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Cooperation and Competition in China's Telecom Triopoly: A Repeated Prisoner's Dilemma Analysis

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Abstract. As an important infrastructure to the digital economy, the telecommunications industry in China now shows a triopoly market structure by three operators: China Mobile, China Unicom, and China Telecom. Currently, this structure triggers vicious price wars, constraining the industry revenue and development. This paper uses the theory of the repeated Prisoner's Dilemma and a case study of China's 5G market from 2019 to 2025 to explore this dilemma. After investigation, the study finds three main obstacles to the formation of trustworthy cooperation: the concern of merely profit in the short term, the degree of information transparency, and the ineffective punishments for betray actions. To solve this dilemma, a mathematical model is constructed to try to find the conditions for accessible cooperation. As a result, the finding indicates that sustainable cooperation requires various conditions, such as the net benefits of cooperation. To do this, the study recommends creating policies that include mechanisms such as a tit-for-tat response strategy to defend from betray actions, third-party information platforms to ensure information transparency, and a hierarchical information sharing to guarantee the stability of collaboration. Consequently, cooperation will occur among the operators, contributing to the overall health and sustainability of the telecommunication industry.

Keywords: telecommunications triopoly, price war, repeated prisoner's dilemma, cooperation mechanism, industrial organization

1. Introduction

1.1. Research background

Contemporarily, China's telecommunications market is dominated by a triopoly with frequent price competition: China Mobile, China Unicom, and China Telecom. This market structure presents a classic case of the Prisoner's Dilemma: strategies with individual rationality lead to collectively undesirable outcomes. Specifically, the total revenue of China's telecommunications industry in 2025 was 1.75 trillion yuan, with merely a growth rate of 0.7%, which is the lowest in recent years (Figure 1) [1]. Indeed, the primary reason for this occurrence is due to the intense price competition for services. The result will be that all revenue growth in the industry will be restricted and cause serious market failure.

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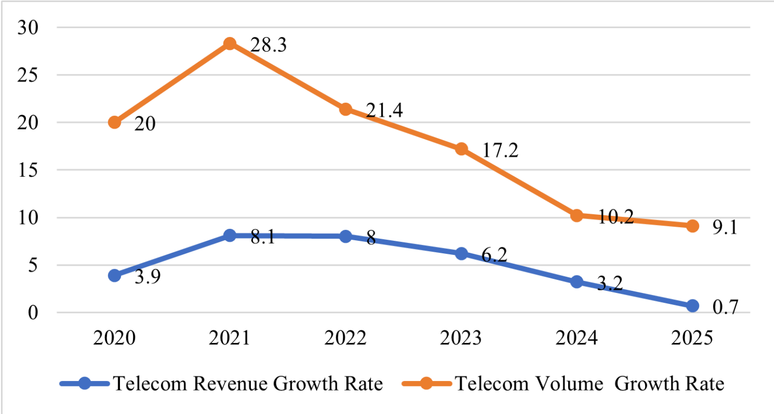

Figure 1. Overall growth condition of China's telecom revenue and volume

To this end, price wars have become a severe problem and have a negative impact on the entire industry. Price competition among various telecommunications providers has caused the cost of service for 5G to drop from 128 yuan per month to only 40 yuan per month. In essence, the result of this ongoing price war will continue to decrease the price of services [2]. Additionally, this extreme price competition also negatively impacts the industry's overall revenue growth rate from 32.1% in 2022 to 4.7% in 2025 (Figure 2) [1]. Thus, this vicious price competition will continue to decrease the profits across the entire industry.

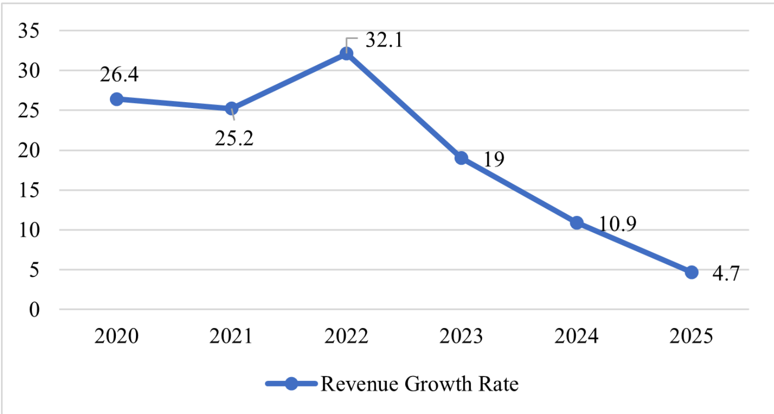

Figure 2. Revenue development of emerging businesses from 2020 to 2025

The price war in China's telecommunications industry is a typical case of the Prisoner's Dilemma in game theory. According to Table 1, both firms have a dominant strategy of setting a "Low Price," since the payoff they receive is always higher than the payoff if they set a "High Price." In fact, this theorical choice aligns perfectly with the reality because consumers are willing to buy products at low prices. Thus, both firms will choose to set a "Low Price", leading to a negative outcome: both firms suffer losses. Nevertheless, the interaction between telecommunication firms is a long-term process, similar to the Repeated Prisoner's Dilemma Game. Fortunately, in the Repeated Prisoner's Dilemma Game, cooperation between firms is possible. Taking a long-term perspective, the firms will maximize their joint profit while avoiding economic losses. Thereby, exploring the cooperation from the perspective of the Repeated Prisoner's Dilemma has practical research significance.

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Table 1. Rules to format sections

Price War Game		Operator 2	
		High Price	Low Price
Operator 1	High Price	5, 5	-5, 10
	Low Price	10, -5	-1, -1

1.2. Literature review

Existing research related to price wars in oligopolies can be categorized into two types. The first one examines the theoretical foundations of cooperation in Repeated Prisoner's Dilemma Games, exploring mechanisms that can overcome the one-shot Prisoner's Dilemma. The second applies these game-theoretic bases to analyze strategic interactions in specific industries, including telecommunications.

Axelrod & Hamilton proposed that the "tit-for-tat" strategy is the most effective for promoting cooperation among participants and noted that repeated, long-term interaction can help overcome the problem in the single-stage Prisoner's Dilemma Game [3].

Han & Guo established a tri-oligopolistic competition evolutionary game model for China's telecommunications industry. They analyzed the dynamic evolutionary process of price competition and service competition among the three oligopolistic operators. The study found that excessive price competition reduces overall industry profits, while service competition and moderate cooperation enable the stable development of the telecommunications market. Their results provide a theoretical basis for understanding the mechanisms of competition and cooperation among China's three major telecommunication operators [4].

Li's article explores the logic of price games among enterprises and their impact on management decisions. It finds that managers' pricing is affected by anchoring bias. Thus, the price games will easily form a "prisoner's dilemma". In this case, effective decisions can break this vicious cycle [5].

1.3. Research gap

Most existing studies on the causes of price wars or the effective strategies to promote cooperation merely analyze one particular factor in the Repeated Prisoner's Dilemma Game, such as the tit-for-tat strategy. However, few studies concentrate on the impact of more than one important variable, such as the degree of information transparency, which may be more reflective of real life. Furthermore, almost no research concentrates on the possibility of cooperation among the three major telecommunications operators in China, which depends on the variations of multiple key factors. For operators, all the variables should be considered when examining the value of cooperation.

1.4. Research framework

To address the research gap, this paper follows a step-by-step research framework.

First, this study reviews the basic theories of the Prisoner's Dilemma and the current condition of price competition in China's telecommunications industry, particularly among the three major operators.

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Second, this paper identifies the current problems caused by the price wars between the firms, complementing the background information of the status quo of the industry.

Third, this paper constructs a mathematical model based on the Repeated Prisoner's Dilemma for the price competition. To find the solutions, several key variables, such as information transparency, will be incorporated into the model. By using mathematical prediction and analysis, this paper calculates the cooperation probability that conforms to the real-world situation.

Finally, this paper proposes specific and effective strategies to address the issues and impacts of continuous price competition. Simultaneously, the study offers practical significance for both the current state and the future of China's telecommunications market.

2. An analytical case study: price wars and cooperation in China's 5G triopoly (2019-2025)

The article selects China's 5G market from 2019 to 2025 as the specific case of study. In fact, China's 5G market is a typical oligopolistic market. To elaborate, the three major telecommunications operators in China - China Mobile, China Unicom, and China Telecom - dominate the market and engage in a long-term mix of competition and cooperation. Their interaction clearly evinces the logic of the Repeated Prisoner's Dilemma, showing the formation and strategies of the price war.

2.1. The initial stage: tacit collusion and the first betrayal (2019-2020)

In 2019, the three major operators in China's telecommunications market launched 5G packages with starting prices ranging from 128 to 599 yuan per month, forming a temporary cooperation structure to maintain current profits [6]. However, due to rising 5G demand, China Mobile launched a 70% discount package (89.6 yuan per month for 40GB) first. This act indeed triggers the real price war among its competitors [7].

2.2. The subsidy spiral and collective loss (2020-2024)

To keep enough market share, China Unicom and China Telecom quickly followed the trend of cutting prices. Consequently, the minimum price of 5G packages in China dropped from 128 yuan per month to 40 yuan per month by 2024, resulting in a continuous decline in the industry's overall profit [2].

To break this vicious circle, cooperation is required. In September of 2019, China Telecom and China Unicom signed an important protocol about 5G network co-construction. This is the start of virtuous cooperation in the background of severe price competition. Merely a year later, the world's largest 5G co-construction network was built jointly by them. Later, they actively cooperated for 5 years, resulting in effective savings of more than 400 billion yuan altogether by 2024 [8].

2.3. Seeking cooperation: network co-construction and challenges (2019-2024)

In 2025, the major telecommunications firms launched a proposal in Bazhong to constrain the extreme price competition. In fact, this act aims to encourage potential cooperation among operators, thereby maximizing the joint profit across the entire society [9].

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2.4. The current equilibrium: regulated competition and tacit understanding (2025-present)

The current market state represents a regulated, repeated-game equilibrium. Regulatory interventions, such as the Bazhong initiative, change the payoff matrix of operators by raising the cost of extreme price-cutting behavior. At the same time, operators have a higher effective discount factor for looking into future interactions and therefore are much more cautious about starting a new round of all-out price war activity. There is a complex interplay of ongoing service competition, localized pricing strategies, and non-price cooperative efforts taking place. These processes lead to the following central question of this paper: under which specific conditions can this equilibrium be stabilized and become tipped toward a more sustainable and welfare-enhancing form of cooperation?

3. The triopoly dilemma: a game-theoretic description of price wars and unstable cooperation

3.1. The dual edges of strategic interaction: potential gains and distorted incentives

3.1.1. Potential efficiency gains from cooperative equilibria

Concurrently, the game between operators in the telecommunications market is dominated by price competition. Nevertheless, the player's rational choice, given the long-term profit, is to cooperate to maximize joint profit. This conforms with the idea of the Repeated Prisoner's Dilemma, in which the cooperation between players becomes the resultant Nash Equilibrium. In 5G construction, co-construction among dominant operators can save a significant amount of investment. As a result, cooperation improves construction efficiency and optimizes the allocation of network resources [10]. These massive savings represent the potential cooperative surplus—the (5, 5) outcome in Table 1—that is foregone when operators are locked in price wars. Realizing this surplus requires mechanisms to ensure that all parties adhere to the cooperative agreement, resisting the short-term temptation to defect (e.g., by secretly poaching the partner's customers with lower prices).

3.1.2. The theoretical path to innovation through service competition

The competition amongst telecommunications suppliers based on price has played a critical part in driving the ongoing evolution of technology and services throughout society. In the Repeated Prisoner's Dilemma, each operator needs to find ways to remain competitive against others for an extended period of time by continually upgrading and differentiating their products. This requires that firms continuously invest resources in research and development of technology and enhancement of specific product offerings. As long as operators continue to innovate with respect to product enhancements, they will not fall behind the competition. During the build-out of their networks, telecommunications operators offered a variety of differentiated product offerings, such as higher-speed data plans, to create additional product offerings, while at the same time encouraging the upgrading of services offered by all telecommunications suppliers. That is, the competition amongst suppliers based on price will produce great value to all members of society by encouraging suppliers to be more competitive in their core business and, thus, to maximize their long-term profitability [11].

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3.2. The prevailing dilemma: systemic barriers to cooperation and healthy competition

3.2.1. The lock-in effect: price war as a dominant-strategy equilibrium

The continuity of vicious price wars among telecommunications operators has now become one of the most severe issues. As a result, the players will fall into the betrayal equilibrium in the Prisoner's Dilemma, which is the worst outcome of the game, theoretically. In fact, in an oligopolistic market, once one operator cuts its price to capture market share, the others have to respond in kind to avoid economic losses. Consequently, as the price war continued, a vicious cycle of "price-cutting momentum" formed, leading to a "downward spiral" in profits for all operators [12]. From the perspective of the Repeated Prisoner's Dilemma, this phenomenon is due to the low discount factor of some operators. To elaborate, these operators pay more attention to short-term attainment than to long-term profit. Thus, in the long run, the whole market in this industry will suffer a reduction in profitability. This idea perfectly matches the real situation. For instance, the Nigerian telecommunications operators also fell into the pattern of repeated betrayal due to a price war. Specifically, the rational pursuit of short-term profit led to losses across the industry [13].

3.2.2. The trust deficit: information asymmetry and cooperative fragility

The three major telecommunications operators in China have initiated cooperation activities, such as the co-construction of 5G stations, over the past few years. Nonetheless, this kind of cooperation is indeed unstable. One reason for this instability is information asymmetry. A study of the Repeated Prisoner's Dilemma finds that transparency in strategic choice information is a key factor in maintaining cooperation. That is, information asymmetry will directly undermine mutual trust between cooperators and even lead to the collapse of collusive arrangements [5]. In China's telecommunications industry, the lack of transparency between operators is common. To be more specific, operators in China want to hide their core data, such as operational plans and the resources they use, to prevent competitors from exploiting them. This kind of obscure information makes it impossible for all potential cooperators to supervise their work and to absolutely trust the operator to form an agreement. A case in China's telecommunication market is the punishment of Chengdu Unicom. At that time, China Unicom was cooperating with China Telecom. Since Chengdu Unicom at the time wanted to capture short-term interest and gain more users quickly, it shut down the base-station-sharing function for a period without negotiating with its cooperators or notifying the public. This leads to a large-scale network disconnection and service interruptions affecting China Telecom users in many areas of Chengdu. As a result, the company was punished and fined 250,000 yuan for this unfair action. This instance fully reflects the betrayal behavior caused by information asymmetry. Specifically, one party can defect at low cost due to asymmetric information. That is, once one player betrays, the other cannot quickly be informed about the accurate betrayal information. This not only reduces the cost of betrayal actions but also makes cooperation risky. This will ultimately harm the industry's long-term health and development.

3.2.3. The enforcement gap: lack of credible deterrence against betrayal

One issue caused by the limited ability to punish betrayers of fair pricing is that the telecommunications industry currently has no means to enforce fair pricing practices. In game theory, punishing players for violating the Prisoner's Dilemma provides a greater incentive for players to cooperate than if they could choose to betray one another without consequence. Since

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punitive measures for violating fair pricing are not currently implemented in the telecommunication industry, it follows that players will choose to consistently betray one another, thus creating a pattern of Nash Equilibria that can cause long-term harm to the overall long-term profitability of all companies involved. Theoretically, many punishment mechanisms and strategies can mitigate the effect of price war. For example, there is a strategy called "tit-for-tat". Indeed, this strategy is regarded as the most stable and effective for solving the Repeated Prisoner's Dilemma Game, due to its defense capabilities and forgiveness mechanism [3]. Nevertheless, none of them has been applied in the real telecommunication market.

4. A framework for fostering cooperation: from theory to policy

4.1. Theoretical foundations and policy levers: insights from the game-theoretic model

To solve the problem, the mathematical model shows the relationships among variables in the real market, providing a theoretical foundation for practical suggestions.

4.1.1. Model assumptions

The article makes some basic assumptions to make the model clear and effective, which align with the real competition in China's telecommunications market. First, there are 3 telecommunications operators, and each wants to maximize profit. Second, each operator has two choices: "cooperate" or "betray": Cooperating means keeping prices high enough; Betraying means cutting prices.

Then, the article uses simple letters to show different kinds of profit: the profit when all three operators cooperate (R); the profit when one operator betrays, and the other two cooperate (T); the profit when one operator cooperates, but others betray (S); and the profit when all three operators betray (P).

Besides, the model also incorporates four profit-related factors: the cost of breaking promises (C); the cost of unclear information (I); the profit from non-price competition (V); and the punishment from regulators (K).

4.1.2. The nash equilibrium in the theoretical case

Begin with the normal situation in Prisoner's Dilemma, where the only factor this study needs to consider is the explicit profit gained from the game. That is, when no other factors are involved, operators consistently choose to betray. Thereby, the only pure strategy Nash Equilibrium is all three operators betraying, which in fact harms their profit [14].

4.1.3. Improvement of constraints

In reality, however, improvements in this kind of vicious price war are required. Specifically, when rules such as punishments and information sharing are added to the game, the situation improves [15].

Mathematically, when adding the four profit-related factors and incorporating the different kinds of profit, the payoff matrix changes. Then, the mixed-strategy Nash Equilibrium will show the probability of cooperation (p) for each operator.

$$E_{coop} = p^3(R+V) + 3p^2(1-p)(T-I-C) + 3p(1-p)^2(S-I-C) \tag{1}$$

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$$E_{betray} = (1-p)^3 (P-I-C-K) + 3p(1-p)^2 (S-I-C) + 3p^2\left(1-p\right)\left(T-I-C\right) \quad (2)$$

As shown in Equation 1, when the profit R rises, the expected payoff of the cooperation-related game for each operator will increase; on the contrary, the profit R doesn't affect the expected payoff of the betrayal-related game, as seen in Equation 2. Thus, the probability of cooperation for operators increases when R rises.

As shown in Equation 2, when the profit P rises, the expected payoff of the betrayal-related game for each operator will increase; on the contrary, the profit P doesn't affect the expected payoff of the cooperation-related game, as seen in Equation 1. Thus, the probability of cooperation among operators decreases as P increases [16].

$$p = \frac{\sqrt[3]{P-I-C-K}}{\sqrt[3]{R+V}+\sqrt[3]{P-I-C-K}} \quad (3)$$

The relationship between the remaining parameters is given by Equation 3. Surprisingly, when combining the expected payoffs for cooperation and betrayal behaviors, S and T don't affect the probability of cooperation.

Equation 3 shows an inverse relationship between the cooperation probability p and the composite benefit of cooperation (R+V), which may appear counterintuitive. In fact, this is because Equation 3 is derived from the mixed-strategy equilibrium condition where expected payoffs from cooperation and betrayal are equal. Thereby, the relationship is displayed in an equilibrium state, instead of a dynamic situation.

To interpret the model's implications for practical solutions, this study analyzes the effect of changing parameters. An increase in the cooperative profit R or the value of non-price competition V raises the payoff of cooperation, encouraging a shift toward cooperative behavior. Likewise, increasing the costs of betrayal (C+K) or reducing information transparency (I) decreases the payoff of betrayal, making cooperation more attractive.

Thus, the model indicates that cooperation is promoted by: (1) increasing the profit for cooperation (R) and non-price competition profit (V); (2) raising the costs of betrayal (C, K); and (3) improving information transparency (I). This forms the theoretical base for the practical solutions advice.

In short, when considering all the possible factors pertinent to their profit, it is the fluctuation of the market that determines the extent of the price war [17].

4.2. Establishing credible deterrence mechanisms

Based on the model, the study demonstrates the basic mechanism of a practical solution to minimize the price war.

4.2.1. The application of the tit-for-tat strategy

The "Tit-for-Tat" strategy refers to the tactic of copying previous choices from competitors, known as the best strategy, to minimize losses in the Repeated Prisoners' Dilemma Game [3]. In reality, therefore, an effective automatic response rule is required to simulate this promising strategy: if one operator chooses to betray (price-cut), the other two operators must respond with equivalent price-cutting within a short time. Effectively, this change increases the cost of breaking promises (C). For example, if Operator A cuts prices, Operators B and C can follow within a relative short time to

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prevent loss of profit. Eventually, the price wars will stop, as long as the cost of breaking promisis (C) exceeds the profit gain from betray actions.

4.2.2. Third-party data sharing platform

To reduce the cost of unclear information (I), the article proposes a platform operated by the neutral third parties. On this platform, operators share data to ensure information transparency rather than confidential ones. By doing this, the platform not only successfully builds trust between operators, but also makes betray actions easier to detect. At the same time, the platform provides a foundation of information for the "Tit-for-Tat" strategy [18].

4.2.3. Cooperation security

For large-scale projects, a third party holds a security deposit. If an operator breaks the promise, the deposit compensates its partners. This directly increases the cost of betrayal, thereby increasing the likelihood of cooperation [18].

4.3. Improving trust and transparency of information

In order to minimize market competition, trust between operators is another key to initiating cooperation.

4.3.1. Hierarchical information sharing

The first way operators build trust between them and reduce uncertainty regarding the long term outcomes is by meetings regularly to discuss technology development and long-term investments. Sharing data is also required to build a trust relationship through mandatory sharing all the data to verify the traceability and transparency of information. Additionally, instead of sharing real-time prices, a third party publishes delayed price information to the market versus real time price information that would lead to immediate price wars. Thereby, this creates a buffer between price competition situations.

4.3.2. Commitment actions

Operators should make formal commitments to the public and reach an agreement with competitors. This will increase the cost of breaking promises (C), making cooperation more credible [17].

4.4. Changing incentives to focus on long-term value

As vicious price wars emerged, where betrayal becomes a dominant strategy in the short run (T>R), the transformation of market competition is urgently needed.

4.4.1. Altering the evaluation system

Instead of assessing companies and investors based on outdated metrics like market share, indexes should place importance on more modern indices such as Net Promoter Score (NPS). This encourages companies to take the long view of the market, rather than short term profit. It increases the chance of collaboration by changing companie' priorities.

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4.4.2. Product differentiation for a strategic reason

Operators should createa a unique system for each area like smart homes and cloud computing. Operators can avoid price wars by making users less price-sensitive by offering fitting services that make the product appealing to them. For example, China Telecom uses this strategy with Tianyi Cloud, which has become a major source of revenue growth in China.

5. Conclusion

5.1. Key findings

This study uses the Repeated Prisoner's Dilemma model to analyze price wars in China's telecommunications triopoly market. The analysis shows that vicious price competition greatly reduces the industry's profit growth and limits the development of products and services. The main problems include operators' focus on short-term profit, information asymmetry, and the low cost of betrayal. Therefore, without effective constraints, all operators tend to choose betrayal, leading to an undesirable Nash equilibrium that harms the entire industry. Based on a mathematical model with many related factors, such as cooperation profit and information cost, this study determines the theoretical equilibrium cooperation probability. Additionally, the model shows that several behaviors, such as increasing cooperation rewards, can effectively promote cooperation between operators. This paper also proposes practical solutions to increase the probability of cooperation, such as the application of the tit-for-tat strategy and the use of third-party information platforms.

5.2. Practical value of the research

This research has clear practical value. It explains why price wars persist in China's telecommunication triopoly market and provides a theoretical foundation for understanding the tendency of either cooperation or competition. For the telecommunications industry, the proposed strategies help operators escape the vicious price war and improve their overall profit. For society, ending vicious price competition maintains market stability, promotes the further development of products, and supports the market's future healthy growth. In short, this study responds to the real-world requirements of market stability, which is meaningful for the entire society.

5.3. Limitations and directions for future research

This research also has limitations. First, the research mainly relies on secondary data from official reports, without using first-hand survey or interview resources. Second, the game model uses simplified assumptions to focus on core variables, while omitting other dynamic and unmeasurable factors that exist in the market. In terms of improvements, future studies can collect primary data through interviews. In addition, researchers may also expand the model by adding dynamic real factors, such as the regulatory intensity at different times.

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