Competitive Behavior and Risk Transmission among Internet Financial Platforms Based on Network Diffusion Models

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Abstract. The differences in business models, lending products and risk control of lending products of Internet financial lending platforms have led to the disorderly growth of Internet Financial platforms in China for a long time. With the voice of financial innovation, the number of platforms and the scale of transactions have increased significantly. In this paper, we will enter the network diffusion model to analyze the physical and statistical characteristics of the competitive behavior and fierce competition behavior of the Internet financial lending platform, and understand the overall characteristics of the Internet P2P lending platform under the specific platform classification, and finally put forward the corresponding policy suggestions.

1. Introduction
In this paper, we discuss the differences in business model, lending products and risk control of lending products of Internet financial lending platforms have led to the situation of "barbaric growth" in China's Internet Financial platforms for a long time. With the high voice of financial innovation, the number of platforms and the scale of transactions present Of course, with more and more in-depth research on the nature of Internet Finance and the gradual destruction of Internet finance to the national financial system, the control and measures of Internet finance are also further strengthened. Finally, China's regulatory agencies believe that the risk prevention and control of Internet finance platform is difficult to achieve its regulatory requirements through traditional regulatory measures. By November 2020, according to the notice of China Banking and Insurance Regulatory Commission, China's Internet Finance P2P lending platform has been officially "cleared". In order to study the competitive behavior of Internet P2P lending platform in essence, in this paper, we will enter the network diffusion model to analyze the physical and statistical characteristics of the competitive behavior and fierce competition behavior of the Internet financial lending platform, so as to understand the overall characteristics of the Internet P2P lending platform under the specific platform classification.

In the actual process, the competition between platforms presents different forms. However, in order to effectively study the competition behavior under the network diffusion mode,[1-3] the competition between platforms is mainly described by the transparency of its interest rate setting. In the model of this paper, it is considered that the pricing of trading assets in loan transactions by compliant platforms is information symmetric, and Non compliant platforms take a variety of behaviors, [4-6] which makes it difficult for users, especially investment customers, to fully and reasonably grasp the information disclosure related to loan transactions through their public information.
2. Model of competition behavior of non compliant platforms based on network diffusion

2.1. Basic Information of the Model

Internet financial lending platform, especially for individual users and small and medium-sized enterprise users, connects customers as investment or financing through investment and financing needs between users. Under this framework, it lays a foundation for lending users to realize transactions. It is known that the non-compliance trading platform between users and the non-compliance trading platform are different based on the network compliance platform. Based on this mechanism, we can use the evolutionary dynamic model in complex network to simulate it better, so as to get the competition mechanism between compliant platform and non compliant platform in a certain period of time.

Based on the existing compliance lending platform, another non-compliance platform is ready to enter the personal online lending market. It is assumed that there is a corresponding transaction between users in the online financing market. In this situation, the transaction behavior of competitive platform lending users can be effectively described by the complex network in network science: the nodes in the network represent the transaction subjects constituted by the borrowing and lending transaction users, each side in the network represents the actual borrowing and lending transaction constituted by the lending transaction entities, and the weight of the side in the network represents the transaction in the lending transaction. Through such a model, it can be seen that transactions between users in the platform can form a complete complex network. In this study, matrix \( W = \{ w_{ij} \} \), \( i, j = 0, \ldots, M \) is used to describe the connectivity, transaction amount and flow direction among the nodes in the matrix. In order to further illustrate the model, this paper assumes that it represents the users who invest in a certain platform and the users who finance. Because only the actual users can be observed through data, this study assumes that each side of the complex network has the relationship of actual transaction. It is assumed that there is a substantial relationship between customer lending and other investment platforms. At the same time, in order to simplify the model, this paper mainly studies the non weighted directed network composed of 0-1 matrix \( w_{ij} \). If \( a_{ij} = 1 \), then \( w_{ij} \leq 0 \); and if \( a_{ij} = 0 \), then \( a_{ij} = 0 \).

In order to further illustrate the main characteristics of the network, the proportion of investment customers with degree \( k \) in the network is expressed by \( P(k) \), when \( 0 < k < M \).

If an investment and financing user has conducted cross platform transactions, it is assumed that the total cost of its compliance platform \( O \) and non-compliance platform \( n \) is expressed as

\[
\frac{e^{-Ch}}{e^{-Co}+e^{-Cn}}
\]

From this point of view, the cost of entering the platform has no direct relationship with the number of trading partners, but has a specific correlation with the process cost of a specific platform.

If both sides of the platform's investment and financing transactions are conducted through non compliant platforms, their respective costs in the process of platform transactions are not; if the original compliance platform is used, the expenses incurred are; but when potential customers or registered customers with investment and financing needs bypass the platform and adopt other modes to conduct transactions to meet their investment and financing needs, the transaction can be middle class. The cost of production is expressed as. It is not difficult to see that the non-compliance platform carries out a lot of "subsidies" in the transaction cost and stimulating users to carry out investment and financing transactions compared with the compliance platform, on the one hand, it increases the income of investment customers on the surface, on the other hand, reduces the financing cost of financing users. Therefore, in the platform competition, we can assume that the relationship among the three types of transaction costs is. Through the above relations, the game matrix can be formed in three situations, as shown in table I. Through the matrix, we can know that in the game coordination of non-compliance platform, the following four situations may occur.
Table 1. Game matrix for compliance non-compliance coordination

| Platforms | N      | O  |
|-----------|--------|----|
| N         | (S,S)  | (F,F) |
| O         | (F,F)  | (I,I) |

2.2. Network Diffusion Process of Lending Platform

In order to describe the relationship between compliance platform and non-compliance platform, in the initial state of competition between compliance platform and non-compliance platform, the market share of non-compliance platform is assumed to be $\Psi(0)$. In this study, because there are only two types of platforms, the market share of compliance platform is $1 - \Psi(0)$. $\Theta_k(t)$ represents the proportion of the financial investment customers with degree at this moment that the nodes connected with them adopt the non-compliant platform. It can be seen that the proportion is a function of the customers at a certain moment. Similarly, according to the characteristics of bilateral market platforms, investment and financing users not only consider the possible costs or gains in Internet finance, but also include the strategies of the same investment and financing customers in platform selection and investment and financing transactions. Since the platform is divided into compliance platform and non-compliance platform in this part, the behavior and acquisition of investment and financing customers are inspired by different platforms. There is a big difference in nominal returns.

Let $U_h$ represent the specific cost of entering the platform at a certain time. Similarly, $V_h$ represents the total capital flow of investment and financing transactions at a certain time. According to the functional relationship between capital flow and process cost in the previous paper, we can further know that the process cost can be expressed as: $T_h = V_h \cdot \text{Ratio}$. where Ratio is the proportion of process cost at that time. In order to further understand the relationship between user behavior and platform competition behavior, we first assume that the investment and financing transaction customers in their potential Internet financial lending platform transactions through random equal probability in different types of platforms to achieve investment and financing demand matching.

The proportion $\Phi_h(t)$ of investment and financing customers set at the time $t$, conducting investment and financing transactions through non-compliance Internet Financial platforms $N$, as is similar to the above, the proportion of transactions conducted through the compliance platform is $1 - \Phi_h(t)$. The client of investment and financing transaction mainly estimates the transaction cost and related expenses at the current stage by proposing the transaction cost of the previous stage, that is, the time $t-1$. The above formula represents the total transaction cost $\Pi \left(h_t, \Phi_k(t-1)\right)$ (including registration fee and transaction process fee) of the customers of the platform in the stage of compliance platform and non-compliance platform. Therefore, the cost function of the total cost at that particular time can be expressed as follows:

$$
\Pi \left(O, \Phi_k(t-1)\right) = U_O + (1 - \Phi_k(t-1))kV_OI + \Phi_k(t-1)kV_OF
$$

(2)

$$
\Pi \left(N, \Phi_k(t-1)\right) = U_N + (1 - \Phi_k(t-1))kV_NS + \Phi_k(t-1)kV_NF
$$

(3)

At the same time, through the following formula, it can be seen that the ratio of compliance and non-compliance platforms of investment and financing users with degree can be expressed as follows:

$$
P(O,t) = \frac{e^{-\Pi(O, \Phi_k(t-1))/V_O}}{e^{-\Pi(O, \Phi_k(t-1))/V_O} + e^{-\Pi(N, \Phi_k(t-1))/V_N}}
$$

(4)

$$
P(N,t) = \frac{e^{-\Pi(N, \Phi_k(t-1))/V_N}}{e^{-\Pi(O, \Phi_k(t-1))/V_O} + e^{-\Pi(N, \Phi_k(t-1))/V_N}}
$$

(5)

It can be seen from the above formula that under the condition of platform selection and investment and financing transaction strategy of investment and financing customers, considering that the process cost of compliant platform and non compliant platform in investment and financing strategy and the
It can be concluded that the proportion of users in the compliance platform and non-compliance platform at the next moment is respectively:

\[ P(O, t) = \frac{e^{-n(O, \frac{m}{T})/v_O}}{e^{-n(O, \frac{m}{T})/v_O} + e^{-n(N, \frac{m}{T})/v_N}} \]  

(6)

\[ P(N, t) = \frac{e^{-n(N, \frac{m}{T})/v_N}}{e^{-n(O, \frac{m}{T})/v_O} + e^{-n(N, \frac{m}{T})/v_N}} \]  

(7)

Therefore, the dynamic evolution process of \( R^O_{k,m}(t) \) and \( R^N_{k,m}(t) \) in complex networks can be expressed as the following two formulas:

\[
\frac{dR^O_{k,m}}{dt} = -F^M_k R^O_{k,m} + H^M_k R^N_{k,m} - \beta^O(k - m)R^O_{k,m} + \beta^O(k + 1)R^O_{k,m-1} - \gamma^O(m + 1)R^O_{k,m+1} + \gamma^O \]

(8)

\[
\frac{dR^N_{k,m}}{dt} = -H^M_k R^N_{k,m} + F^M_k R^O_{k,m} - \beta^N(k - m)R^N_{k,m} + \beta^N(k + 1)R^N_{k,m-1} - \gamma^N(m + 1)R^N_{k,m+1} + \gamma^N \]

(9)

In this moment \( 0 \leq m \leq k \), the intermediate variable \( \beta^O, \gamma^O, \beta^N, \gamma^N \) in the time-varying can be expressed by the following formula:

\[
\beta^O = \frac{\sum_{m=0}^{k}(k-m)F^M_k R^O_{k,m}}{\sum_{m=0}^{k}H^M_k R^N_{k,m}} \]  

(10)

\[
\gamma^O = \frac{\sum_{m=0}^{k}H^M_k R^N_{k,m}}{\sum_{m=0}^{k}(k-m)R^O_{k,m}} \]  

(11)

\[
\beta^N = \frac{\sum_{m=0}^{k}mF^M_k R^O_{k,m}}{\sum_{m=0}^{k}mR^N_{k,m}} \]  

(12)

\[
\gamma^N = \frac{\sum_{m=0}^{k}mH^M_k R^N_{k,m}}{\sum_{m=0}^{k}mR^N_{k,m}} \]  

(13)

From (10) to (13), although the proportion of clients diffusion at non compliant platforms at different times \( t-1 \) is shown in the form of differential equations, it is difficult to find specific solutions through deterministic algorithms. Therefore, it is necessary to use the numerical calculation algorithm to carry out the simulation calculation based on the time and carry out the corresponding iteration.

2.3. Diffusion Mode and Key Competitive Factors of New Loan Trading Platforms

In the bilateral market composed of Internet financial platform as an intermediary, its investment and financing trading products show a more steep diffusion mode than the traditional S-type diffusion mode of traditional products. Therefore, in the process of new product diffusion, it will disappear step by step, which is related to the greater competitive advantage obtained by the original platform or product.

However, Internet Financial platforms, especially non compliant platforms, have cross network externalities. Therefore, it is easy to obtain the characteristics of platform takeoff. Platform take-off in Internet finance can be considered that this kind of platform is easy to obtain a considerable number of investment and financing customers and obtain competitive advantage. On the contrary, if the non-compliance platform does not reach the user scale of take-off, the proportion of users of such platform will gradually decrease, which makes it difficult for the number of users to support its continuous development, thus gradually shrinking and even dying out. In such a situation, the non-compliance platform in the market corresponding proportion model, and compared with the original compliance platform, evaluate the simulation effect and obtain the corresponding explanation.

Figure 1. mainly depicts the changing process of market share \( \Psi(t) \) of non compliant platforms with time t. By changing the graph, we can describe the competition diffusion and failure scenarios of non-compliance platforms in the macro context, and effectively explain the competitive characteristics...
of non-compliance platforms in the Internet Financial bilateral market. The figure describes two diffusion modes of success and failure of new entry platform diffusion under the macro diffusion mode, which shows that the model constructed in this paper can effectively describe the actual macro diffusion process of new entry lending platform.

Figure1. The ever-changing overall diffusion ratio of non compliant platforms

Figure2. Comparison of non-compliance diffusion modes of macro level user nodes

It can be seen from the above two figures that, due to its advantageous position in dealing with unfair competition, after entering the Internet financial market, the proportion of successful diffusion of non-compliance platforms exceeds 0.56, and has rapidly become the main type of Internet finance platform, which is worthy of vigilance.

At the same time, in order to further the formation mechanism of the competition diffusion mode of non-compliance platforms, this paper also studies the change process of the proportion $\Psi_K(t)$ of users joining the non-compliance lending platform with time $t$. It is not difficult to find that the diffusion speed of investment and financing customers is not necessarily related to the degree. Customers with lower degree, that is, less transaction contact, can also use the non compliant platform to successfully borrow and become important customers, which is also the unfair advantage of the non compliant platform over the compliant platform. It is not difficult to find that, on the contrary, the original high-quality customers, that is, the users with higher degree nodes, may withdraw from the Internet
financial market in the macro platform competition and diffusion because of their prudence in risk control, forming the effect of "bad money driving out good money".

Furthermore, this study simulates the diffusion model of investment and financing customers from the micro level, studies the micro competition diffusion level, and describes the change process of parameters $R^N_{k,m}(t)$ with time $t$. The time-varying process of customer diffusion success and diffusion failure on two kinds of platforms is represented by the following three diagrams.

Figure 3. Comparison of diffusion modes of non compliant platform user nodes in micro level

Compared with Figure 2 and Figure 3., it can be seen that the higher the degree of investment and financing customer nodes, the greater the correlation between the success of its diffusion in the non-compliance platform and whether the adjacent nodes on the network become customers of non-compliance platform. From another point of view, the smaller the proportion $k/m$, the greater the success rate of non-compliance diffusion, and the more able to occupy the original Internet financial market share. On the contrary, the smaller the proportion $k/m$ of users entering the non compliant platform, the lower the diffusion success rate. However, it is not difficult to find that due to the strong social attributes of the Internet financial market, the "herding effect" of users' investment and financing behavior is obvious. Therefore, the customer diffusion of non compliant platforms will continue to increase due to the "profit-seeking" of customers.

Figure 4. Time-varying process of diffusion failure for the number of neighbors $M = 8$ of non compliant platform user nodes
The neighborhood of non-compliance platform user nodes is more obvious. It can be seen from Figure 4. and Figure 5. that the probability of diffusion failure of non-compliance platform is significantly higher if the proportion of investment and financing user nodes with higher degree and the number of nodes adjacent to the new platform is low. At the same time, the proportion of gradually withdrawing from non compliant platforms has also increased, which also reflects the situation of some highly experienced customers who will conduct short-term transactions on non compliant platforms and gradually withdraw according to the possible problems of the platform. On the contrary, the probability of diffusion failure of investment and financing customers in non compliant platforms is low, and the proportion of gradual extinction is also small. This is one of the reasons why inexperienced customers account for a large proportion of non compliant platforms.

From the above five figures in this study, through the numerical analysis method, the competition diffusion of non-compliance platform at the macro level and micro level is described in detail. Therefore, the policy-making can predict and judge the competition diffusion of non-compliance platform at the macro level and micro level through this method. As for the diffusion of the Internet, the failure of the platform and the failure of the platform should be paid attention to.

2.4. The main reasons for the formation of competitive advantages of non compliant platforms

Through the above analysis, the non-compliance platform can quickly form a competitive relationship with the original compliance platform after entering the field of Internet finance. Therefore, this part analyzes the key factors of the non-compliance platform to gain advantages in the competitive behavior, so as to provide the corresponding reference and draw relevant conclusions for policy makers. This part studies the competitive advantage of non-compliance platform through the research of five elements, including registration cost (entry cost), period cost (process cost), investment and financing transaction volume, network density of investment and financing customers and network heterogeneity, and draws corresponding conclusions.

The relationship between the above factors and the equilibrium solution in the diffusion model can be regarded as a multivariate function of the above five factors. Based on the combination of the above four factors, through numerical calculation, it can be seen that a large number of solutions with different equilibrium results can be obtained through the combination of different parameters. The results of numerical calculation show that the period cost, as well as the investment and financing customer network Density and network heterogeneity have strong correlation with non-compliance platform to obtain competitive advantage. Therefore, the above factors are analyzed in detail.

The important factor for investment and financing users to switch from internet financial platform is the period cost. Through Figure 5.6, the numerical calculation of the conversion is analyzed.
It is not difficult to find from the figure that in the investment and financing customer relationship networks (random network and SF network) under different characteristic networks, investment and financing customers are highly sensitive to the over period cost, and show obvious negative correlation, that is, the lower the over period cost, the lower the user diffusion ratio. This shows that the period cost has an important impact on investment and financing customers' trading decisions. At the same time, the non-compliance platform can quickly accumulate users due to period cost by using high-yield and low-risk publicity means. There are two elements worthy of attention in the period cost. One is about the withdrawal cost of investment and financing users on the platform, and the other is based on the profit ratio of transaction. Although the non compliant platform will damage the interests of investment and financing customers in the long run, under the influence of factors such as high short-term income and platform packaging marketing, even if investors face risk losses, the non-compliance platform promises high income Low risk investment is highly attractive. At present, there is no good regulatory means to effectively supervise the compliance of various Internet Financial platforms. Its capital flow and transaction mode are highly hidden, which leads to its highly negative impact on financial security.

However, the original compliance platform, due to the huge competitive advantage of non-compliance platform in the period cost, also unavoidably takes the non-compliance platform as the benchmark in the business model, compliance and risk control means. Under such factors, the non-compliance platform is highly infectious and exemplary in the Internet financial investment and financing trading platform, leading to "chaos" in the Internet financial industry.

![Figure 6. Diffusion relationship between period cost (process cost) and non compliant platform](image)

In the theory of two-sided market, customers with investment and financing transaction relationship at both ends of the platform intermediary play a very important role in the success of the platform and the formation of scale effect. Therefore, this part studies the relationship between the customer network density of investment and financing transaction and the competitive advantage of non compliant platform. It is not difficult to see that the higher the network density, the higher the probability of successful transactions between investment and financing customers. In the case of non-standard network financing, the proportion of investment and financing in social network has a high degree of negative correlation There is a highly positive correlation between density and competitive advantage of non compliant platforms. Scholars have made a lot of analysis on the "herding" of the Internet financial market. Therefore, through the recommendation or "Commission drawing" of customers on the social network, and even the temptation of high returns with the nature of pyramid selling, compared with the compliance platform based on real investment and financing needs and other information intermediaries, the customer network density of the non-compliance platform may expand rapidly.
Figure 7. Relationship between customer network density of investment and financing transactions and diffusion ratio of non compliant platforms

Similarly, in order to gain competitive advantage, both compliant and non compliant platforms will expand new business models and strive to be more attractive in business models, which also makes the platform construction strive to have corresponding network heterogeneity.

It can be seen from Fig.8 that whether it is a random network or a scale-free network, the influence of network heterogeneity of investment and financing transaction customer network has obvious differences. In SF network, the value of heterogeneity has no strong positive correlation with diffusion ratio in the initial stage and the middle stage, but when the heterogeneity reaches the critical value, it has a very meditative positive correlation with the diffusion ratio. However, the random network has a strong positive correlation with the diffusion ratio in the whole range of values. Therefore, the non-compliance platform often carries out the development of new business model under the banner of "financial innovation", which leads to the obvious network heterogeneity between the non-compliance platform and the compliance platform, and also becomes one of the key factors for the non-compliance platform to form an advantage in the competition diffusion.

Figure 8. The relationship between the heterogeneity of investment and financing lending transaction network and the diffusion ratio of non compliant platforms

In the new market entry period of Internet financial platform, non-compliance platform attracts customers' attention through the second mark of high return, and attracts customers through the marketing means of high subsidy or even risk-free and high return. Therefore, compared with
compliance platform, the proportion of investment and financing customers in the new stage is much higher than that of compliance platform.

This paper compares the impact of the proportion of new investment and financing customers on the diffusion of competition in the two networks. In random networks, the proportion of new investment and financing users has only a small positive impact on the diffusion of platform competition, but when it reaches a certain critical value, it even has a small negative impact, which indicates that in random networks, the proportion of new investment and financing customers has little impact and has limited impact on the competition of platform; in scale-free networks, the proportion of new investment and financing customers has little impact. The proportion of successful transactions of investment and financing customers has a very strong positive impact on the diffusion of competition, which is also one of the important factors for the Internet Financial non-compliance platform to make every effort to promote investment and financing customer transactions in this field.

3. Regulatory implications based on above Models

In the actual business field, the above four factors have positive significance to explain that the non-compliant platforms can quickly gain competitive advantage in the field of Internet finance. Due to the "short-term" of investment and financing transactions in the field of Internet Finance and the "accessibility" of users' conversion between platforms, the dominant position of non-compliant platforms is becoming increasingly obvious in the competition diffusion.

Because the non-compliant platform can obtain competitive advantages in the above four factors compared with the compliant platform in the competition diffusion, and the compliant platform is difficult to survive in such a competitive environment. At the same time, even compliant platforms gradually presents the phenomenon of non-compliant platforms under the guidance of high profits, which also explains the high-yield of platforms in China's Internet financial industry, especially in the field of Internet financial lending platforms. It is shown that non-compliant platforms are more likely to gain competitive advantages in the factors such as period cost, network density of investment and financing transaction customers, transaction proportion of new platform customers and network diversity, which makes the proportion of non-compliant platforms in the Internet financial industry increasing in a certain period of time.

4. Conclusions

In this paper, on the basis of identifying different types of Internet financial platforms, we put forward targeted risk prevention and control suggestions according to the different risk characteristics faced by the platform. On the other hand, we should take comprehensive measures to prevent the formation of market access and high-risk financial platform "Bad money drives out good money" has become the mainstream of Internet financial platform. Based on complex network theory, we study the evolution mechanism of the competition platform in the competitive market. The simulation results show that once the illegal platform appears in the Internet financial field, because of its unreasonable competitive advantage, it will quickly spread in the Internet financial market and occupy the dominant position of the market. It has been verified in the development process of personal online lending platform, and it also explains the reason why our country increases the strict rectification of illegal platforms to make them "zero", which also provides a theoretical basis for increasing the comprehensive risk prevention of Internet Finance in the later stage.

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