Postprint of an Inter-firm Knowledge Dissemination Model Considering Knowledge Innovation and Dissemination Willingness

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Abstract

[Purpose/Significance] In the era of knowledge economy, enterprise knowledge is regarded as the primary driving force for enterprise development. How to discover the laws of knowledge dissemination and conduct effective knowledge dissemination has become a growing concern among scholars. [Method/Process] Building upon the classic SEIR epidemic model, we categorize enterprises into knowledge-innovative enterprises and general knowledge-unaware enterprises. Considering that knowledge-innovative enterprises are capable of knowledge innovation, and incorporating the impact of enterprises' knowledge dissemination willingness, we construct a B-STEHIR model that incorporates enterprises' knowledge dissemination willingness, and derive the mean-field equations for this model. Furthermore, the basic reproduction number is derived using the next-generation matrix method, and simulations are conducted using Matlab2020a. [Results/Conclusion] Under the leadership of knowledge innovation from innovative enterprises, dissemination willingness emerges as a critical factor in the process of enterprise knowledge dissemination. Compared with knowledge dissemination models that do not consider dissemination willingness, knowledge propagation occurs more slowly in models that consider dissemination willingness. Stronger willingness for innovative knowledge dissemination leads to slower general knowledge propagation. Enterprises and governments may employ various strategies to promote effective enterprise knowledge dissemination.

Full Text

Inter-Firm Knowledge Dissemination Model That Considers Knowledge Innovation and the Willingness to Disseminate Knowledge

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Abstract

[**Purpose/Significance**] In the era of the knowledge economy, enterprise knowledge is considered the primary driver of corporate development. Identifying the patterns of knowledge dissemination and achieving effective knowledge transfer have become increasingly important concerns for scholars. [**Method/Process**] Building upon the classic SEIR infectious disease model, we categorize enterprises into knowledge-innovative enterprises and general knowledge-unknown enterprises. Considering that knowledge-innovative enterprises can generate new knowledge and incorporating the influence of enterprises' willingness to disseminate knowledge on the knowledge transfer process, we construct a B-STEHIR model that accounts for knowledge dissemination willingness under the guidance of innovative enterprises' knowledge creation, and derive the mean-field equations for this model. The basic reproduction number is calculated using the next-generation matrix method, and simulations are conducted using Matlab 2020a. [**Result/Conclusion**] Under the leadership of innovative enterprises' knowledge creation, the factor of dissemination willingness plays a crucial role in enterprise knowledge transfer. Compared with knowledge dissemination models that ignore willingness, knowledge spreads more slowly when willingness is considered. A stronger willingness to disseminate innovative knowledge slows the spread of general knowledge, and both enterprises and governments can employ various measures to promote effective knowledge dissemination.

Keywords: corporate knowledge, knowledge dissemination, SEIR model, willingness to disseminate, B-STEHIR model
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1. Introduction

Enterprise knowledge is recognized as the main driving force for enterprises to gain competitive advantages in the knowledge economy era, powerfully propelling corporate development. In 1993, management guru Peter Drucker proposed that "the knowledge and knowledge workers of an enterprise are its most important assets" [1]. With the advent of the knowledge economy, scholars from various fields—including psychology, communication, management, and sociology—have studied knowledge dissemination from multiple perspectives, making the identification of knowledge transfer patterns and effective knowledge dissemination major research topics in the field.

Protection of intellectual property rights affects enterprises' willingness to disseminate knowledge. While foreign countries have long emphasized IP protection, China has placed IP protection work in a more prominent position since the 18th National Congress of the Communist Party, issuing a series of policies such as the *Action Plan for Deeply Implementing the National Intellectual Property Strategy* and *Several Opinions of the State Council on Accelerating the Construction of an Intellectual Property Powerhouse Under New Circumstances*. President Xi Jinping has pointed out that innovation is the primary driving force for development, and protecting intellectual property means protecting knowledge innovation. IP protection will inevitably receive increasing attention in the future, making the leakage of new knowledge, innovative technologies, and inventions less likely. Against this backdrop of strengthening IP protection, the willingness of knowledge-innovative enterprises to proactively share innovative knowledge, technologies, and inventions with other enterprises significantly influences inter-firm knowledge dissemination.

Furthermore, P. Babcock' s research indicates that, according to International Data Corporation (IDC) statistics, Fortune 500 companies lose as much as $31.5 billion annually due to unsuccessful knowledge dissemination [2], while G. W. Bock and Y. G. Kim argue that this result is fundamentally caused by the influence of knowledge dissemination willingness [3].

In the knowledge economy era, enterprise knowledge serves as a crucial resource for corporate knowledge management, creating significant competitive advantages and economic benefits, with knowledge dissemination acting as the driving force for enterprise development [4]. Scholars hold various perspectives on knowledge dissemination, with most viewing it as an interactive process between knowledge-unknown and knowledge-possessing entities, where knowledge is transmitted and received through communication, learning, and interaction. Current research on knowledge dissemination can be broadly divided into empirical and theoretical studies.

Empirical research focuses on identifying factors that positively influence enterprise knowledge dissemination through field investigations and surveys, such as promoting a culture of organizational sharing and extensive application of knowledge assets and technological inventions [5-7]. A representative study by

S. C. Goh suggests that dissemination capacity significantly affects knowledge transfer, integrating various factors into a conceptual framework that elaborates key factors influencing the effectiveness of knowledge transfer processes [7]. However, empirical research has limitations, including small sample sizes from field investigations and subjectivity in survey responses, making theoretical studies the mainstream approach.

Theoretical research applies infectious disease models to knowledge dissemination studies, continuously improving models by considering different propagation groups and mechanisms. Infectious disease models were among the earliest methods used to study knowledge dissemination dynamics. As early as 1927, W. O. Kermack and others proposed the classic SIR infectious disease model [8]. In the 1960s, W. Goffman creatively combined the SIR model with knowledge dissemination to study the spread of scientific knowledge related to mast cells [9]. S. G. Liao et al., based on waterborne disease principles, argued that some ignorant individuals actively learn from existing knowledge repositories, constructing a knowledge dissemination network that incorporates knowledge bases and verifying theoretical results through numerical simulation [10]. H. Wang et al. built a knowledge dissemination model considering self-learning mechanisms, deriving mean-field equations and conducting simulations to demonstrate that incorporating self-learning mechanisms better reflects reality [11]. S. G. Liao et al. proposed that knowledge has an internalization mechanism, where nodes undergo transformation between tacit and explicit knowledge during dissemination, introducing a new RHS model [12]. Z. Yue et al. suggested that a latent population exists in knowledge dissemination systems—individuals who possess knowledge but temporarily do not disseminate it, requiring time to digest new knowledge, thus proposing the SEIR model for knowledge dissemination [13].

Domestic scholars such as Hu Xuhua et al. divided enterprises into two heterogeneous categories (large and small) to construct a knowledge dissemination model among heterogeneous enterprises within clusters, finding that both interfirm contact rates and learning success rates affect the reproduction rate of knowledge dissemination [14]. Tan Jian et al. established an enterprise knowledge dissemination model using cluster employees as network nodes, analyzing employees' roles in knowledge dissemination [15]. Qi Liangqun et al. built an evolutionary game model for knowledge sharing among advanced manufacturing enterprises, service organizations, and third-party users based on knowledge characteristics and their impact on knowledge dissemination in collaborative innovation networks, analyzing equilibrium strategy conditions and simulating key influencing factors [16]. Ma Yutong et al. developed a knowledge dissemination model based on the SEIR model, using the HITS algorithm to improve propagation patterns, revealing that knowledge dissemination faces "cold start" difficulties and scale limitations, and validated conclusions using dynamic response data from the Zhihu platform [17]. While existing studies based on classic infectious disease models have considered self-learning and internalization mechanisms, few have incorporated dissemination willingness mechanisms. In reality, knowledge dissemination networks are complex networks, and considering more state nodes yields results closer to actual conditions.

Numerous studies demonstrate that knowledge dissemination involves a willingness mechanism. For instance, Ma Yonghong et al. showed that under Nash noncooperative and Stackelberg leader-follower game conditions, core enterprises are unwilling to change their knowledge dissemination willingness, but will increase it after receiving knowledge-sharing subsidies [18]. Yao Kai et al. found that employment relationships and distributive fairness significantly affect interfirm knowledge dissemination willingness [19]. Tang Houxing constructed game models from a market competition structure perspective, demonstrating that market competition structure significantly influences knowledge-leading enterprises' dissemination willingness [20]. A. Udin et al. argued that leaders have the willingness to disseminate knowledge among employees to facilitate innovative work [21]. M. Azeem et al. showed that knowledge dissemination is a key driver for enterprises to gain competitive advantages [22]. Hao-Fan Chumg et al. used structural equation modeling to demonstrate that improving employee well-being can enhance enterprises' internal knowledge dissemination willingness [23].

I. Ajzen and M. Fishbein' s Theory of Reasoned Action (TRA) posits that individuals' decisions to engage in specific behaviors are determined by behavioral intentions; in other words, individuals decide whether to implement a behavior based on their own willingness [24]. When knowledge-innovative enterprises create new knowledge (e.g., new marketing methods, production technologies, or inventions), they typically do not make such innovations public but rather use them as trade secrets. However, some innovative enterprises are willing to share innovative knowledge with subsidiaries or business partners due to cooperative relationships. Therefore, considering both the innovation process of knowledge-innovative enterprises and their willingness to disseminate innovative knowledge, we divide knowledge-unknown enterprises into general knowledge-unknown enterprises and knowledge-innovative enterprises. This study constructs a knowledge dissemination model that considers enterprises' knowledge dissemination willingness under the guidance of innovative enterprises' knowledge creation, based on the classic SEIR model. We derive mean-field equations, conduct simulation verification, and provide strategic recommendations to help better understand enterprise knowledge dissemination patterns and achieve more effective knowledge transfer. Drawing from the *High-tech Enterprise Recognition Management Measures*, we define knowledge-innovative enterprises as those whose R&D expenses reach a certain proportion of revenue, whose R&D personnel account for more than 10% of total employees, and that possess knowledge innovation capabilities to create new technologies, methods, and marketing models.

2. B-STEHIR Enterprise Knowledge Dissemination Model Construction

Rapid development of information technology has profoundly influenced knowledge dissemination methods. The emergence of the internet, particularly mobile internet, has ushered knowledge dissemination into a new era of "electronic propagation" and "network diffusion" [25]. Due to strong similarities between inter-firm knowledge dissemination processes and real-world virus transmission [26-27], this study builds upon the classic SEIR infectious disease model, assuming enterprise knowledge dissemination occurs in a closed, well-mixed network with N nodes, where each node represents an enterprise' s state. Inter-firm interactions (such as mutual inspections, learning, and collaborative knowledge sharing) serve as the knowledge dissemination mechanism, with the total number of nodes N remaining constant. Simultaneously considering the knowledge creation process of innovative enterprises and the impact of dissemination willingness, we classify enterprise states in the knowledge dissemination system into seven categories: B (knowledge-innovative enterprise), S (general knowledge-unknown enterprise), T (innovative knowledge-possessing enterprise), E (general knowledge-possessing enterprise), H (innovative knowledge-disseminating enterprise), I (general knowledge-disseminating enterprise), and R (enterprise knowledge removal). This constructs the knowledge dissemination model considering dissemination willingness (hereinafter referred to as the "B-STEHIR model"), as illustrated in [Figure 1: see original paper].

- **B (Knowledge-Innovative Enterprise):** Possesses knowledge innovation capabilities and undergoes a knowledge creation process.
- **S (General Knowledge-Unknown Enterprise):** Refers to the population that has not yet encountered other enterprises' knowledge.
- **T (Innovative Knowledge-Possessing Enterprise):** Refers to enterprises that have mastered innovative knowledge through the knowledge creation process of innovative enterprises or through dissemination from innovative knowledge-disseminating enterprises.
- **E (General Knowledge-Possessing Enterprise):** Refers to enterprises that possess general knowledge.
- **H (Innovative Knowledge-Disseminating Enterprise):** Refers to enterprises that disseminate innovative knowledge.
- **I (General Knowledge-Disseminating Enterprise):** Refers to enterprises that disseminate general knowledge.
- **R (Knowledge Removal Enterprise):** Refers to enterprises that pursue new knowledge or eliminate/upgrade existing knowledge.

According to [Figure 1: see original paper], enterprise knowledge dissemination follows these rules:

The knowledge-innovative enterprise necessarily undergoes a knowledge innovation process—creating knowledge, technologies, methods, etc. As shown in the figure, the transition from state B to state T does not participate in the overall enterprise knowledge dissemination system' s propagation.

General knowledge-unknown enterprises receiving knowledge from innovative knowledge-disseminating enterprises accept this knowledge with probability and transform into innovative knowledge-possessing enterprises. Since general knowledge also plays a dissemination role in the knowledge dissemination system, general knowledge-unknown enterprises also receive knowledge from general knowledge-disseminating enterprises, accepting it with probability and transforming into general knowledge-possessing enterprises.

After the B-to-T state transition, knowledge-innovative enterprises become innovative knowledge-possessing enterprises. Due to development opportunities brought by new marketing methods, technologies, and approaches, innovative knowledge-possessing enterprises have a certain probability of disseminating such innovative knowledge to subsidiaries or partner enterprises for mutual benefit, thereby becoming innovative knowledge-disseminating enterprises. We define this probability as the innovative knowledge dissemination willingness rate . Innovative knowledge-possessing enterprises transform into knowledge removal enterprises with probability by pursuing new knowledge and eliminating old knowledge. General knowledge-possessing enterprises receiving knowledge from general knowledge-disseminating enterprises accept and disseminate this knowledge with probability , becoming general knowledge-disseminating enterprises, and transform into knowledge removal enterprises with probability due to knowledge elimination or upgrading.

Innovative knowledge-disseminating enterprises and general knowledge-disseminating enterprises transform into knowledge removal enterprises with probabilities and , respectively, due to knowledge elimination or upgrading.

Let B represent the knowledge creation state of knowledge-innovative enterprises, and let S(t), T(t), E(t), H(t), I(t), and R(t) denote the densities of general knowledge-unknown enterprises, innovative knowledge-possessing enterprises, general knowledge-possessing enterprises, innovative knowledge-disseminating enterprises, general knowledge-disseminating enterprises, and knowledge removal enterprises at time t, respectively, with the condition S(t) + T(t) + E(t) + H(t) + I(t) + R(t) = 1, where 0 < , , , , , , , < 1.

Based on these assumptions and enterprise knowledge dissemination rules, we construct the mean-field equations for the enterprise knowledge dissemination model considering knowledge innovation and dissemination willingness, where represents the network average degree. The specific equations are given as formulas (1)-(6):

$$\frac{dS}{dt} = -\alpha\langle k\rangle S(t)H(t) - \beta\langle k\rangle S(t)I(t)$$

Formula (1)

$$\frac{dT}{dt} = \alpha\langle k\rangle S(t)H(t) - \delta T(t) - \gamma T(t)$$

Formula (2)

$$\frac{dE}{dt} = \beta\langle k\rangle S(t)I(t) - \mu E(t) - \omega E(t)$$

Formula (3)

$$\frac{dH}{dt} = \delta T(t) - \varepsilon H(t)$$

Formula (4)

$$\frac{dI}{dt} = \mu E(t) - \theta I(t)$$

Formula (5)

$$\frac{dR}{dt} = \gamma T(t) + \omega E(t) + \varepsilon H(t) + \theta I(t)$$

Formula (6)

Where S(t), T(t), E(t), H(t), I(t), and R(t) are all continuously differentiable functions.

3. B-STEHIR Enterprise Knowledge Dissemination Model Analysis

3.1 Equilibrium Point Solution and Stability Analysis

Setting $\frac{dS}{dt} = \frac{dT}{dt} = \frac{dE}{dt} = \frac{dH}{dt} = \frac{dI}{dt} = 0$ yields two equilibrium points for the model: (1) $P_0(0,0,0,0,0,0)$, a no-knowledge-dissemination equilibrium point; and (2) $P_1(m_1, m_2, m_3, m_4, m_5, m_6)$, a knowledge-dissemination equilibrium point. The calculations for m_1-m_6 are as follows:

$$m_1 = \frac{\varepsilon\gamma\delta}{\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta\langle k\rangle}$$

$$m_2 = \frac{\mu\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta}{\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta}$$

$$m_3 = \frac{\beta\varepsilon(\gamma+\delta)}{\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta}$$

$$m_4 = \frac{\mu\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta}{\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta} \cdot \frac{\delta}{\varepsilon}$$

$$m_5 = \frac{\mu\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta}{\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta} \cdot \frac{\mu}{\theta}$$

$$m_6 = 1 - \frac{\varepsilon\gamma\delta}{\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta\langle k\rangle} - \frac{\mu\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta}{\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta} \cdot \left(1 + \frac{\delta}{\varepsilon} + \frac{\mu}{\theta}\right)$$

Where P_1 is the knowledge-dissemination equilibrium point, and when $\beta\varepsilon(\gamma+\delta) - \theta\alpha\delta > 0$, formulas (1)-(5) are locally asymptotically stable.

Proof: The Jacobian matrix of formulas (1)-(5) at the knowledge-dissemination equilibrium point P_1 is:

$$J = \begin{bmatrix} -\alpha\langle k\rangle m_4 - \beta\langle k\rangle m_5 & 0 & 0 & -\alpha\langle k\rangle m_1 & -\beta\langle k\rangle m_1 \\ \alpha\langle k\rangle m_4 & -(\delta+\gamma) & 0 & \alpha\langle k\rangle m_1 & 0 \\ \beta\langle k\rangle m_5 & 0 & -(\mu+\omega) & 0 & \beta\langle k\rangle m_1 \\ 0 & \delta & 0 & -\varepsilon & 0 \\ 0 & 0 & \mu & 0 & -\theta \end{bmatrix}$$

Let $\Delta_i (i = 1, 2, 3, 4)$ denote the i-th order principal minor of J. Since the 4th-order principal minor of matrix J is greater than zero, the 4th-order submatrix of J is positive definite, meaning all its eigenvalues are positive. By matrix definition, a matrix' s trace equals the sum of its eigenvalues, so all eigenvalues of J are greater than or equal to zero, and thus all eigenvalues of matrix M are less than or equal to zero. According to the Routh-Hurwitz criterion, the knowledge-dissemination equilibrium point P_1 is locally asymptotically stable.

3.2 Basic Reproduction Number Solution

Drawing from the definition of the basic reproduction number [27], we define the basic reproduction number R_0 in the enterprise knowledge dissemination model as the number of general knowledge-unknown enterprises that a single general knowledge-disseminating enterprise can convert into general knowledge-disseminating enterprises during the dissemination process. This parameter measures the infection capacity of enterprise knowledge dissemination. When $R_0 = 1$, it represents the threshold for enterprise knowledge dissemination; when $R_0 < 1$, enterprise knowledge cannot form a dissemination trend; when $R_0 > 1$, enterprise knowledge can form a dissemination trend within a certain scope. Following the method used by O. Driessche and I. Al-Darabsah [28,30], we calculate R_0 using the spectral radius of the regeneration matrix.

Let $X = (I(t), T(t), E(t), H(t))^T$, and construct $F(x)$ and $V(x)$, where $F(x)$ represents the density of newly added general knowledge-disseminating enterprises and $V(x)$ represents the density of other groups. Formulas (2)-(5) can be expressed as $\frac{dx}{dt} = F(x) - V(x)$. If we consider only the transformation of general knowledge enterprises into general knowledge-disseminating enterprises as new infections, then:

$$F(x) = \begin{bmatrix} \beta\langle k\rangle S(t)I(t) \\ \alpha\langle k\rangle S(t)H(t) \\ 0 \\ 0 \end{bmatrix}$$

Formula (9)

$$V(x) = \begin{bmatrix} (\mu+\omega)E(t) \\ (\delta+\gamma)T(t) \\ -\mu E(t)+\theta I(t) \\ -\delta T(t)+\varepsilon H(t) \end{bmatrix}$$

Formula (10)

When enterprise knowledge dissemination exists in the system, we take the equilibrium point $E_0 = (m_5, m_2, m_3, m_4)$, then:

$$F = \begin{bmatrix} 0 & 0 & \beta\langle k\rangle m_1 & 0 \\ 0 & 0 & 0 & \alpha\langle k\rangle m_1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Formula (11)

$$V = \begin{bmatrix} \mu+\omega & 0 & 0 & 0 \\ 0 & \delta+\gamma & 0 & 0 \\ -\mu & 0 & \theta & 0 \\ 0 & -\delta & 0 & \varepsilon \end{bmatrix}$$

Formula (12)

The basic reproduction number R_0 is calculated as:

$$R_0 = \rho(FV^{-1}) = \frac{\beta\varepsilon(\gamma+\delta)}{\theta\alpha\delta\langle k\rangle}$$

Formula (13)

From the expression of R_0, when θ and δ cannot be determined, increasing β, ε, γ or decreasing α—that is, increasing the absorption rate of general knowledge, accelerating knowledge renewal, or reducing the dissemination capacity of innovative knowledge-disseminating enterprises—will cause R_0 to increase. As R_0 increases to 1, the dissemination scale of general knowledge expands, which can enable small and medium-sized enterprise groups to form a virtuous cycle of knowledge sharing and create economic value [2]. Therefore, enterprises can facilitate general knowledge dissemination by appropriately reducing innovative enterprises' dissemination speed of innovative knowledge, accelerating the renewal of innovative knowledge, and eliminating outdated technologies and methods.

4. B-STEHIR Model Simulation

This section uses Matlab 2020a software for simulation, employing the Runge-Kutta method to solve formulas (1)-(6). We simulate the model under scenarios with and without dissemination willingness, different dissemination willingness rates, different innovative knowledge dissemination rates, and different innovative knowledge elimination rates. Assuming enterprise knowledge disseminates in a well-mixed network with N nodes, where each node represents an enterprise, we set N = 100. Based on the *High-tech Enterprise Recognition Management Measures* and our definition of knowledge-innovative enterprises, we consider an initial state of 10 knowledge-innovative enterprises and 1 general knowledge-disseminating enterprise, with the remainder being general knowledge-unknown enterprises: I(0) = 0.01, B(0) = T(0) = 0.1, S(0) = 0.89, E(0) = H(0) = R(0) = 0. All subsequent simulation results are based on this initial state.

When = 0.8, = 0.5, = 0.8, = 0.2, = 0.4, = 0.6, = 0.05, = 0.07, and = 20, the density changes of each group over time are shown in [Figure 2: see original paper]. During enterprise knowledge dissemination, the density of innovative knowledge-disseminating enterprises and general knowledge-disseminating enterprises first increases slightly, then declines, and finally stabilizes; the density of general knowledge-possessing enterprises increases to a peak before declining and stabilizing; the density of knowledge removal enterprises continuously increases until reaching a maximum and stabilizing. Simulation results indicate that compared with knowledge dissemination models ignoring knowledge innovation and dissemination willingness, the model considering these factors shows slower dissemination speed of general enterprise knowledge, slower decline and stabilization of densities for both innovative and general knowledge-disseminating enterprises, and slower growth rate of general knowledge-possessing enterprises. This further demonstrates that dissemination willingness significantly impacts the entire enterprise knowledge dissemination system.

[Figure 3: see original paper] compares density changes of general knowledge-disseminating enterprises and knowledge removal enterprises with and without dissemination willingness, with state transition probability parameters set to = 0.8, = 0.5, = 0.8, = 0.2, = 0.4, = 0.6, = 0.05, = 0.07. Figure 3: see original paper shows that ignoring dissemination willingness results in higher peak density for general knowledge-disseminating enterprises and longer time to reach stability compared with considering willingness. Figure 3: see original paper shows that considering dissemination willingness leads to shorter time to stability and lower stable density values for knowledge removal enterprises. These results indicate that dissemination willingness significantly affects the rate of density change and stable density values for both general knowledge-disseminating and knowledge removal enterprises.

[Figure 4: see original paper] illustrates density changes of general knowledge-unknown, general knowledge-possessing, general knowledge-disseminating, and knowledge removal enterprises under different dissemination willingness rates (varying values), with other parameters consistent with [Figure 3: see original paper] except for and (which changes accordingly). Figure 4: see original paper shows that as dissemination willingness strengthens, general knowledge-unknown enterprises reach stability faster, with accelerated decline rates. Figure 4: see original paper demonstrates that weaker dissemination willingness results in longer time to peak and higher peak density for general knowledge-possessing enterprises, with more noticeable changes when decreases from 0.4 to 0.2. Figure 4: see original paper reveals that weaker dissemination willingness yields higher peak density for general knowledge-disseminating enterprises, with particularly significant changes when decreases from 0.4 to 0.2, though time to peak and stabilization remains relatively unchanged. Figure 4: see original paper shows that knowledge removal enterprise density increases with stronger dissemination willingness, but time to stability shows no significant change. These results indicate that changes in innovative knowledge-possessing enterprises' dissemination willingness substantially affect densities across the entire knowledge dissemination system.

[Figure 5: see original paper] presents density changes of general knowledge-disseminating, innovative knowledge-disseminating, and knowledge removal enterprises under different innovative knowledge dissemination rates (varying values), with other parameters set to $= 0.5$, $= 0.8$, $= 0.2$, $= 0.4$, $= 0.6$, $= 0.05$, $= 0.07$. Figure 5: see original paper shows that lower innovative knowledge dissemination rates (smaller) result in higher peak density and greater density variation for general knowledge-disseminating enterprises. Figure 5: see original paper demonstrates that knowledge removal enterprise density decreases as innovative knowledge dissemination rate increases, with larger rates yielding smaller stable densities. Figure 5: see original paper indicates that higher innovative knowledge dissemination rates (larger) produce slightly larger peak densities for innovative knowledge-disseminating enterprises with minimal growth. These results show that innovative knowledge dissemination rate significantly affects general knowledge-disseminating enterprise density, moderately affects knowledge removal enterprise density, and has minimal impact on innovative knowledge-disseminating enterprises.

[Figure 6: see original paper] displays density changes of innovative knowledge-possessing and general knowledge-disseminating enterprises under different innovative knowledge elimination rates (varying values), with parameters set to $= 0.8$, $= 0.5$, $= 0.8$, $= 0.2$, $= 0.4$, $= 0.6$, $= 0.07$. Figure 6: see original paper shows that lower innovative knowledge elimination rates result in higher (though not significantly different) peak densities for innovative knowledge-possessing enterprises, requiring longer time to reach stability. Figure 6: see original paper reveals that general knowledge-disseminating enterprise density increases minimally with higher innovative knowledge elimination rates. These results indicate that innovative knowledge elimination rate affects innovative knowledge-possessing enterprise density but has minimal impact on general knowledge-disseminating enterprise density.

5. Conclusion

Drawing on the classic SEIR infectious disease model, this study considers the impact of knowledge-innovative enterprises' creation of new knowledge, technologies, and inventions, incorporating the influence of enterprise knowledge dissemination willingness to construct the B-STEHIR model. We derive mean-field equations, calculate the basic reproduction number, and conduct simulations using the Runge-Kutta method to analyze the enterprise knowledge dissemination process, explore its patterns, and examine specific parameter effects. Simulation results demonstrate that under the guidance of innovative enterprises' knowledge creation, dissemination willingness significantly impacts the knowledge dissemination system, with the willingness-considered model better reflecting reality than willingness-ignored models. The knowledge creation process of knowledge-innovative enterprises directly increases the number of innovative knowledge-possessing enterprises, diversifying their sources—they originate not only from dissemination by innovative knowledge-disseminating enterprises but also from innovative enterprises' own knowledge creation activities, which aligns more closely with reality. This provides new insights for enterprises to enhance competitive advantages, disseminate knowledge efficiently, and better understand knowledge dissemination patterns.

Through basic reproduction number calculation and simulation analysis, we conclude that increasing , , or decreasing can facilitate knowledge dissemination across the network, while decreasing increases the population density of general knowledge-disseminating enterprises. In practice, enterprises can accelerate general knowledge dissemination, renew innovative knowledge faster, and eliminate outdated technologies and methods; governments can promote knowledge dissemination by introducing policies that encourage knowledge sharing.

Enterprise knowledge dissemination is influenced by many factors. This study' s assumption of a uniform network has certain limitations, as scale-free networks may better reflect reality. Future research should explore scale-free networks and consider additional factors.

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Author Contributions

Lian Zhuoyi: Conceptualized the research topic and wrote the manuscript;
Wang Xiaoli: Supervised research direction and revised the manuscript;
Zhang Jing: Revised the manuscript;
Qian Mengdi: Revised the manuscript;
Chen Shuqin: Revised the manuscript.

Note: Figure translations are in progress. See original paper for figures.