accelerates the speed of information dissemination and increases the number of residents participating in information dissemination. Since the larger the average degree is, the larger the overall scale of the network
is, and the less the closeness of relationships between subjects will be, the results indicated that, no matter in traditional interpersonal network with small $k$ value or in interpersonal network in new media with large $k$ value, stigmatization has the stimulating effect on information dissemination.
3.4.3. Impact of Public Risk Perception Indicators on Information Dissemination of PX Project. Based on equation (10), indicators of spatial relationship and humanistic risk were selected to perform sensitive analysis when the environmental risk indicators remained unchanged in the same NIMBY project, that is, PX project. Using MATLAB to draw the image of key indicators and $R_0$, comparing the slopes of those indicators, indicators with greater influence could be found. What matters in the information dissemination of PX projects will be clear. Choose construction site $A_1$, population density $A_2$, education degree $A_3$, and income level $A_4$ to make analysis. The image of $R_0$ and the four indicators was as shown in Figure 8.

According to Figure 9, the image can be approximately regarded as a straight line in the range of $A_i$. The slopes of $A_1$, $A_2$, $A_3$, and $A_4$ are 0.031, 0.105, 0.064, and 0.052, respectively. It indicated that when the research object was PX project, population density had the greatest impact on the basic regeneration number of the system among the four indicators. The denser the population was, the more likely the information of NIMBY project would disseminate. Secondly, education degree and income level had a rather greater impact on the basic regeneration number. However, the impact of construction site on the information dissemination was small, which indicated that urban residents, rural residents, and suburban residents had similar willing to spread information about PX project.

4. Discussion

Based on the simulation results, impact path of stigmatization on information dissemination of NIMBY project can be summarized as the following three:

(1) Stigmatization accelerates the information dissemination of NIMBY project. Stigmatization shortens the time when each parameter in the information dissemination system reaches the peak and tends to be stable, indicating that stigmatization makes the information of NIMBY projects widely spread in a short time. This means that the time for government intervention and government governance is reduced; that is, when the government intervenes, the information dissemination of NIMBY projects often has already had a certain impact.

(2) Stigmatization promotes the conversion from the silent to the disseminator. In the information dissemination system, the number of the silent decreases and the number of the disseminator increases, and the silent persons are more likely to participate in the information dissemination of NIMBY projects. This means that the public’s risk perception is intensified under stigmatization. After knowing the relevant information, the public wants to spread the information and express their panic urgently.

(3) Stigmatization inhibits the conversion from the disseminator to the uninterested. The number of the uninterested in the information dissemination system decreases and the number of the disseminator increases, indicating that it is difficult to reduce the number of people participating in the information dissemination of NIMBY projects. This means that once an individual becomes the disseminator of NIMBY information, its risk perception on NIMBY project makes it difficult to get rid of. The stereotype formed by stigmatization is deep-rooted, and the difficulty of destigmatization is increased.

Take Jiujiang PX project as an example, which was obviously affected by stigmatization. According to the requirements of national EIA guidelines, the company held several public announcements about EIA. On April 10, 2012, announcements were posted on the bulletin boards in local governments, street offices, village committees, and schools to meet the requirements of online and offline publicity by local Environmental Protection Agency for the first time. The second time was on September 27, 2012, which was announced in newspapers, government websites, EPA websites, and bulletin boards for 27 days. On April 29, 2013, with the support of the municipal government, the company carried out publicity of Jiujiang PX projects in Xunyang Evening News for the third time. As reported by the news about Jiujiang PX project in Sohu websites, “At the beginning, we heard that the refinery was going to install new devices, we did not feel anything. Just go. Over the years, they have not had any impact on the lives of our people.” Uncle Tao, 68, who lives in Jinjipo Street Community in Jiujiang.

“Residents in Jiujiang were very calm for the first time, the project did not attract any public attention, and passed peacefully… Jiujiang Petrochemical has settled down here for more than 30 years and lived in harmony with the surrounding residents, which has led to the improvement of residents’ lives, and has not caused disturbing impressions...”
such as explosion and pollution” Yang Airong, a spokesman for Jiujiang Petrochemical.

As can be seen from the reports, Jiujiang PX project could go smoothly before stigmatization. The environmental risk of Jiujiang PX project was low so it led to low risk perception of residents in Jiujiang, who were not stimulated to spread relevant information.

On September 27, 2012, after the preparation of the EIA report, Jiujiang Petrochemical carried out the second publicity for 27 days. This time, Jiujiang PX met the anti-PX incident of Ningbo people. PX instantly became the focus of attention in this publicity.

“There were some negative voices on the Internet that time, but the scale was relatively small. We invited several netizens who strongly opposed PX to communicate with the moderator and publicize science popularization. The doubts soon subsided,” Yang said.

As mentioned before, PX was stigmatized as “highly toxic” and “carcinogenic” in Xiamen PX incident and Ningbo PX incident. The bad impression from Ningbo PX incident enlarged the risk perception of some residents in Jiujiang and arouse their negative emotions and attitudes. Those residents spread their objections through the Internet. Ramana believed that the main concern for people opposing nuclear power was the stereotype that nuclear was a risky technology [59], which was one of the components of stigmatization. Once the negative impression of PX becomes a stereotype through information dissemination, it is hard to site and build new projects.

According to the national EIA guidelines, two publicities of Jiujiang Petrochemical were enough. However, Ministry of Environmental Protection believes that PX is a sensitive and highly concerned topic, but response of residents in Jiujiang was relatively calm. For prudence, Ministry of Environmental Protection required to carry out extended publicity and published a half-page of the publicity content in Xunyang Evening News of Jiujiang.

Not many people paid attention in the first few days. However, since May 4, 2013, due to the impact of the PX incident in Kunming, the number of consultation calls on PX projects in Jiujiang increased sharply.

Flame, backpacker, heard from his friends that PX was poisonous and harmful, and he also saw reports of Kunming’s opposition to PX in newspapers and periodicals.

“I was firmly opposed to building PX in Jiujiang at that time. If PX was good, why would not other places build it?” Flame said. At that time, Flame renamed his QQ group, which usually chatted with friends, as PX project discussion group. “At the beginning, there were only more than 100 people in my group, and one day later it grew to 600 ~ 700. More than 90% of the group were opposed to PX project. Occasionally, several voices said they wanted to discuss rationally, and they would be scolded and dare not speak.” Flame said.

“There were countless QQ groups built to discuss PX in Jiujiang at that time.” Yang said.

The reports showed that the information dissemination of Jiujiang PX project accelerated after stigmatization compared with the former two. Negative attitude of residents in Jiujiang towards PX was strengthened through Ningbo PX event and Kunming PX event. The word “PX” caught the attention from residents with high risk perception. Wu found that perceiving utility and perceiving risk were the most important factors affecting people's NIMBY risk acceptability [11]. Stigmatized PX enlarged risk perception of residents in Jiujiang and made them believe that PX was very dangerous. This kind of feeling made them fear PX and want to spread information to prevent the construction of PX project. Comparing information dissemination this time with it in the first publicity and the second publicity, the number of residents stimulated to participate in information dissemination for opposition greatly increased, which verifies that stigmatization will promote residents to spread relevant information. Before taking effective measures, residents' objections became stronger and stronger, and more and more people participated in information dissemination for opposition, which also verifies that stigmatization inhibited residents' withdrawal from information dissemination without external intervention.

5. Conclusions and Policy Recommendations

5.1. Conclusions. This paper takes stigmatization into information dissemination of NIMBY project. Based on SARF, impact path of stigmatization on information dissemination of NIMBY project was studied by SEIR model in small world network. Stigmatization strengthens the public risk perception by enlarging the negative attributes of environmental risk of NIMBY projects and intensifying the public's negative attitude towards the project and stimulates the public to spread information of NIMBY project. Based on the simulation results of information dissemination of PX project under stigmatization, it is found that stigmatization accelerates the information dissemination of NIMBY project, promotes the public to spread information, and makes it harder to reduce the number of people participating in the information dissemination of NIMBY projects.

The main contribution of this paper is verifying and quantifying the impact of stigmatization on information dissemination of NIMBY project by using SEIR model in small world network and case study. Research on information dissemination of NIMBY projects in dynamic, coupled, and multilayer networks will be further direction, such as how online information dissemination and offline information dissemination interact.

5.2. Policy Recommendations. Based on the conclusions, there are ways to control information dissemination of NIMBY project.

(1) Establish a multiagent collaborative governance framework for destigmatization. Without external intervention, it is difficult for the public to identify the correct information related to NIMBY projects and spontaneously crack the stereotypes of NIMBY projects. Therefore, it is necessary for multiple subjects to cooperate, select scientific management means, and resolve the stereotypes caused by
stigmatization from different dimensions. Government should clearly define its own role, establish trust and risk communication mechanism, make decisions on NIMBY projects transparently, and improve the public’s right to know; communities should introduce participatory governance, establish nonprofit community organizations and community participation system, adopt consultation and dialogue mode to promote communication, and improve the public’s awareness of NIMBY projects; the public should strengthen their participation on decision-making and deepen their understanding of NIMBY projects.

(2) Strengthen the popularization of public science education, and create a social environment for rational communication. Popularize the real information of NIMBY projects through community publicity, media introduction, and expert interpretation, to reduce public risk perception on the project. Make use of nongovernment organizations to carry out offline popular science education for residents or villagers, and make use of new media technology to carry out online popular science education on the application software used by the public daily. Projects that have been stigmatized should take the initiative to resolve the stigma. Projects that have not been stigmatized should actively prevent and stifle the signs of stigma, so that the public can think rationally and identify stigma information.

(3) Enhance the supervision on information dissemination channels, and reduce the impact of stigmatization on information dissemination. On the one hand, strengthen the audit of information published on the new media platform to reduce the dissemination of stigma information; focus on the review of information published by experts and other opinion leaders to reduce the influence of stigmatized information; On the other hand, publish destigmatization information on the new media platform to promote the dissemination of destigmatization information, publish destigmatization information with the help of experts and opinion leaders to strengthen the influence of destigmatization information.

(4) Scientifically demonstrate the location of major projects. In the process of site selection demonstration, in addition to ensuring the objective conditions required for project construction and operation, it is also necessary to identify the risk perception level of residents in the construction site of NIMBY projects and their ability to distinguish information. In the risk media society, there is a large amount of information and the authenticity of those information needs to be verified. Selecting residents who can rationally understand the relevant information of NIMBY projects is the key to the smooth progress of the project. With the successful implementation of NIMBY projects, the rumours of stigmatization will be broken.

Data Availability

The data supporting the results were incorporated in article.

Conflicts of Interest

The authors declare no conflicts of interest.

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References


