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# DIGITAL PAYMENTS IN CHINA: ADOPTION AND INTERACTIONS AMONG APPLICATIONS<sup>1</sup>

## LE PAIEMENT NUMÉRIQUE EN CHINE : ADOPTION ET INTERACTIONS ENTRE APPLICATIONS

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 **Keywords:** mobile-payment, payments in China, electronic wallets, online payment, strategic complementarities

 **Mots-clés :** paiement mobile, paiements en Chine, porte-monnaie électronique, paiement en ligne, complémentarités stratégiques

## 1. INTRODUCTION

During the last decade, mobile phone and smart phone use has increased hugely in China. According to the Ministry of Industry and Information Technology of the People's Republic of China (2020), by the end of 2019, there were 1.6 billion mobile phone users in China, and by 2019 mobile

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phone coverage in China had reached 114.4 sets per 100 people. A particularity of the Chinese situation is the parallel adoption and rapid generalization of mobile payments. Mobile payments have extended the range of consumers, and for most have replaced cash or credit card transactions.

Two applications emerged and rapidly became dominant, i.e. WeChat Pay and AliPay, and account for hundreds of millions of users per month. According to the Tencent Holdings Limited 2019 annual report, there were 1.16 billion active WeChat Pay monthly users at the end of 2019 compared to over 824 million active Alipay users.

A large body of research has examined the reasons for the outstanding success of the services. Some see this success as due to the specificities of the Chinese financial and payment systems. For others, it is due to particularities of the companies' business models or marketing expertise. However, although the research highlights some of the characteristics that are unique to digital payment activity in China, they do not explain why two solutions and not a single one emerged, or why the entrant has become so successful alongside the increased level of penetration of the incumbent. The thesis we develop in this article is that their success is the result of their respective industrial strategies which did not include outright competition during the first few years, nor involve any collaborative agreements or explicit cooperative arrangements.

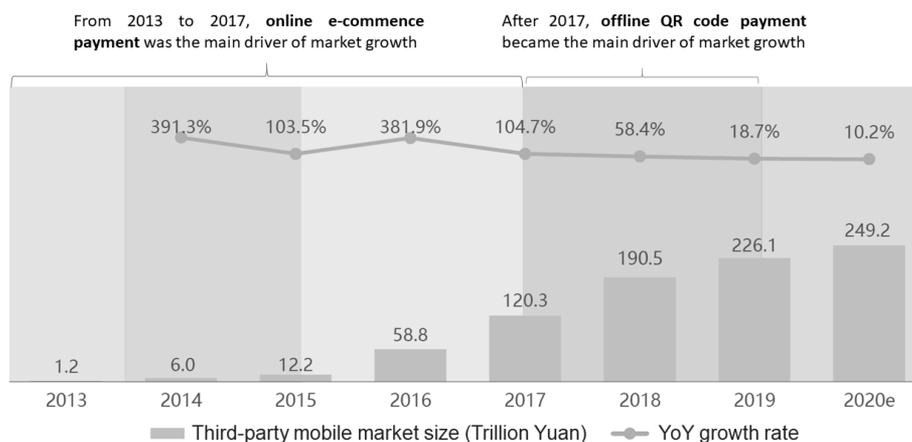
We address this issue by proposing a theoretical setting which mimics the characteristics of the Alibaba and Tencent offers. Far from competing by offering very similar services, the operators mostly differentiated the types of service and utility provided to consumers. However, this model does not explain why the partners decided at a certain moment in time to adopt different strategies, and especially, why Tencent decided to differentiate from Alipay. We assume that the two operators are different, and that the population of Chinese users is heterogeneous. Since the adoption costs for users are not independent, they generate indirect externalities. We can represent this situation formally (very little competition but indirect strategic complementarities) and find that the limited competition between the operators and the indirect positive externalities from adoption were mutually beneficial to each company's diffusion of its services, and ultimately resulted in generalized spread of m-payment services throughout the population.

In section 2 we describe the emergence of the two applications, and review the main arguments explaining their success in the literature. Section 3 and section 4 present the model and the main results. Section 5 concludes.

## 2. TENCENT AND ALIBABA

The adoption of mobile-payment services in China falls into two sub-periods. Up to 2017, online payments were embedded in the services offered by the main providers. After 2017, offline contactless QR code payment became the main driver of market growth.

**Figure 1.** China's third-party mobile payment transaction scale, iResearch (2020), "China's Third-Party Mobile Payment Industry Report 2020", <http://report.iresearch.cn/report/202004/3552.shtml>

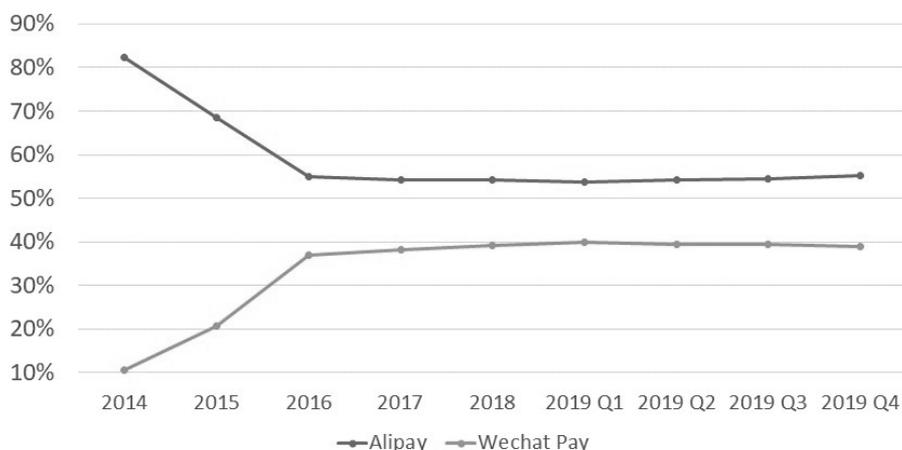


Tencent and Alibaba, two giant information and communication technology (ICT) at the international level, dominate the mobile payment market in China. According to the iResearch Consulting Group (2020) report (see figure 1), in 2019, China's third-party mobile payment<sup>4</sup> transactions reached 226.1 trillion Yuan representing year-on-year growth of 18.7%. China's third-party mobile payment market is highly concentrated: Alibaba's Alipay and Tencent's WeChat Pay are first-tier companies which

4 A third-party mobile payment service is a mobile payment service provided by a non-bank company licensed by the Central Bank.

accounted for nearly 93.8% of the market at the end of 2019 (iResearch Consulting Group, 2020). Based on iResearch Consulting Group (2014, 2015, 2017, 2018, 2019, 2020) reports, it seems that the market shares of Alipay and WeChat Pay have been stable in recent years (see figure 2).

**Figure 2.** Market share of third-party mobile payment in China



## Alipay

With the objective of making it easy to do business anywhere, the Alibaba Group created an online ecosystem which included multiple businesses such as online payments, cloud services, music streaming, maps, retail outlets, mobile operating systems, cloud storage, group buying, car services, mobile messaging, etc.

Alipay was launched originally in 2004 as a department of the Alibaba Group's online platform, Taobao.com, to act as an e-wallet and a one-stop payment portal. In 2005, Alipay embarked on a strategic cooperation with several Chinese banks. In 2008, it launched a public utility payment service and in 2009, introduced a mobile payment service based on its mobile application. In 2011, it was granted a license from the Chinese Central Bank to act as a payments business and in 2013, it launched "Yu E Bao" which gives Alipay users the possibility to buy or redeem wealth management products at the very low purchasing limit of 1 RMB, around 0.13 euro cents (Ant Financial Services Group, 2019).

In 2014, Alipay was rebranded Ant Financial Services Group to serve small and micro enterprises' financial services, and later became a wholly owned subsidiary of Ant Financial (Alibaba Group 2019). Ant Financial is currently one of the world's biggest fintech companies and provides various kinds of financial services in addition to payments.

## WeChat Pay

WeChat was launched in 2011 by Tencent and is the most important app in China, providing instant messaging, social space, online shopping, mini programs, online games, a search engine, etc. WeChat is of major significance for Chinese people's daily lives since it combines the major functions of Facebook, WhatsApp, Instagram, Uber, Apple pay, etc.

WeChat Pay is an in-app payment feature of WeChat. It was introduced in 2013 and has become the second largest payment platform offering O2O, B2C, C2C and P2P services. WeChat was ingenious in its mobile payment service. Traditionally, Chinese people make gifts of red envelopes which contain money, to relatives and friends for occasions such as birthdays, weddings, funerals, etc. Also, children receive their pocket money in red envelopes during the Spring Festival which symbolizes good wishes (Huang, 2019). In time for the 2014 Spring Festival, WeChat introduced its WeChat Red (virtual) Envelope which resulted in the gifting of more than 40 million WeChat Red Envelopes to over 8 million Chinese people. In order to use this function, users needed to link their bank accounts to the WeChat mobile wallet which allowed WeChat to penetrate mobile payments that until then had been dominated by Alipay.

WeChat offered other attractions for customers: (i) WeChat launched a red envelope lucky draw-type gamble which resulted in distribution among a group of a random amount of the money that had been deposited in the envelope on a "first come, first serve" basis, with all the members of the group able to see how much the others had received; (ii) on May 20, 2017, WeChat introduced its special red envelope containing 520 RMB (520 means "I love you" in Chinese) so that young (and not so young) people could send this special red envelope to declare their love for the recipient.

## 2.1. User penetration of WeChat & Alipay

Ipsos (2019) research on third-party mobile payment markets in major Chinese cities shows that: (i) at the end of the 3rd quarter of 2019, the number of mobile payment users in China was about 1,050 billion, among which WeChat Pay and Alipay accounted for respectively 1 billion users and 780 million users; (ii) at the end of 2019, WeChat Pay's and Alipay's respective penetration rates were 92.4% and 72.1 (see table 1); (iii) 21.7% of WeChat Pay users do not use Alipay and 1.4% of Alipay users do not use WeChat Pay; (iv) 70.6% mobile phone users use both WeChat Pay and Alipay; and (v) the total penetration by WeChat Pay and Alipay is 93.8%.

**Table 1. User penetration of WeChat & Alipay**

Time period	2017	2018 Q1 Q2	2018 Q3	2018 Q4	2019 Q1	2019 Q3
Alipay user penetration rates	68,30%	68,70%	63,60%	70,90%	69,50%	72,10%
WeChat Pay user penetration rates	84,80%	85,40%	84,30%	86,40%	89,20%	92,40%
Only Alipay user	4,90%	4,30%	3,50%	6,90%	5,10%	1,40%
Only WeChat Pay user	21,40%	21,00%	24%	22%	24,80%	21,70%
Both Alipay and WeChat Pay user	63,40%	64,40%	60,10%	64,00%	64,40%	70,60%
Total user penetration rates	89,70%	89,10%	87,40%	93,30%	94,30%	93,80%

## 2.2. Users preference: WeChat VS Alipay

The 2019 Q1 China Mobile Payment Market Research Report published by iiMedia Research (2019) describes the two operators as asymmetric in that WeChat Pay offers easier offline payment through QR code payments, whereas Alipay dominates online e-commerce payments. The convenience offered by WeChat Pay makes it more popular for micropayments while most large mobile payments are accomplished through Alipay. In other words, the users of these services tend to differ. Young people prefer WeChat Pay to Alipay whereas the reverse tends to hold for older individuals. People living in big cities are likely to use both services whereas in rural areas penetration can be limited. These facts justify our model assumption that the reasons for the adoption of these services are not correlated; adoption tends to be based on different reasons.

According to Ipsos: 2019 Q3 Third Party Mobile Payment User Research Report (2019), by the end of September 2019, the total number of Chinese Internet users was about 1.598 billion, and the number of users using

mobile phones to surf the Internet was about 1.304 billion. Table 2 shows that mobile payments involved personal transactions 97%<sup>5</sup>, online transactions 93%<sup>6</sup>, offline transactions 95%<sup>7</sup>, and other financial transactions 35%<sup>8</sup>. Except for financial transactions, the other types of mobile payment are used widely and have become routine for Chinese people.

**Table 2.** The usage rates of mobile payment 2019 Q3

	Personal transaction	Online transactions	Offline transactions
Transaction value of Alipay	39%	61%	41%
Transaction volume of Alipay	32%	59%	39%
Transaction value of WeChat Pay	48%	30%	48%
Transaction volume of WeChat Pay	59%	32%	52%

WeChat Pay prevails for personal transactions (CtoC), especially for social transactions such as red envelopes, mobile phone bill payments, and household bills while Alipay continues to dominate for online shopping. Offline transactions are the most active mobile payments sector: WeChat Pay has a slight advantage here, especially in relation to paying for food and drink, and supermarket bills, while Alipay tends to dominate for daily travel and cross-border payments.

### 2.3. The reasons for their success

In the early 1990s, China was a mostly cash economy. However, there was substantial saving and deposit account activity, and the banking system was prepared for imminent digital innovations. In the late 1980s, the banks began to issue debit cards (in greater numbers than credit cards) but their adoption and use was constrained by poor infrastructure (paucity of cash dispensers, terminals) and lack of interoperability among solutions

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- 5 Personal transactions include mobile phone bill payments, “red envelope” payments, utility bill payments, other household payments.
  - 6 Online transactions include payments for online shopping, payments to book leisure & entertainment activities, travel and tourism reservations, online gaming payments.
  - 7 Offline transactions include payments for food and drink, supermarket bills, daily transportation costs, etc.
  - 8 Financial transactions include financial market investments, insurance payments, loan payments.

(Torre and Xu, 2019). The Chinese government's *Golden Card* project resulted in the creation in 2002 of *China UnionPay*. However, although it was an efficient interbank network which facilitated the adoption of credit card payments its success in China was limited. The rapid implementation of fixed Internet connections, followed by 3G and 4G standards, motivated the parallel and rapid interconnection of personal computers and widespread use of smartphones. In turn, this led to the implementation by service providers of e-wallets on laptops and smartphones which connected to the user's bank account and debit card.<sup>9</sup> Alipay and WeChat Pay—the sector leaders—tended to have low transaction costs compared to credit card fees. Also, both third-party payment companies used relatively unsophisticated technology to enable face to face payments which allowed rapid up-scaling and encouraged widespread acceptance of the service.

The size of the Chinese market generates market externalities which frequently benefit the adoption of new products and technologies. However, this advantage often does not extend to the digital realm. Chinese software such as operating systems and search engines, and local brand hardware and components such as laptops, processors, and other electronic devices, found it difficult to compete with goods from abroad. Even Huawei and Xiaomi, which in 2020 represented around 33% of the global smartphone market, accounted for less than 50% of the domestic Chinese market in that year. Thus, the cases of Alipay and WeChat Pay are singular: they account for more than 90% of the mobile payment market in China despite the more sophisticated alternatives offered by Apple, Google, and Samsung among others. The development of m-payments practices then remains at its level an isolated case in China. The literature has proposed supply side and demand side arguments to explain this situation.

On the supply side, the specificities of the Chinese payment system, and the particularities of the Alipay and Wechat Pay business models have been proposed.

- The late interoperability of payment cards probably slowed their diffusion in a population familiar only with cash payments before 2000. This likely promoted adoption of the first Internet Explorer compatible payment solution offered by Alibaba over the fixed

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9 Nowadays WeChat Pay and Alipay support foreign credit cards but in the early stages only Chinese debit cards were accepted for payments.

Internet in 2004, long before the widespread diffusion of smartphones and mobile Internet connections. According to Alibaba Group (2008, 2009, 2010) reports, there were 60 million registered Alipay users at the end of 2007 and this number rose to 100 million by end August 2008, 150 million by end February 2009, and 300 million by March 2010. Alipay's take-up remained stable until the wider diffusion in China of smartphones which would suggest that over time, credit/debit cards and mobile payment solutions were not substitutes but rather developed quite slowly and in parallel in the early years. After this initial phase and with the introduction of mobile payment services in the late 2010s, the increased penetration of credit cards suggests (see Weng, 2020) that their introduction helped rather than hindered Alipay and WeChat Pay services adoption. This is underlined by the fact that Alipay and WeChat Pay e-wallets were often linked to credit or debit cards, thus payment cards and mobile payment devices became complements rather than substitutes for mobile-payment apps. Therefore, apart from the very first years after Alipay's introduction, the view that the late development of credit cards networks explains the joint success of the duopoly of m-payment service providers in China is not supported.

- Next, let us consider the Alibaba and Tencent business models. Alibaba represents a huge market and Tencent is an original virtual platform (see Yang, Li Sun, Los, 2016). Unlike Amazon, Alibaba acts purely as an intermediary between sellers and buyers,<sup>10</sup> while Tencent offers very different services such as games, social networks, and cloud storage, and attracted advertisers interested in younger mobile users. Alibaba transaction costs are quite high for sellers but more reasonable for buyers. Tencent/WeChat's revenue derives from a range of initiatives but mostly from games and

<sup>10</sup> The term "transactional two-sided platform" is a somewhat confusing label for an intermediation platform between buyers and sellers. Clearly, a higher number of sellers increases the number of buyers and vice versa. The positive effect of supply on demand, and the positive effect of demand on supply complies only with the "law of supply and demand" and nothing else. This makes the notion of a transactional two-sided platform spurious and confusing in terms of the idea of a "two sided market" which should be used only to describe those cases where the platform does not act as an intermediary (or at least mainly as an intermediary) between two populations both of which generate and benefit from externalities.

online shopping, and over the years, has come more and more from advertising. Alipay represents an additional way for Alibaba to earn revenue and retain its users. WeChat promoted WeChat Pay services which provided a new target for advertisers and additional revenue for the platform. Finally, Alibaba's installed base undoubtedly was instrumental in promoting adoption of Alipay services, while WeChat's two-sided platform was increased by the introduction of WeChat Pay. However, what is surprising is that Alipay continued to develop after the emergence of the new and dynamic competitor WeChat Pay which proposed very competitive fees. At the same time, Tencent/WeChat's flexible business model cannot by itself explain why WeChat Pay succeeded in a market already dominated by the incumbent Alipay which had created the original market. In other words, the competitors' business models do not explain the mobile payment tsunami which occurred in China.

We turn now to the demand side arguments for the incredible success of these two apps, and the importance of fundamentals, perceptions, and social influences for explaining the adoption of Alipay and WeChat Pay services.

The fundamentals refer to the advantages or benefits of the services offered such as compatibility and ubiquity (Mu and Lee, 2017). Early adopters of Alipay were interested in the performance of the system *i.e.* its capacity to conclude an online transaction rapidly (Guo, Huang, and Craig, 2015). The security or perception of the security of the service (Xu, 2017, Li; *et alii*, 2019) is also important as is the balance between its risks and benefits (Xu, 2017): adoption depends on the service being reliable, advantageous, and low cost.

Perception can be important when fundamentals are not completely observable. Perceived utility (Li, *et alii*, 2019) is the subjective counterpart of the return from the service. Perceived convenience and security were important for the adoption of Alipay services (Choi and Sun, 2016). Trust includes perceived risks and benefits. Trust has a subjective component but also depends on social interactions and influences. Thus, there are sociological explanations for the rapid adoption of WeChat Pay services (Guo, Huang, and Craig, 2015; Wang and Gu, 2017). Reputation, personal experience, and imitation generated trust in mobile payment services

which were perceived as more reliable and more convenient than cash or other traditional substitutes.

These supply and demand arguments seem to apply to some of the features of adoption of mobile payment in China. However, they do not explain the stable duopoly and near-absence of aggressive competition among the actors during the early years. Neither does it explain the sequential emergence of these competitors and the lack of concrete efforts from the incumbent to prevent the entrant from increasing its market share and achieving leadership in the number if not the value of transactions. Our illustrative model (see section 3) uses industrial organization arguments to explain the exceptional success enjoyed by both actors.

### 3. AN ILLUSTRATIVE ADOPTION MODEL

The model presented in this section captures the strategies of two service providers/operators specialized in different online services and their proposition of a mobile payment service for their clients. They face a population of heterogeneous consumers with different propensity to consume their initial services and different interest in using mobile payment services. The marginal costs of adopting m-payment services decreases with the number of services adopted. The model considers only the rational decisions of operators and consumers and is studied at stable sequential stationary equilibria. Agents (operators and clients) interact but their decisions are sequential which captures the leading roles of the services providers.

#### 3.1. Potential users and payment services

There is a unit mass of potential users consuming different bundles of material, immaterial, and virtual goods which provide the same basic intertemporal utility  $\bar{u}$ . They are uniformly distributed in a square unit area<sup>11</sup> and characterized by two coordinates  $(i, j)$ ,  $(0 \leq i \leq 1, -1 < j \leq j + 1)$ , with  $j < 0$ . The abscissa coordinate  $i$  captures the propensity of user  $(i, j)$  to buy online on the Alibaba platform, and consequently the propensity

<sup>11</sup> Using a rectangle instead of a square does not change the results.

of the user  $(i, j)$  to use the Alipay services. The ordinate  $j$  measures the propensity of the same consumer to use WeChat services, and other joint interactive services and applications provided by Tencent. Given that the use of WeChat services is time consuming and leisure oriented, they can generate positive or negative utility which explains the negative lower bound of  $j$ .

Given the initial preference of the population for cash payments in a country with a low level of penetration of credit cards, all adoption of digital payment entails a subjective cost for the payer. However, the marginal cost of adoption decreases with the number of different services adopted. The cost is  $c$  if the user  $(i, j)$  adopts only one digital payment service, and is  $c'$ , ( $c' < 2c$ ) if the user adopts both Alipay and WeChat Pay services. Alipay provides to user  $(i, j)$  an instantaneous advantage  $ai$  where  $a$  relates to the quality of the Alipay service. Each user has an advantage also from the payment services offered by Tencent. This advantage stems from access to the *Red Envelope* service and other services involving interaction with a payee but depends on the number of WeChat users since it is linked to the capacity of the sender of a Red Envelope to identifying a receiver who uses the WeChat service. In this case, it gives the sender an instantaneous utility  $b'n_W$ ,  $0 < b' < 1$  additional to its current utility  $j$  as a WeChat user, where  $n_W$  is the number of WeChat users following access to the WeChat Pay service.

Each user has two choices to make: paying online via the Alipay application or not, and using the WeChat Pay service or not. These services do not compete. There is only one complementarity link between the two decisions: adoption of digital payment using one of the two services decreases the cost of adoption of the other m-payment service if the latter service is available and is adopted by the user. Given this, the utility of user  $(i, j)$  is the maximum among the following four expressions:

$$u(i, j) = \bar{u} + \max \left\{ 0, \frac{j}{r} \right\} \quad (1)$$

$$v(i, j) = \bar{u} - c + \frac{ai}{r} + \max \left\{ 0, \frac{j}{r} \right\} \quad (2)$$

$$w(i, j) = \bar{u} - c + \frac{j}{r} + bn_W^e \quad (3)$$

$$t(i, j) = \bar{u} - c' + \frac{ai}{r} + \frac{j}{r} + bn_W^e \quad (4)$$

where  $b = \frac{b'}{r}$ ,  $r$  figuring the rate of interest<sup>12</sup>. Expression (1) describes the intertemporal utility of user  $(i, j)$  as a cash only user. This utility is additional to the basic intertemporal utility and the intertemporal utility provided by the WeChat (free) basic programs (games, movies, mini-programs, etc.) if agent  $(i, j)$  has any interest in these apps<sup>13</sup> (if  $\frac{j}{r}$  is positive). Expression (2) describes the utility of the same agent who decides to use the Alipay online payment services: the net intertemporal additional utility of this service is  $\frac{ai}{r} - c$ . Expression (3) corresponds to the adoption of the WeChat Pay service. The net utility provided is  $bn_W^e - c$ , where  $n_W^e$  corresponds to the expected number of users of the WeChat Pay service. In this case, since the mobile payment app represents an advanced functionality of WeChat, the basic functionalities must be accepted by the WeChat Pay user even if they involve a disutility: this is the reason why the value of  $\frac{j}{r}$  is not truncated at 0. Last, expression (4) represents the utility of an agent who uses both payment systems. In this case, the cost of adoption  $c'$  is such that  $(c < c' < 2c)$ .

### 3.2. Alipay and Tencent

Both service providers offer a particular activity which is not mutually competitive. The payment services they provide for free allow them to increase their income either directly or indirectly. The Alibaba business model is mostly a marketplace<sup>14</sup>. Every Alipay payment service adopter increases the profits of Alibaba generated by Alipay. To simplify the benchmark, we suppose that the profits generated by Alipay are proportional to

12 More explicitly,  $b = \frac{b'}{r} = \lim_{r \rightarrow \infty} \sum_{t=1}^T \frac{b'}{(1+r)^t}$ .

13 For simplicity, we consider the network externalities involved in this generic WeChat application content to be negligible. Including a specific externality associated to this generic content (for instance free social network) would serve only to make the model more complex and add another loop but without qualitatively changing the results.

14 The diversification of Alibaba's activities from pure intermediary to a more versatile platform provider introduces cross externalities among diverse segments of its activity. Integrating these evolutions explicitly complicates the model without changing the results which is why we ignore them in our setting.

the number of users. Then, the intertemporal profit generated by Alipay is given by the expression (5),

$$\pi_A = n_A \bar{\pi}_A - \alpha a \quad (5)$$

where  $\bar{\pi}_A$  is the unit intertemporal discounted income generated by each user of the Alipay service which we suppose is independent of the number of users<sup>15</sup>.  $a$  captures the quality of the service provided by Alipay to users of Alipay service, and  $\alpha$  is a positive constant which captures the cost corresponding to the quality  $a$ .

Tencent offers a range of different basic services associated to online interactions (instant messenger, mini program, games, etc.). To make the setting as simple as possible, we suppose that Tencent's income is generated only by its two sided market nature<sup>16</sup>: the larger the number of adopters of WeChat Pay, the greater the advantage for advertisers e.g. the higher the cost of advertising and the greater the number of advertisers. Symmetrically, the higher the number of advertisers and messages, the more important the information available to end-users who might choose to consume the advertised goods and services. Only the user to advertiser externalities generate direct income for WeChat. This suggests that we should consider the externalities generated by users for the platform's income without explicitly introducing the advertisers involved. Finally, the intertemporal profit of Tencent is given by expression (6):

$$\pi_T = \max \{ \pi_w, \pi_W \} \quad (6)$$

with  $\pi_w = n_w \bar{\pi}_T$ , and  $b = 0$ , and  $\pi_W = (n_W \bar{\pi}_T - \beta b)$ , where  $n_w$  is the number of WeChat services users if WeChat Pay is not provided,  $\bar{\pi}_T$  is the intertemporal discounted unit profit generated by the users of WeChat services,  $\beta$  is a positive constant, and  $\beta b$  includes the cost corresponding to the WeChat payment service.

Each service provider chooses its strategy: Alipay decides to offer or not its m-payment service, and Tencent decides to implement or not the Red

<sup>15</sup> In reality this profit would include fixed costs whose weight would decrease with the number of users. To avoid complicating the model we ignore them.

<sup>16</sup> This simplification has no real effect on the results.

Envelope service and the joint WeChat Pay service which is equivalent to choosing the term which maximizes expression (6).

### 3.3. Sequence and solution concept of the game

Given the chronology of the digital payment services offers, we assume that Alibaba is the leader.<sup>17</sup> Then, in the short term, the sequence is as follows: in the first step of the game, Alibaba determines to offer or not its Alipay service to users. In the second stage, given the choice made by Alibaba, Tencent decides to offer or not the *Red Envelope* and WeChat Pay services. In the third stage, consumers choose to adopt or not a single digital payment service, or both services, or to consume the Alibaba and WeChat services minus the mobile payments' facilities.

The relevant solution is the subgame perfect equilibrium of the game associated to the sequence described above. Given the externalities generated by the WeChat Pay service, the number of adopters depends on the number of users of the service with whom they could interact. We consider a stationary equilibrium where expectations (of the number of service adopters) are fulfilled. To study the inter-period sequential pattern of the economy outside the stationary equilibrium, we use order 1 autoregressive expectations.

When expected and effective WeChat Pay users coincide, the subgame perfect equilibrium is then specified as a perfect expectation concept.

## 4. RESULTS

The model is solved backwards. Given the decisions of the service providers, each user chooses between the four possible strategies associated to expressions (1) to (4). Tencent expects these decisions rationally, and, given the quality of services previously offered by Alipay, decides to offer or not the services associated to WeChat Pay. Alipay expects all subsequent reactions rationally when it determines its own service offer  $a$  in the first step of the game.

<sup>17</sup> We tested the reverse sequence; this did not change the results.

## 4.1. Third stage of the game

We begin with the third stage of the game where consumers have to choose between adopting one, both, or none of the services.

Lemma 1 sets the necessary condition between  $a$ ,  $b$  and  $c$  to make WeChat Pay adoption possible.

**Lemma 1.** If some users adopt WeChat Pay alone or Alipay alone, then  $\min(a, b') \geq cr$ .

*Proof:* Given that the cost of adoption of a single service is at least  $c$  and that  $i \leq 1$ , no user will adopt Alipay service in the third stage of the game if  $cr > a$  e.g. if the most intensive online buyer shows no interest in adopting it. Similarly, since  $n_W^e \leq 1$ , no agent will adopt WeChat Pay alone if  $c > b$  and  $b' > cr$ . ■

There are two possibilities: in the first case, the WeChat Pay service is offered, and in the second case it is not. We define a Nash equilibrium of adoption of the third step of the game as the situation where the actual number of adopters of the WeChat Pay service corresponds to the number of expected adopters among potential users e.g. such that  $n_W = n_W^e$ .

We then derive lemma 2 corresponding to the distribution of users at the Nash equilibrium:

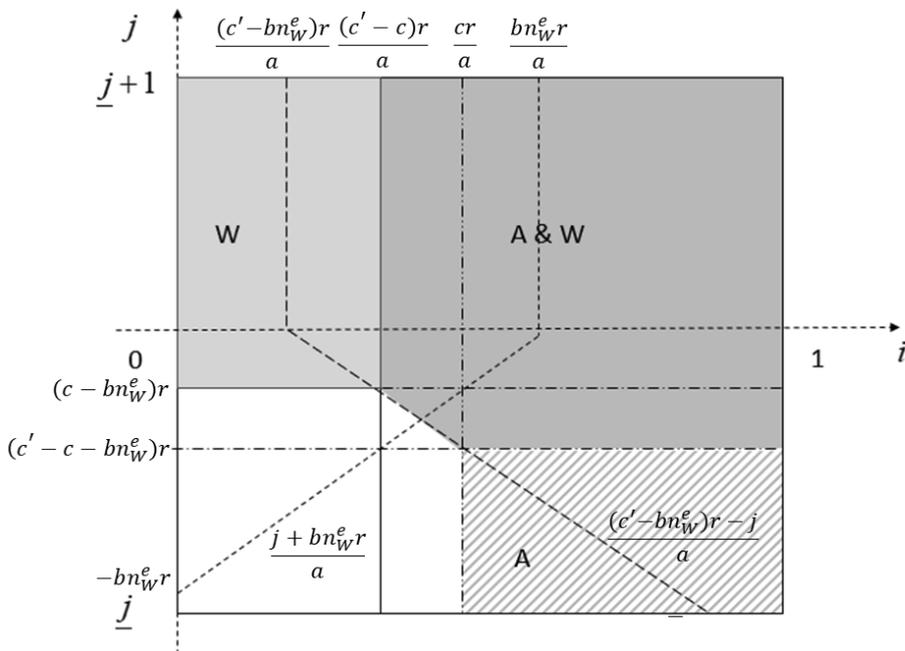
**Lemma 2.**  $\forall a, b, c, c'$  satisfying Lemma 1, and given expectations  $n_W^e$  about the level of adoption of the WeChat Pay service, the study of the third step of the game provides the following distribution of users:

- (i) users  $(i, j)$  such that  $i \leq cr/a$ ,  $j \leq (c - bn_W^e)r$ , and  $j \leq -ai + (c' - bn_W^e)r$  are pure cash users,
- (ii) users  $(i, j)$  such that  $i \geq cr/a$ , and  $j \leq (c' - c - bn_W^e)r$  are Alipay users,
- (iii) users  $(i, j)$  such that  $i \leq (c' - c)r/a$ , and  $j \geq (c - bn_W^e)r$  are WeChat Pay users,
- (iv) users  $(i, j)$  such that  $j \geq -ai + (c' - bn_W^e)r$ ,  $i \geq (c' - c)r/a$  and  $j \geq (c' - c - bn_W^e)r$  are both Alipay and WeChat Pay users.

Proof: see Appendix. ■

Figure 3 illustrates this for given values of  $a, b, c, c'$  and  $n_W^e$ . We observe four different zones. To the right of the vertical line  $i = \frac{cr}{a}$  are consumers able to adopt the Alipay service even without provision of the WeChat Pay service. Above the horizontal line  $j = (c - bn_W^e)r$  are consumers able to adopt the WeChat Pay service without the introduction of the Alipay services. The area shaded dark gray represents consumers who adopt both services when the Alipay and WeChat Pay services are proposed together. Note that this area is wider than the former two i.e. some Alipay adopters who would not adopt the WeChat Pay service if it were proposed on its own would adopt it if both services are proposed together (and vice versa). Overall, we observe also that some consumers who would not adopt either one of the applications they proposed on their own, would adopt both if they are proposed together.

**Figure 3.** Distribution of Alipay users (A), WeChat Pay users (W) and both Alipay and WeChat Pay users (A & W) according the type  $\{i, j\}$  of agents, for given values of  $a, b, c,$  and  $c'$



Unlike the Alipay service, theoretically WeChat Pay integrates potential success or failure due to the role of externalities. This is a general result: when a technology generates positive externalities there can be many equilibria for the same parameters, values, and decision variables. Therefore, we need to study this potential for Alipay given parameters and decision variables. To do this, we consider that the introduction of mobile-payment services occurs after a first period when Alibaba and Tencent already provide the basic services of an online marketplace and of a versatile platform without mobile-payment service. In this case, the number of WeChat users is given by  $n_w = \underline{j} + 1$ . Then Lemma 3 is derived:

**Lemma 3.** With order 1 autoregressive expectations, the stage 3 equilibrium is always unique and sequentially stable if  $\frac{c}{\underline{j}+1} \leq b < \frac{1}{r}$ .

*Proof:* see Appendix. ■

It is not surprising that the level of  $b$  e.g. the utility generated by the possibility to make CtoC payments is an important determinant of the success of the WeChat Pay service. This level of  $b$  is determined by the fundamental qualities of the WeChat Pay service (possibility to make reliable and rapid interpersonal transfers and payment) and by initiatives such as the Red Envelope and associated services proposed by Tencent which provide network externalities among users.

## 4.2. Second stage of the game

We next limit the study to the values of  $b$  satisfying Lemma 3. The following lemma verifies the existence and the unicity of the game equilibrium restricted to stages 2 and 3.

**Lemma 1.** Whatever the level of the parameters and controls of Alipay, a perfect expectations equilibrium of the subgame restricted to stages 2 and 3 of the initial game always exists. It is unique, except in cases of vanishing measure.

*Proof:* Given Lemma 2, and whatever  $a$ , the number of WeChat clients when the WeChat Pay service is not offered is  $n_w = \underline{j} + 1$  and, according to (6),  $\pi_T = \pi_w = n_w \bar{\pi}_W$ . The service is offered if

$$n_W = \min \left[ 1, \frac{1}{1 - rb} \left( \underline{j} + 1 - cr + \frac{(2c - c')^2 r^2}{2a} + (2c - c')r \left( 1 - \frac{cr}{a} \right) \right) \right]. \quad \blacksquare$$

Given Lemma 3, whatever the values of  $a, c, c', b, r, n_W$ , can be defined according to expression (6),  $\pi_W = n_W \bar{\pi}_W - \beta b$ . Comparison between  $\pi_W$  and provides unambiguous results which prove the existence. Except for isolated cases of parameters such that  $\pi_W = \pi_W(n_W)$ , the choice of Tencent between implementing or not WeChat Pay service is unique.

Lemma 4 shows that Tencent's decision is unambiguous. Note also that if it is possible to adjust the level of  $b$  in a continuous way with linear costs, we could obtain a corner solution. The expression of  $n_W$  in the function  $b$  is such that its first and second derivatives are positive until the limit of full adoption  $n_W = 1$  is obtained. This evolution would make the profit  $\pi_W$  increasing with  $b$  given the linearity of the costs  $\beta b$ . Consequently, the possibility to adjust  $b$  with linear costs would fuel a scenario of full adoption of the WeChat Pay service. However, this observation can be tempered by two remarks. The first is that the level of  $b$  depends partly on non-technological components such as the innovativeness of advertisers and marketers, which probably is limited to a moment in time or is subject to increasing costs. The second is that the utility functions we chose do not include reluctance to adopt m-payment by a part of the population (older or rural populations) whatever the advantages of the services. These effects naturally would exclude a corner solution of full adoption even with WeChat Pay service linear costs.

### 4.3. First stage of the game and joint results

In the first stage of the game, Alipay decides to implement or not its own payment service, taking account in its decision of the expected reactions of its partner and consumers. Proposition 1 is then derived:

**Proposition 1.** Whatever the values of parameters, the equilibrium of the game exists and is unique.

*Proof:* The profit of Alibaba generated by Alipay service is given (see Figure 3) by

$$\pi_A(n_W) = \min \left( 1, \left[ 1 - \frac{cr}{a} + \frac{(2c - c')^2 r^2}{2a} + \frac{(2c - c')r}{a} (\underline{j} + 1 + (bn_W - c)r) \right] \bar{\pi}_A \right) - \alpha a$$

when the number of Wechat user is  $n_w$  and by  $\pi_A(n_w) = \min(1, 1 - \frac{cr}{a})\bar{\pi}_A - \alpha a$  when the number of WeChat user is  $n_w$ . Given that  $2c' - > 0$ ,  $\pi_A(n_w) > \pi_A(n_w)$  2 cases are then possible:

- (i)  $\max(\pi_A(n_w), \pi_A(n_w)) < 0$ : in this case, Alibaba does not implement the m-payment service;
- (ii)  $\max(\pi_A(n_w), \pi_A(n_w)) \geq 0$ : in this case, Alipay is implemented. ■

The equilibrium then always exists and is unique.

The existence solution is not surprising given the standard form of all the objective and adoption functions which involve no discontinuity in the variables. The result of uniqueness is more interesting. Multiplicity might have emerged given the positive effects generated by the adoption of each service on the other service. This situation might be the result of the unpredictable risk of success or failure of the WeChat Pay service. Network externalities often generate this situation of potential coordination failure where the same parameter levels can generate different stable stationary equilibria. In the present case, as observed in Lemma 3, this situation is excluded given the installed base of WeChat. Since there is no reason to consider the same role of network externalities for the Alipay service (no CtoC payment), the first round of the game does not add specific risk of multiplicity.

We need to comment also on the expression  $\pi_A = \min(1, 1 - \frac{cr}{a})\bar{\pi}_A - \alpha a$  corresponding to Alipay's profit if the WeChat Pay service is not proposed. Historically, this corresponds to the profit generated by Alipay before the availability of WeChat Pay. This profit presumably is positive since the app was launched in 2004 and persisted between 2004 and 2013 when the WeChat Pay service was introduced. This makes irrelevant one of the cases covered by proposition 1.

#### 4.4. General results

This section examines from an industrial economics point of view the reasons for the successful implementation of the two services. We limit to comment the interior solutions in  $n_T$  and  $n_A$  which seem relevant until the situation of full adoption. Note  $\gamma = 2c - c'$  the adoption cost saved by an agent

and the level of adoption of each service increases with the quality of the other service.

*Proof:* From Lemma 4,

$$n_W = \min \left[ 1, \frac{1}{1-rb} \left( \underline{j} + 1 - cr + \frac{\gamma^2 r^2}{2a} + \gamma r \left( 1 - \frac{cr}{a} \right) \right) \right] \quad \text{when Alipay}$$

is proposed. Then,  $\frac{\delta n_W}{\delta a} = \frac{1}{1-rb} \left[ \frac{\gamma r(c-\gamma)}{2a^2} \right] > 0$ . Consequently, given

expression (6), and all things equal,  $\frac{\delta \pi_W}{\delta a} > 0$ . Given that  $n_W$  and

$\pi_W$  do not depend on  $a$ ,  $\frac{\delta \pi_T}{\delta a} > 0$  and the break-even of WeChat

Pay service decreases when  $a$  increases. Similarly, given that

$$n_A = 1 - \frac{cr}{a} + \frac{(2c-c')^2 r^2}{2a} + \frac{(2c'-c)r}{a} \left( \underline{j} + 1 + (bn_W - c)r \right),$$

and the expression of  $\pi_A(n_W)$ ,  $\frac{\delta \pi_T(n_W)}{\delta b} > 0$  is sufficient to obtain the symmetric

effect for Alipay profit. Writing  $B = \left( \underline{j} + 1 - cr + \frac{\gamma^2 r^2}{2a} + \gamma r \left( 1 - \frac{cr}{a} \right) \right)$ ,

$$\frac{\delta \pi_T(n_W)}{\delta b} = \frac{r}{(1-rb)^2} B \bar{\pi}_T - \beta. \quad \text{This expression vanishes for}$$

$$b = \frac{1 \pm (1 + \beta/rB\bar{\pi}_T)^{1/2}}{r}. \quad \text{Given the values of parameters, only one of}$$

the solutions is positive, namely  $b_1 = \frac{1 + (1 + \beta/rB\bar{\pi}_T)^{1/2}}{r}$  with  $b_1 \gg 1$

given that  $r \ll 1$ .  $\frac{\partial^2 \pi_T(n_W)}{\partial b^2} = \frac{(1+r^2b^2-2rb-2r^3b+2r^2)B\bar{\pi}_T}{(1-rb)^4}$  is always negative

for realistic values of  $r$  when  $b = b_1$  which then is a maximum.  $b_1$  is also

such that  $rb_1 > 1$  which given Lemma 1, implies that when  $n_W$  is interior,

the actual value of  $b$  is smaller than  $b_1$ . In the neighborhood of the value

of  $b$ , we can verify that  $\frac{\delta \pi_T(n_W)}{\delta b} > 0$  as soon as  $n_W$  is not a corner. From

the sign of  $\frac{\delta \pi_T(n_W)}{\delta b}$ , we can derive  $\frac{\delta \pi_A}{\delta b} > 0$  if  $n_W$  is interior, and that the

Alipay break-even consequently decreases if  $b$  increases. ■

Propositions 2 and 3 address most of the questions raised about the success of these two service providers. The entry of WeChat Pay increased the number of Alipay service users and increased its profit. Thus, there was

no reason for Alipay to prevent the entry of the competitor. The word of competitor is even poorly adapted: as the same service was not proposed in the initial phase of the two apps implementation, the two competitors had mutual advantage to be gained from their simultaneous development. The advantage that the entry of WeChat Pay provided to Alipay was reciprocal: the early adopters of Alipay were also the first adopters of the WeChat Pay service. Proposition 4 summarizes these observations.

**Proposition 4.** Alipay's existing offer increased the chances of success of Tencent's offer of m-payment services and the offer of Tencent increased the success of Alipay's digital payment service.

*Proof:* The proof is a direct consequence of propositions 2, and 3. ■

Propositions 2 to 4 represent the coexistence of the Alipay and WeChat Pay services as the ideal case where strong strategic complementarities within an industry fuel the rapid development of two companies using quite similar technologies but with different installed bases and specialization. However, there are two clear limits to this scenario.

- The first is already operating: as the situation of full adoption becomes closer, each partner will be tempted to offer the same service as its competitor is offering. The Alipay services now are available offline and for small payments while WeChat Pay is offering asset management services—initially a possibility offered by Alipay only to its older aged users. Increasing competition in a market where the effects of strategic complementarity have already been exploited can provide different results. For instance, the rate of penetration of one app could decrease if both providers offer the same service.
- The second limit of the scenario is also associated to the nearness to full adoption. The intuition is as follows: when in the absence of a competitor, a given improvement in the payment technology is followed by a large increase in the level of adoption of a given service, there is an incentive for the service provider to invest in technology improvements. However, if the number of potential adopters decreases due to the strategic complementarity which increased adoption previously, the service provider will have little interest in incurring similar R&D costs. This situation is likely to become relevant to both competitors soon in the Chinese context.

## 5. CONCLUSIONS

Alipay and WeChat Pay dominate the Chinese m-payment market. Brunnermeir, James and Landau (2019) point out that they produced an inversion in the hierarchy of activities between finance and payment: “payments are at the center of any economic platform, and all other activities would organize themselves around the central payment functionality”. This inversion has an industry origin: the decisions of Alipay and WeChat Pay to provide very accessible means of payments to clients and users. The industrial organization approach proposed in this article completes the usual analysis which locates the reasons for the companies’ success in the financial environment of the Chinese economy. Undoubtedly the low level of organization of the credit/debit card system helped Alipay’s emergence. However, following the introduction of UnionPay which corresponds to the Visa/Mastercard system, the two Fintechs did not reduce their activity but rather increased it.

The moment when WeChat Pay proposed its service was statistically speaking at the origin of the generalization of both systems. The simplified setting presented in this paper shows that the differentiation of the proposed initial service allowed Alipay and WeChat Pay to benefit from indirect positive externalities but without competing initially over provision of the same service to the same population. Since the services were different, the adoption of both systems by the active fringe of the population was not illogical. In this situation, the adoption costs supported during the first adoption proved to be a way to reduce the adoption costs of the second adoption. Without explicitly cooperating, the two companies initially avoided competing over specific services. Many developments were positive for both partners; any technology improvements by one partner boosted the activity of the other. The differentiation of business models echoes the differentiation of services (Calzano and Polo, 2020).

Despite both companies being cautious about extending their activities beyond China, they seem progressively to have adopted a more traditional approach to competition. Both the solutions are now available for proximity payments and cover a large range of banking services. At the same time, each application retains its specialization in remote payments (online markets for Alipay, chatrooms, small transfers, social networks for WeChat Pay). The next chapter of the Fintech emergence in China will

probably focus on the companies' consolidation and on their decisions whether or not to export their models outside of China.

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## APPENDIX: DERIVATION OF STEP THREE RESULTS

*Proof of lemma 2:* Step 3 of the game distributes potential users among four sub-categories: those who do not adopt e-payment services, Alipay services adopters, WeChat Pay service adopters, and consumers who use both services. This distribution is derived from expressions (1) to (4). Namely:

- (i) Expressions (1) and (2) determine the threshold straight line  $i = cr/a$ .
- (ii) Expressions (1) and (3) determine another threshold straight line  $j = (c - bn_W^e)r$ .
- (iii) Expressions (1) and (4) determine other threshold values of parameters. For all  $j \leq 0$ , the threshold is  $j = -ai + (c' - bn_W^e)r$ . For  $j \geq 0$ , it is  $i = (c' - bn_W^e)r/a$ .
- (iv) The threshold curve between expressions (2) and (3) is also  $j = ai - bn_W^e r$  for  $j \leq 0$  and  $i = bn_W^e r/a$  for  $j \geq 0$ .
- (v) The threshold curve between expressions (2) and (4) is  $j = (c' - c - bn_W^e)r$ .
- (vi) Expressions (3) and (4) determine another threshold straight line  $i = (c' - c)r/a$ . ■

Given that  $bn_W^e > c > c' - c$ , these threshold curves determine 21 different subsets in the set of potential users. After comparison among the 6 conditions, these 21 subsets determine 4 sub-populations, namely cash only users, Alipay services users, WeChat Pay services users, and consumers using both Alipay and WeChat Pay services. Those populations are distributed in the square as shown in Figure 3.

*Proof of lemma 3:* In the absence of any m-payment service offers ( $a = b = 0$ ), users  $(i, j)$  consuming WeChat services are such that  $j > 0$ . The total number of WeChat basic service adopters then initially is  $\underline{j} + 1$  (with, as previously defined,  $\underline{j} < 0$ ). Suppose now that only the WeChat Pay service is available. If every WeChat user takes the current number of WeChat users as potential WeChat Pay users, they will adopt WeChat Pay services if  $w(i, j) \geq u(i, j)$ , e.g.  $b(1 + \underline{j}) \geq c$ . Suppose then that  $b(1 + \underline{j}) = c$ . Then all previous WeChat users will adopt WeChat Pay services without any increase in the number of WeChat services. If  $b(1 + \underline{j}) > c$ ,

the dynamics of the WeChat Pay (and WeChat) last user takes the form  $j^{t+1} = \max [j, rbn_W^t - r(b - c) - rb(1 + j)]$  where  $j^t$  denotes the smallest  $j$  user of WeChat Pay in the period  $t$  ( $n_W^t = 1 + j - j^t$ ). Given that  $b(1 + j) \geq c$  and that  $1 + j < 1$ ,  $b > c$  the condition  $b < \frac{1}{r}$  is sufficient to verify the value of  $j$  such that  $j^{t+1} = j^t$  is negative. Without considering the lower bound  $\underline{j}$  of  $j$  the sequential dynamic equilibrium then becomes  $j^* = \frac{r(c - b(1 + \underline{j}))}{1 - rb}$ . Given the negativity of the numerator,  $j^* < 0$  when  $rb < 1$ , this same condition also ensures the stability of this equilibrium. This stability persists if  $j^* < \underline{j}$ . Finally, the stationary equilibrium of the dynamics of partial adoption is  $j^* > \underline{j}$  e.g.  $(b - c) > -\underline{j}/r$ . If the Alipay service is also available, the scenario does not change. Following introduction of the WeChat Pay service, agent  $(i, j)$  will adopt it if  $\max(w(i, j), t(i, j)) \geq u(i, j)$ . The condition  $b(1 + j) \geq c$  is still sufficient to avoid adoption failure with adaptive expectations. Figure 3 shows that the expression of  $n_W$  now becomes more complex. After simplification, the sequential dynamics of the population of WeChat Pay users can be denoted  $n_W^{t+1} = \min [1, rbn_W^t + (1 + j) - cr + \frac{1}{2a}(2c - c')^2 r^2 + (2c - c')r(1 - \frac{cr}{a})]$ . The condition  $rb < 1$  still ensures stability of this equilibrium which can be interior or not according to the values of  $a$  and  $b$  in particular. ■