PREANNOUCEMENT STRATEGY OF PLATFORM-TYPE NEW PRODUCT FOR COMPETING PLATFORMS: TECHNICAL OR MARKETING INFORMATION

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ABSTRACT. What message should be released to consumers and developers is an important part of the preannouncement strategy of platforms’ new product. From the perspectives of consumers and developers’ information perceptions, we develop a game model of two-sided market, which can better describe the impacts of information preannouncement on consumers, developers, and platforms behavior in a competitive environment. There are two preannouncement strategies: Technical or marketing information. Our studies reveal that (i) when the development capabilities are heterogeneous enough, both platforms release technical information; (ii) both platforms preannounce marketing information when the heterogeneity of development capability is sufficiently small, even if it decreases total social welfare; (iii) the platform lacking competitive advantage is more inclined to adopt a strategy different from the competitive advantage platform, and competitive advantage platform is likely to change the preannouncement strategy constantly; (iv) the heterogeneity of platforms is the prerequisite for the asymmetric equilibrium, even if it may decrease the overall social welfare.

1. Introduction. New product preannouncement (NPP for short) is an important means of marketing for platforms. How to choose the message of NPP (marketing or technical information) has become one of the prominent business edges for market competition [4, 31, 33, 38]. Business practices show that the message of NPP not only can bring huge returns to platforms, but also incur potential risk, because NPP’s information may affect future market expectations and strategic choices of all stakeholders [3, 30, 31]. As a form of network economy, there are many NPP in the two-sided markets recently. For instance, Apple preannounced its operating

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system iOS12 in the world developers conference on June 2018\(^1\), Xiaomi released a marketing push “We are really 6” on its official WeChat account and preannounced some key performances on April 10, 2017\(^2\), and Huawei revealed its operating system Harmony OS on August 9, 2019\(^3\), respectively. There are many similar example, such as game console controllers (e.g. We Game, Nintendo and Xbox), computer operating systems (e.g. Windows and Mac OS), and mobile handsets (e.g. iOS and Android). We call this as Platform-type New Product Preannouncement (PNPP for short).

According to the existing literature, scholars mainly focus on whether, when, how and how much money to make NPP under one-sided market, such as Bayus et al. [4], Lee and Oconnor [23], Lilly and Walters [24], Su and Rao [31], Zhang et al. [38], and Villena and Contreras [35]. Few studies focus on preannouncement strategy in the two-sided market. Lack of preannouncement strategy research has been difficult to meet the needs of a large number of preannouncement strategy management problems. Our studies show that there exist many differences between two-sided market and one-sided market, such as strong cross-network may distort equilibrium and reduce the power of platforms making preannouncement strategy. In addition, the heterogeneity of developers’ APP development capacities and differences of platforms’ competitiveness all have a direct effect on preannouncement strategy.

In addition, as a way of communication between platforms and users (consumers and developers), NPP may affect some consumers’ consumption budget and schedule [33,37]. For example, Xbox Project director Phil Spencer said, “By preannouncing Project Scorpio today, we want to give developers and partners have enough time to leverage their capabilities so that APP developers have more time to react and reduce the risk of new product development for various APP developers”. That is, platforms need to take into account the information perception and interests of users and developers when making NPP decisions [7]. In fact, in the competition process of Xiaomi and Apple, some of the preannouncements of their smartphones (e.g. iPhone 5c and the Xiaomi 5S) focus more on the appearance, style, and time of pre-orders. Although these platforms all claim that the new product has a lot of technical innovation. However, from the real perceptions of consumers and developers’ information, it still belongs to the marketing promotion and cannot bring about the real improvement of the utility. The purpose of their preannouncement is to reduce consumers’ migration to the rival platform and lock-in consumers’ future purchase plans, rather than to create more added values. We define this type of message as marketing information, i.e., strategy $M$. On the contrary, some of Xiaomi and Apple’s smartphones (e.g. iPhone 4 and Xiaomi 4) emphasize technical information, such as some technical advantages, attracts the favor of many technical sensitive consumers and developers. The motivation of its latest product preannouncements is to concentrate on creating more added values. Developers believe that early announcements can result in significant cost-savings, not just product advertising. We define this type of message as technical information, i.e., strategy $T$. As you known, both Apple and Xiaomi have benefited from and suffered from the design of new product preannouncement information from the perspective of their user characteristics (consumers and developers). However,
more extant researches are from the perspective of the message publisher. There are less studies about how the message receiver would be impacted after the release of information, and what effect the feedback behavior of the information receiver will have on the notice strategy of message publisher [6, 31]. Therefore, this paper divides NPP information into technical information and marketing information, and builds quantitative modeling from the perspectives of consumers and developers. Our studies show that consumers and developers’ different perception and response behaviors to preannouncement information have a direct impact on preannouncement strategy. For instance, consumer reaction is only good for platforms to adopt strategy $M$, however, developer reaction may be good for all participants to adopt strategy $T$.

In this paper, we develop a two-sided market model in which two incumbent platforms need to balance what type of new platform-type product message should be preannounced. Our results show that the asymmetric strategy may be a subgame perfect Nash equilibrium even if the two platforms are identical. The rest is organized as follows. We review the extant literature from three perspectives in Section 2, and give out notations and set up the basic model in Section 3. We solve the equilibrium and give some management suggestions under the scenario of two identical platform competitions in Section 4. To examine the influence of platform heterogeneity, we extend the model in Section 5. In Section 6, we consider the issue of overall social welfare. We conclude in Section 7.

2. Literature review. Literature related to this study mainly includes two-sided market, new product preannouncement strategy, and impact of information on decision-makers.

2.1. Two-sided market. Many researchers stress that new product preannouncement has distinct two-sided market characteristics, the cross-network effect [5, 19]. However, most of them focus on the industrial organization and other issues, such as pricing [13, 25], network neutrality [11], platform competition [2], and user heterogeneity [36] under the two-sided market. Armstrong [2] and Rochet and Tirole [27, 28] make pioneering researches on two-sided market.

It is exciting that there are some researchers have started to study preannouncement strategy in a two-sided market and made a preliminary exploration from different perspectives [6, 19]. For example, Ke et al. [19] investigate the occurrence of cannibalization between the new product and the used product. Chellappa and Mukherjee [6] construct formal and informal preannouncement strategy models based on Rochet and Tirole [27]and Armstrong [2]. Hagiu and Halaburda [16] study information disclosure strategies under a two-sided market scenario.

However, there is no more detailed classification of the specific content of NPP information in Ke et al. [19].Unlike Chellappa and Mukherjee [6] focus on information release channels and methods (Formal and Informal preannouncement), we study information content selection (marketing and technical information). Although Hagiu and Halaburda [16] are not about NPP, its results can support the hypothesis of information perception differences in this paper. According to the above literature, there are still many works on preannouncement strategy that need to study. This paper seeks to contribute to this field.

2.2. New product preannouncement strategy. NPP is a signal that platforms intend to convey to their relevant participants, who mainly include competitors,
consumers, dealers and shareholders [12, 23]. Therefore, what information should be preannounced is a crucial thing for platforms. Previous studies mainly focus on “whether”, “when”, and “how” to do. For example, Gerlach [14] develops a game model to study whether to conduct a NPP or not. He believes that although preannouncement information is beneficial to lock-in the potential market, but it may create some potential risk of information leakage. Ofek and Turut [26] adopt a game model to examine an incumbent’s preannouncement strategy when there is uncertainty regarding the commercial viability of a new product opportunity and a threat of rival entry. Jung [18] and Ofek and Turut [26] believe the platforms adopt a bluff and dishonest preannouncement when the impact of NPP on consumers is very limited because it may attract more competitors. Besides, there are some scholars studied the basic conditions for platforms to conduct NPP, its influence on the market, timing, and frequency [20, 29]. Although these scholars all adopt game models to study related problems, they are only applicable to unilateral market scenarios.

It is worthy to note that studies above examine NPP from the perspective of information sender. They focus on platform’s decisions and fewer studies from the perspective of information receivers. However, this paper mainly emphasizes the receiver’s information perception, anticipate, and behavior response. Our studies show that consumers’ lock-in effect and APP developer’s cost-saving from NPP affect the strategic selection of platforms directly. The unit travel cost of consumers not only affects NPP strategy directly but also affects whether platforms have an incentive to implement NPP indirectly.

Besides, some scholars take “network externality” as an important factor for preannouncement strategy and examine the intrinsic relationship between network effect and NPP effect. For instance, Dranove and Gandal [10] find that there are network effects in the DVD preannouncement market by employing the empirical analysis method. Nagard-assayag and Manceau [21] study the diffusion and penetration of new products under the indirect network effects. Choi et al. [8] analyze the impacts of NPP in the presence of network effects when both platforms strategically make false announcements and show the incentives for preannouncement are stronger in markets with network effects. However, the above studies more focus on NPP strategy in the one-sided market, the preannouncement strategy in the two-sided market is still relatively absent. Unlike Choi et al. [8], our studies show that the increase of network effect will reduce the power of platforms preannouncement. Unlike Nagard-assayag and Manceau [21], and Dranove and Gandal [10], who study the game relationship between consumer and platforms under the same-sided network effect, our study focuses on the game relationship among consumers, developers and platforms under cross-network effect.

2.3. Impact of information on decision-makers. A large number of studies have shown that information and uncertainty have a direct effect on the behavior of individuals or organizations [22], such as aircraft demand predicting and flow shop scheduling [1, 15]. Lilly and Walters [24] show that the notice information will have a direct impact on the follow-decision behavior of the message receiver whether it is clear, complete, and contains different contents. Su and Rao [32] develop a general approach focusing on the target audiences and the incentives in sending signals to each audience. They believe that the content of NPP needs to adjust when its objects change.
According to Hoxmeier [17] and Su and Rao [32], there are significant differences in the level of information perception among decision-makers of different types, and perceptions of different types of information affect their decision-making behaviors. Schatzel and Calantone [29] point out that new product announcement information influences the behavior through the variable of an individual’s future expectation. Chen and Wong [7] divide NPP information into clear message and unclear message from whether it contains enough clues and find that a platform is more likely to communicate more clearly NPP messages with more cues for a strongly branded product. However, Hagiu and Halaburda [16] show that it is wise not to inform pricing information under competition because knowing more information increases consumer power. Besides, Chellappa and Mukherjee [6] divide preannouncement messages into formal and informal messages and show that informal message may be more conducive to platforms to avoid the potential risk.

It is very important to design the content of preannouncement information that can arouse consumers’ resonance from information perception ability of information receiver. Because it directly affects the cost and profit of a new product forecast. According to Trope and Liberman [34], Construal Level Theory also holds that construal level, the abstraction of psychological representation of an indicator, increases with the psychological distance. However, this paper divides preannouncement information into marketing information and technical information, and studies the impact of information type on the consumers, developers and platforms through game theory, which is very consistent with the actual situation. This can help us better understand the difference between consumers and developers’ perceptions and behavioral responses to the platforms’ preannouncement information, to provide a decisive reference for the platform’s preannouncement information content design.

2.4. Contributions and innovations. It can be seen from the above literature that the previous research on new product preannouncement mostly adopts the empirical investigation method firstly [12, 23]. At present, although some scholars use the game model to study the strategic selection of new product forecast, most of them focus on the new product forecast under the unilateral market environment [14, 26]. Besides, there are few pieces of research on the new product preannouncement from the perspective of information received in the context of the two-sided market game model. To illustrate the innovations and contributions of this article, it is outlined below.

Our studies give out a quantitative framework for analyzing platforms’ optimal preannouncement strategy under two-sided market competition and find some counterintuitive results, including the following points:

(i) It is a remedy for the emergence of a large number of new platform-type product preannouncement problems due to the lack of studies in a two-sided market environment.

(ii) The paper develops a game model of the two-sided market, which is a supplement to the empirical research [7].

(iii) This paper develops a game model from the perspective of the NPP information receiver rather than the sender, and the relevant studies’ results can form mutual support with the studies from the perspective of the sender [32].

(iv) This paper describes the effect of preannouncement information as consumers’ lock-in effect and developers’ cost-saving effect, rather than the direct change
of the numbers of consumers and developers access to the platform, which is an important supplement to Chellappa and Mukherjee [6].

3. Basic model. Consider a market where there are two platforms (denoted by subscript \(i = 1, 2\)), a group of platforms’ consumers (denoted by subscript \(b\)), and a group of application program (APP) developers (subscript \(d\)). Both platforms provide a platform-type product to consumers and developers, consumers buy a product (or service) through the platform, and developers offer APP for both platforms. According to Doganoglu and Wright [9], consumers have heterogeneous preferences for the two platforms, and developers are multi-homing. For instance, consumers differ in their preferences for promotion, color, and style of platform-type products (e.g. smart phones, game controllers, etc.). Similarly, the developers on the other side of the platform are heterogeneous in their APP development capacity because of their preferences for programming languages, application program interface management, and other software development environments. In order to attract more consumers and developers to join their platforms, the platforms need to choose the preannouncement strategy before the new platform-type product goes on sales.

3.1. Notations. For convenience, we use the following notations (\(i = 1, 2\)) throughout the paper:

**Decision variables:**
- \(p_{bi}\): price for consumers, i.e., the price consumers need to pay when they use the platform-type product, \(p_{bi} > 0\);
- \(p_{di}\): price for developer, it means the registration fee they need to pay, \(p_{di} > 0\);
- \(n_{bi}\): number of consumer accesses to platform, \(n_{bi} > 0\);
- \(n_{di}\): number of developer accesses to platform, \(n_{di} > 0\);

**Relevant parameters:**
- \(t\): unit travel cost of consumers under initial state, \(t > 0\), it is also called the initial strength of consumers’ preference for the platform;
- \(t_e\): consumers’ lock-in effect when platforms adopt strategy \(M\), \(t_e > 0\);
- \(t_j\): unit travel cost of consumers under strategy \(j\), \(j \in \{M, T\}\);
- \(c_d\): average cost of developer’s APP development, \(c_d > 0\);
- \(\epsilon\): fluctuation of developer’s APP development cost, which follows the uniform distribution within unit distance, \(\epsilon \in [1 - g, 1 + g]\);
- \(c_M\): heterogeneity of developer’s APP development capacity, \(0 < g < 1\);
- \(c_T\): potential risk cost under strategy \(T\), \(c_T \geq 0\);
- \(f_j\): developers’ APP development cost when platforms adopt strategy \(j\), \(j \in \{M, T\}\);
- \(f_e\): cost-saving of developers when a platform adopts strategy \(T\), \(f_e > 0\);
- \(\beta_b\): cross-network effect on developers when a consumer accesses to platform, \(\beta_b > 0\);
- \(\beta_d\): cross-network effect on consumers when a developer accesses to platform, \(\beta_d > 0\);
- \(x\): location of consumer, which is distributed over the Hotelling line segment, \(x \in [0, 1]\);
- \(x_i\): distance between consumers and platform \(i\);
- \(v_{bi}\): basic utility of consumers when they access to a platform, \(v_{bi} > 0\);
- \(v_{di}\): basic utility of developers when they access to a platform, \(v_{di} > 0\).
3.2. **Platform-type new product preannouncement description.** This paper assumes that there are only two types of preannouncement strategies for the platforms: marketing information (strategy $M$) and technical information (strategy $T$).

Strategy $M$ means that the message preannounces is marketing information mainly, such as time to market, advertisement, promotion, and appearance style. This information can be used to target future spending plans of consumers, but it doesn’t help developers to reduce APP development costs. The purpose of their preannouncement is to reduce consumers’ migration to the rival platform and lock-in consumers’ future purchase plans, rather than to create more added values. This type of message is generally released through publicity and advertising.

Strategy $T$ means that the message preannounces is technical details information mainly. The programming language, application program interface, game engine, and hardware configuration requirements are the core content. The motivation of its new product announcements focuses on creating more added values. Therefore, this type of message will help developers reduce development costs and improve development efficiency, but it does nothing to change the future consumption plans. Most consumers have a hard time understanding such esoteric technical information. This type of information is usually posted through developer conferences or technology forums. Obviously, there are four strategic profiles: $(T,T)$, $(M,M)$, $(M,T)$, and $(T,M)$. For example, $(M,T)$ represents the platform 1 adopts strategy $M$ and platform 2 adopts strategy $T$.

Assumes that consumers’ lock-in effect is $t_e$ and developers’ APP development costs-saving effect is zero when receiving information of strategy $M$. Then, the updated unit travel cost of consumers under strategy $M$ is $t_M = t + t_e$ and updated developers’ APP development cost is $f_M = c_d + f_e$ when their platforms adopt strategy $M$. It means that strategy $M$ is valuable for consumers, it locks consumers’ purchase plan. However, strategy $M$ is of negligible value to developers’ APP development.

It supposes that developers’ cost-saving effect is $f_e$ and consumers’ lock-in effect do not change when receiving information of strategy $T$. Then, the updated developers’ APP development cost is $f_T = c_d + f_e$ and the updated unit travel cost of consumers under strategy $T$ is $t_T = t$ when their platforms adopt strategy $T$. It means that the developer obtains much useful information about APP development from strategy $T$, which can help them to shorter development cycle and cost indiscriminately. However, the consumers are not sensitive to the message of strategy $T$ because they lack knowledge background and do not care about technical issues. Thus, the unit travel cost of consumer remains.

Unlike Chellappa and Mukherjee [6] depict the impact of preannouncement messages as the increase of the number of users (i.e. consumers and developers) access to the platform, the impact of preannouncement information in our paper is described as the increase of consumers’ lock-in effect $t_e$ and developers’ APP development cost-saving effect $f_e$. The advantage of such model extensions is that it takes more account of the information perception differences between consumers and developers.

3.3. **Two-sided market description.** Assumed that consumers can access to one platform at a time (it means that consumers are single homing and belong to old consumer), the developers can develop online APP products for both platforms to get more trading opportunities (they are multi-homing) and two platforms compete with each other. We develop the base model along the lines of Armstrong [2] and
Rochet and Tirole [27], where consumers and developers enjoy cross-side network effects with each other. We use $\beta_b$ and $\beta_d$ to denote the cross-network effects on developers and cross-network effects on consumers. It means that consumers gain value from more developers and developers gain value from more consumers.

We assume that two platforms locate at opposite ends of the unit line. Here on the line of unitary length, platform 1 is located at 0, platform 2 is located at 1, and the consumer is located at $x$ in the preference space. Therefore, the travel costs of the consumer access to platform 1 and platform 2 are $tx$ and $t(1-x)$, respectively. The scale of consumers is normalized to one unit such that the consumer density is 1.

Besides, we use $c_d\varepsilon$ to denote the cost of developers’ access to the platform where the fluctuation of developer’s APP development cost $\varepsilon$ is uniformly distributed over the interval $\varepsilon \in [1-g, 1+g]$. The scale of developers is normalized to one unit, which implies that developer density is $1/(2g)$.

To ensure that the price of the platform for consumers and developers is not negative, this paper assumes that $\beta_b \geq \beta_d > 0$ is satisfied, which does not affect the result. Therefore, if consumers and developers access to a platform, the network values are added by $\beta_d n_{di}$ and $\beta_b n_{bi}$, respectively. Here the anticipated numbers of consumers and developers access to the platform are $n_{bi}$ and $n_{di}$.

If a consumer purchases from platform $i$ under strategy $j$, its utility is

$$u^j_{bi} = v_b + \beta_d n_{di} - p_{bi} - t_j x_i, j \in (M,T), i \in \{1,2\}$$

(1)

where $i \in \{1,2\}$ represents the platform tag, $j \in (M,T)$ represents the type tag of the platform’s new product preview information (The rest of the article is provided in the same way and will not be repeated). Besides, $x_1 = x$, $x_2 = 1 - x$, $t_T = t$, and $t_M = t + t_e$. Obviously, Eq.(1) indicates that the consumer utility $u^j_{bi}$ will decrease because the unit travel cost of consumer increases from $t$ to $t + t_e$ after the platform releases marketing information (strategy $M$) of the new product in advance. This also means that the impact of the new product information released by the platforms on the transportation cost of the consumer switching platform $(t + t_e)x$ is heterogeneous. Besides, a higher level of service provided by platforms to consumers or the greater the cross-network utility on consumers, the greater the consumers’ utility $v_b$ will be. To ensure consumers have an incentive to buy a platforms’ controller, we assume that the basic utility of consumers $v_b$ is large enough.

Similar to Eq.(1), if a developer accesses to platform $i$ under strategy $j$, its utility is

$$u^j_{di} = v_{di} + \beta_b n_{bi} - p_{di} - f_j$$

(2)

where when the platform adopts strategy $M$, the cost of developers is $f_M = c_d\varepsilon$, and when the platform adopts strategy $T$, the cost of developers is $f_T = c_d\varepsilon - f_e$. Obviously, Eq.(2) indicates that the developer will benefit, and its utility $u^j_{di}$ increases when the platform releases technical information (strategy $T$) in advance. Moreover, the paper shows that platforms and consumers may also take advantage of it. Besides, a higher level of technical support offered by platforms to developers or a greater the cross-network utility on the developer, lead to the greater utility of the developers. To ensure that developers have the basic motivation to access (register) a platform, we assume that the basic utility of developers $v_{di}$ is large enough.

Platforms’ profit mainly comes from the sales revenue of controller and the registration fee of developer. We normalize the cost of service to zero. Hence, the profit
function of platform $i$ under strategy $j$ is

$$\Pi_j^i = p_b n_{bi} + p_d n_{di} - c_j$$

(3)

As you known, Eq. (3) indicates that platforms can benefit by increasing the price of consumers $p_b$ and the price of developers $p_d$, but this can lead to fewer consumers and developers number $n_{bi}$ and $n_{di}$ accessing the platform. Especially in the presence of competitors, price adjustments should consider how consumers and developers respond to new product information preannouncement, and then make very cautious judgments. Besides, to ensure that the platforms can obtain a positive profit, we assume that $c_j$ is small enough. This is the one-time potential risk cost that platforms need to pay when they choose $j$-type strategy.

3.4. Game sequence description. According to the preannouncement process of new versions mobile phones from Apple, Xiaomi, Huawei and other companies, we depict Fig. 1.

Specifically, the game sequence is:

(i) The platforms choose preannouncement strategy (strategy $T$ or $M$);
(ii) The unit travel cost of consumers $t_j$ and the development costs of developers $f_j$ under strategy $j$ update when consumers and developers observe preannouncement information;
(iii) The platforms use pre-sales and other methods to release the selling price for consumers $p_b$ and the registration fee for developers $p_d$;
(iv) Consumers and developers decide whether and which platforms to access.

![Figure 1. Game structure of the PNPP](image)

4. PNPP competition between identical platforms. In this section, we discuss the sub-game perfect Nash equilibrium (SPNE) of preannouncement when the two platforms are symmetric and identical, i.e., $v_{d1} = v_{d2} = v_d$.

4.1. Nash equilibrium of identical platform.

4.1.1. Equilibrium outcomes under $(M, M)$. We first consider the sub-game of $(M, M)$ where both platforms adopt strategy $M$. The proofs of all analytical results are given in Online Supplementary Materials. The relevant notations are given by Table 1A in Appendix.

Through the backward induction technique, we summarize the equilibrium outcome in Table 1, where we assume $2(t_t + t_c) \geq \beta_b \beta_d$ to ensure the existence of optimal solution.
 Firstly, from Table 1, we see that the platforms’ profits increase with unit travel cost of consumers $t$ and developers’ basic utility $v_d$; platforms’ profit, consumers and developers’ total utilities decrease with the cost of APP development $c_d(1-g)$; consumer’s utility decreases with unit travel cost $t$. In other words, if platforms wish to achieve higher profits, they should invest more resources in the improvement of unit travel cost and developers’ basic utility.

**Table 1. Equilibrium results under $(M, M)$**

| Decisions | $p_{MM}^{MM} = t + t_e + \beta_h(1-g)/(4g) - \beta_h(2v_d + \beta_h + 3\beta_d)/(8gc_d)$ |
|-----------|----------------------------------------------------------------------------------------------------------------------------------|
| Consumers’ price | $p_{MM}^{MM} = [2v_d - 2c_d(1-g) + \beta_h - \beta_d]/4$ |
| Developers’ price | $n_{MM}^{MM} = 1/2$ |
| Consumers’ number | $n_{MM}^{MM} = [2v_d - 2c_d(1-g) + \beta_h + \beta_d]/(8gc_d)$ |
| Developers’ number | $n_{MM}^{MM} = [2v_d - 2c_d(1-g) + \beta_h - \beta_d]/(8gc_d)$ |
| Platforms’ profit | $\Pi_{MM}^{MM} = (t + t_e)/2 + (4V_e^2 - B_t - 2\beta_h\beta_d)/(32gc_d) - c_M$ |
| Consumers’ total utility | $BS_{MM}^{MM} = [4v_d - 5(t + t_e)]/8 + [B_t + 2(\beta_h + \beta_d)V_1]/(16gc_d)$ |
| Developers’ total utility | $DS_{MM}^{MM} = (2V_1 + \beta_h + \beta_d)^2/(64gc_d)$ |

Lemma 1 discusses how consumers’ lock-in effect affects the equilibrium outcome under $(M, M)$.

**Lemma 1.** Under $(M, M)$,

(i) $p_{MM}^{MM}$ increases with $t_e$, $t$, and $c_d$, but decreases with cross-network effect $(\beta_h, \beta_d)$;

(ii) $n_{MM}^{MM}$ increases with $\beta_h$, but decreases with $\beta_d$ and $c_d$;

(iii) $\Pi_{MM}^{MM}$ increases with $(\beta_h, \beta_d)$, but decreases with $c_d$;

(iv) $BS_{MM}^{MM}$ increases with $t_e$ and $t$, but decreases with $(\beta_h, \beta_d)$ and $c_d$;

(v) $DS_{MM}^{MM}$ increases with $v_d$, $(\beta_h, \beta_d)$, but decreases with $t_e$, $t$, and $c_d$;

Lemma 1 implies that higher cross-network effect $(\beta_h, \beta_d)$ increases developers’ number, but decreases consumers’ price. The impacts of cross-network effects on developers’ price are asymmetric, since the developers’ price decreases with $\beta_d$, while increases with $\beta_h$. Thus, higher cross-network effects increase the users’ total utilities. However, it decreases the platforms’ profits.

Lemma 1 also suggests that the profits of both platforms increase when consumers’ lock-in effect $t_e$ increases, but the consumer’s total utility decreases. The reason is that an increase in consumers’ lock-in effect pushes platforms to raise consumer’s price, then consumers need to pay more to access to an ideal platform, the last consumer’s total utility decreases under $(M, M)$. However, due to the isolation effect brought by platform competition, the lock-in effect of the consumer cannot pass to the developers’ side. Therefore, the price, number, and total utility of the developer are independent of strategy $M$.

Lemma 1 shows that the interests of all the participants decrease with the average cost of APP development $c_d$ because the increase of average cost of APP development leads to the price of consumer increase and the number of developer decrease. The last, profits of platforms and total utilities of all users decrease. That is, reducing the cost of APP development is a common goal for all parties.

In general, platforms can adopt strategy $M$ to improve their own profits, but this is at the expense of consumers’ interests. More precisely, it is at the expense of loyal consumers of the platform. At present, Apple’s smartphone, which is not in a position to make better technological innovation, has been questioned by many Chinese users that its warning strategy is strategy $M$. 


4.1.2. Equilibrium outcomes under \((T, T)\). In this part, both platforms adopt strategy \(T\) is examined. Through the backward induction technique, we get the equilibrium outcome in Table 2. We need to note that the profit function of the platform is a concave function when \(t \geq \beta_b \beta_d/2\) is satisfied. In this case, the platforms can obtain the maximum profit at equilibrium. Obviously, comparing to the scenario \((M, M)\), the equilibrium of \((T, T)\) needs a larger value of unit travel cost.

**Table 2. Nash equilibrium under \((T, T)\)**

| Decisions                       | Equation                                                                                     |
|--------------------------------|---------------------------------------------------------------------------------------------|
| Consumers’ price \(p_{bi}^{TT}\) | \(t + \beta_b(1 - g)/(4g) - \beta_b[2(v_d + f_e) + \beta_b + 3\beta_d]/(8gc_d)\)          |
| Developers’ price \(p_{di}^{TT}\) | \((2v_d - 2c_d + 2cg + 2f_e + \beta_b - \beta_d)/4\)                                      |
| Consumers’ number \(n_{bi}^{TT}\) | \(1/2\)                                                                                     |
| Developers’ number \(n_{di}^{TT}\) | \([2v_d + 2f_e + \beta_b + \beta_d - 2c_d(1 - g)]/(8gc_d)\)                               |
| Equilibrium profits/total utilities |                                                                                           |
| Platforms’ profit \(\Pi_{TT}^T\) | \(t/2 + [4(V_1 + f_e)]^2 - B_0 - 2\beta_b\beta_d]/(32gc_d) - ct\)                        |
| Consumers’ total utility \(BS_{TT}^T\) | \((4v_d - 5t)/8 + [B_0 + 2(\beta_b + \beta_d)(V_1 + f_e)]/(16gc_d)\)                    |
| Developers’ total utility \(DS_{TT}^T\) | \([2(V_1 + f_e) + \beta_b + \beta_d]^2/(64gc_d)\)                                        |

The relevant parameter settings see Table 1A in Appendix. Lemma 2 discusses how developers’ cost-saving effect influences the equilibrium outcome under \((T, T)\).

**Lemma 2.** Under \((T, T)\),

(i) \(p_{di}^{TT}\) increases with \(f_e\), but \(p_{bi}^{TT}\) decreases with \(f_e\);

(ii) \(n_{db}^{TT}\) increases with \(f_e\), but \(n_{bi}^{TT}\) is not affected by \(f_e\);

(iii) \(\Pi_{TT}^T\), \(BS_{TT}^T\) and \(DS_{TT}^T\) increases with \(f_e\).

Lemma 2 suggests that the number of the developer and the total utility of developer increases with the cost-saving effect. It means that strategy \(T\) decreases the APP development cost for developers. So the developers are the beneficiaries even if their prices go up since the overall revenue goes up. At the same time, consumers can also benefit from strategy \(T\) due to the decrease of consumer prices. Because they will take advantage of the opportunity to drive down the price when they anticipate that the number of developers increases. At the same time, consumers can also benefit from the increase of developer number itself. Act as a leader and benefits coordinator, the profits of platform increase because they can balance all the interest and benefit from it, i.e., they raise developers’ prices and reduce consumers’ prices to make the benefit outweigh the loss.

To sum up, the interests of consumers, developers, and platforms under \((T, T)\) increase in developers’ cost-savings. It means that if the new platform products are technically complex, they will cooperate closely with developers to reduce the cost of APP software development, accelerate the speed of APP development, and improve the benefits of all participants. For example, in the early development of Xiaomi’s smart phone, it made full use of the intellectual contributions of thousands of developers in the Xiaomi community and achieved success.

Finally, we present a comparative analysis of the equilibrium decisions and result between \((T, T)\) and \((M, M)\) in Proposition 1.

**Proposition 1.** Comparing the equilibrium decisions under \((T, T)\) and \((M, M)\), we have,

(i) \(p_{bi}^{MM} > p_{bi}^{TT}\) and \(p_{di}^{TT} > p_{di}^{MM}\);

(ii) \(n_{bi}^{TT} = n_{bi}^{MM}\) and \(n_{di}^{TT} > n_{di}^{MM}\).
(iii) $BS_i^{TT} > BS_i^{MM}$ and $DS_i^{TT} > DS_i^{MM}$.

Proposition 1 shows that compared with $(M, M)$, consumers pay less to the platforms under $(T, T)$, but developers pay more to the platforms under $(T, T)$. This implies that $(T, T)$ is more attractive for consumer and developer than $(M, M)$. However, the profit of platform under $(T, T)$ is not always greater than that under $(M, M)$ even if $(T, T)$ attracts much more developers to access platform, i.e., according to the benefits of all participants, consumers and developers tend to choose $(T, T)$, but platforms do not always tend to choose $(T, T)$.

From the perspective of long-term strategic goals, the growth of the platform user number, and the growth of platform benefits is equally crucial. As all known, the reasons for the poor sales of both the Xiaomi 5c and the iPhone 5S are that both platforms paid too much attention to themself short-term benefits and fail to balance the relationship between users’ interests and theirs finally.

4.1.3. Equilibrium outcomes under asymmetric strategy scenarios. Considering the symmetric positions of $(M, T)$ and $(T, M)$, the paper only gives out the analysis of the $(M, T)$ scenario.

Through the backward induction technique, we can obtain the equilibrium outcomes in Table 3. The related abbreviation notations are given by Table 1A in Appendix.

Similarly, the profit function of the platform is a concave function when $2t + t_c \geq \beta_b \beta_d$ is satisfied. In this case, the platforms can obtain the maximum profit. To ensure that the equilibrium decisions under each strategy profile exist, we assume that $t \geq \beta_b \beta_d / 2$ is always true.

### Table 3. Nash equilibrium under $(M, T)$

| Decisions | Equilibrium profits/total utilities |
|-----------|-----------------------------------|
| Consumers’ price | $p^{MT}_{b1} = p^{MT}_{a1} + (4gc_1 + 2f_c \beta_b - f_c \beta_d)/(12gc_1)$  
$p^{MT}_{b2} = p^{MT}_{a2} - (4gc_2 + 2f_c \beta_b - f_c \beta_d)/(12gc_2)$  
$p^{MT}_{d1} = p^{MT}_{d1} + (\beta_b - \beta_d)R_2/(4W_3)$  
$p^{MT}_{d2} = p^{MT}_{d2} + (\beta_b - \beta_d)R_2/(4W_3)$  |
| Developers’ price | $n^{MT}_{b1} = n^{MT}_{b1} - (\beta_b - \beta_d)R_2/(2W_3)$  
$n^{MT}_{b2} = n^{MT}_{b2} + (\beta_b - \beta_d)R_2/(2W_3)$  |
| Consumers’ number | $n^{MT}_{d1} = n^{MT}_{d1} + (\beta_b + \beta_d)R_2/(8gc_4W_3)$  
$n^{MT}_{d2} = n^{MT}_{d2} + (\beta_b + \beta_d)R_2/(8gc_4W_3)$  |
| Developers’ number | $\Pi^{MT}_{1} = \Pi^{MT}_{1} + R_3/(12gc_3) + (\beta_b - \beta_d)^2 R_3^2/(96gc_3W_3^2)$  
$\Pi^{MT}_{2} = \Pi^{MT}_{2} + R_4/(12gc_4) + (\beta_b - \beta_d)^2 R_4^2/(96gc_4W_4^2)$  
$BS^{MT}_1 = BS^{MT}_1 - R_2/(12gc_4W_4^2)$  
$BS^{MT}_2 = BS^{MT}_2 + R_2/(12gc_4W_4^2)$  |
| Platforms’ profit | $DS^{MT}_1 = DS^{MT}_1 - f_c R_3/(16gc_3^2) + (\beta_b + \beta_d)^2 R_3^2/(64gc_3^2W_3^2)$  
$DS^{MT}_2 = DS^{MT}_2 + f_c R_3/(16gc_3^2) + (\beta_b + \beta_d)^2 R_3^2/(64gc_3^2W_3^2)$  |
| Consumers’ total utility | $BS^{MT}_1 = BS^{MT}_1 - R_2/(12gc_4W_4^2)$  
$BS^{MT}_2 = BS^{MT}_2 + R_2/(12gc_4W_4^2)$  |
| Developers’ total utility | $DS^{MT}_1 = DS^{MT}_1 - f_c R_3/(16gc_3^2) + (\beta_b + \beta_d)^2 R_3^2/(64gc_3^2W_3^2)$  
$DS^{MT}_2 = DS^{MT}_2 + f_c R_3/(16gc_3^2) + (\beta_b + \beta_d)^2 R_3^2/(64gc_3^2W_3^2)$  |

Besides, it is easy to deduce from Table 3 that, $n^{MT}_{b2} \geq n^{MT}_{b1}, n^{MT}_{d2} \geq n^{MT}_{d1}, BS^{MT}_2 \geq BS^{MT}_1, DS^{MT}_2 \geq DS^{MT}_1, \text{and } \Pi^{MT}_2 \geq \Pi^{MT}_1$ are true. It implies that
compared with platforms with strategy $M$, platforms with strategy $T$ are more attractive because there are more consumers and developers on its platform. Hence, the profits of the platforms with strategy $T$ is larger than that with strategy $M$.

**Lemma 3.** Under $(M, T)$,

(i) The consumer prices of both platforms and developer price of platform 1 decrease with $f_e$, but developer price of platform 2 increases with $f_e$;

(ii) Consumer number of platform 2 and developer number of platform 2 increase with $f_e$, but consumer number and developer number of platform 1 decrease with $f_e$;

(iii) Profit of platform 2, and its consumers’ total utility and developers’ total utility increase with $f_e$.

Firstly, Lemma 3 implies that when platform 1 adopts strategy $M$ and platform 2 adopts strategy $T$, consumers and developers are more willing to join platform 2. Therefore, the total consumer utility and total developer utility of platform 2 increase with $f_e$. This in turn increases the consumers’ number and developers’ number of platform 2. The rest result is that the profit of platform 2 increases and the profit of platform 1 decreases. At the same time, the prices of consumer and developer in platform 1 decrease because the numbers of consumers and developers decrease. However, the consumer’s price in platform 2 decreases and the developer’s price in platform 2 increases because of the numbers of consumers and developers in platform 1 increase.

In short, the asymmetric strategy combination makes the decision-making of new product information forecast more complicated. The asymmetric strategy combination generally appears in the situation that the two platforms are evenly matched in strength and there are no significant differences in the advantages of strategy $M$ and strategy $T$.

4.2. PNPP equilibrium of identical platform competition. In subsection, we study SPNE.

**Proposition 2.** Under identical platforms competition,

(i) $(T, T)$ is a SPNE when $c_T - c_M < \Delta c_1$; $(M, M)$ is a SPNE when $c_T - c_M > \Delta c_2$; $(M, T)$ and $(T, M)$ are SPNE when $\Delta c_1 \leq c_T - c_M \leq \Delta c_2$;

(ii) $(T, T)$ is a SPNE when $f_e < \hat{f}_e$; $(M, M)$ is a SPNE when $f_e < \hat{f}_e$; $(M, T)$ and $(T, M)$ are SPNE when $\hat{f}_e \leq f_e \leq \hat{f}_e$;

(iii) $(T, T)$ is a SPNE when $t_e < \hat{t}_e$; $(M, M)$ is a SPNE when $t_e > \hat{t}_e$; $(M, T)$ and $(T, M)$ are SPNE when $\hat{t}_e \leq t_e \leq \hat{t}_e$.

Part (i) of Proposition 2 shows that $(M, M)$ is a SPNE when the cost of the potential risk of the strategy $T$ is larger than that under strategy $M$ and above a threshold. Because the potential risk costs of strategy $T$ and strategy $M$ are sunk cost, platforms cannot transfer it from themselves to consumers and developers, the platforms have to bear the corresponding costs by themselves. Secondly, part (ii) of Proposition 2 implies that $(T, T)$ is a SPNE when developers’ cost-saving $f_e$ is larger than a threshold. Because strategy $T$ can bring more benefit to the platforms from developers’ price and number increase. It is worth noting that $(T, T)$ will always be a SPNE if there is no significant difference in the potential cost of risk from strategy $T$ and strategy $M$. In addition, part (iii) of Proposition 2 suggests that $(M, M)$ is a SPNE when consumers’ lock-in effect $t_e$ is larger than a
threshold. Because, in this case, strategy $M$ can bring more benefit to the platforms than $(T, T)$ from the increase of consumer price. Finally, we find the asymmetric strategy profile is a SPNE when $t_e, f_e$ and $c_T - c_M$ are a medium value. It means that when a preannouncement strategy is not superior absolutely to another strategy, an asymmetric strategy profile may be a SPNE.

Proposition 2 also suggests that platforms should not only consider the potential risk cost caused by information preannouncement, but also consider the change of perception effect intensity between consumers and developers when choosing a strategy. Platforms tend to choose strategy $M$ when the marketing information can generate a strong consumer lock-in effect, and when the anti-legitimate technical information forecast has a strong cost-saving effect, the platforms tend to choose strategy $T$.

In order to explain more specifically the transformation logic of different strategy combinations, and to provide some results which are not studied in the analytical analysis, a numerical analysis depicted in Fig.2. The default values are $v_d = 10, v_b = 10, c_d = 1, g = 0.99, \beta_b = 1.01, \beta_d = 1, c_T = 0.11$, and $c_M = 0.1$. In addition, for a clearer description, the profit difference curve of platforms under different strategy combinations depicted in all figures as follows, such as $\Delta \Pi_1^{MM} - \Pi_1^{TM} = \Pi_1^{MM} - \Pi_1^{TM}$.

From Fig.2(a), we see that $(M, M)$ is a SPNE when $t_e > \hat{t}_e$. It means that the attraction of strategy $M$ is strong when the lock-in effect is large enough. In the same way, $(T, M)$ or $(M, T)$ may be a SPNE when $t_e \leq t_e \leq \hat{t}_e$. If one platform chooses strategy $T$, the other chooses strategy $M$ is an equilibrium. However, there is not any space for asymmetric strategy profiles to be a dominant strategy for both platforms. An interesting thing is, $(T, T)$ is a SPNE when $t_e < \hat{t}_e$ even if $(T, T)$ is a lose-lose dilemma. The reason for this counterintuitive result is the competition between platforms is a self-interest non-cooperative game.

Similarly, from Fig.2(b), we see that $(M, M)$ is a SPNE superseded by the situation of $(T, T)$ is a SPNE with $f_e$ increase gradually. In this substitution process, $(M, M)$ is a SPNE when $f_e < \hat{f}_e$; $(T, M)$ or $(M, T)$ is a SPNE when $f_{e1} < f_e < \hat{f}_e$; $(T, T)$ is a SPNE when $f_e > \hat{f}_e$.

In order to analyze the distribution characteristics of SPNE of platforms’ preannouncement strategy deeply under the joint action of $f_e$ and $t_e$, a numerical analysis is given as showed in Fig.3.

Fig.3 shows that the larger values of $f_e$ and $t_e$, the more possible the asymmetric strategies profile is a SPNE. The reason is that the more noticeable the effect of strategy $T$ and strategy $M$ is, the larger revolving profit space platforms to choose asymmetric strategies.
In addition, from Fig.3, we see that the cross-network effect may distort the distribution structure of SPNE. For example, no equilibrium interval area (e.g., the white interval area increases) increases with cross-network effect, and there is no asymmetric equilibrium under certain circumstances. Finally, Fig.3 also shows that the larger of $\beta_b - \beta_d$, the greater of no equilibrium interval area, and the higher the probability of asymmetric strategies profile is a SPNE.

In general, in the two-sided market environment, platforms need to pay more attention to the nonlinear distortion effect brought by the cross-network effect when they choose preannouncement strategy, especially, if the cross-network effect of consumers is larger than that of the developer.

From the analysis above, the asymmetrical equilibrium does not always exist because $f_{e2} > f_{e1}$ may not be true. Hence, in order to investigate what and how the factors may affect it, a numerical analysis is showed in Table 4. The default values are the same as those in Fig.2, except $t_c = 15$.

From Table 4, we see, $f_{e2} - f_{e1}$ increases with the average APP development cost $c_d$ but decreases with unit travel cost $t$. It implies that the possibility of $(M, T)$ or $(T, M)$ is a SPNE increases with the average APP development cost of developers, but decreases with unit travel cost. Specifically, increase of the average APP development cost leads to the higher competitive pressure between platforms. Hence, it would increase the possibility of asymmetric strategies combination chosen. In addition, higher unit travel cost leads to lower competitive pressure between platforms, hence the possibility of asymmetric equilibrium decreases.

**Table 4. Factors of effect asymmetric strategy to be a SPNE**

| $c_d$ | $t = 1$ | | $c_d = 1$ | |
|---|---|---|---|---|
| $t$ | $f_{e1}$ | $f_{e2}$ | $f_{e2} - f_{e1}$ | $f_{e1}$ | $f_{e2}$ | $f_{e2} - f_{e1}$ |
| 1 | 0.31 | 0.61 | 0.30 | 1 | 0.31 | 0.61 | 0.30 |
| 3 | 0.93 | 1.72 | 0.79 | 3 | 0.34 | 0.58 | 0.24 |
| 5 | 1.52 | 2.74 | 1.22 | 5 | 0.36 | 0.56 | 0.20 |
| 7 | 2.08 | 3.69 | 1.61 | 7 | 0.37 | 0.54 | 0.17 |
| 9 | 2.62 | 4.59 | 1.96 | 9 | 0.38 | 0.53 | 0.15 |
Proposition 3. Under identical platforms competition, the heterogeneity of development capacity. The specific content is given in Proposition 3.

Proposition 3 suggests that $(M, M)$ is a SPNE when the heterogeneity of development capability is less than a threshold, because platforms cannot obtain sufficient benefits from $(T, T)$ to make up for the potential risk cost of $(T, T)$ implementation. In addition, Proposition 3 shows that platforms adopt strategy $T$ when the heterogeneity of development capability increases to a certain extent. In this case, developers are not motivated enough to join the platform, and adopting strategy $T$ has more advantages than disadvantages for platform profits. $(M, T)$ and $(T, M)$ are an equilibrium when the heterogeneity of developers’ capacity is medium.

In general, platforms tend to adopt strategy $T$ when the heterogeneity of development capability is large; otherwise, they tend to adopt strategy $M$. We need to note that many factors are affecting the heterogeneity of development capabilities, including individual capability heterogeneity, development experience, and platform product technical complexity. Therefore, it is necessary to conduct a market survey on the heterogeneity of development capability before making the strategy selection.

5. Extended model. No one denies that due to some differences in technical strength, the service capabilities of the platforms vary when providing technical services to developers. Moreover, a moderate relaxation of the homogeneity hypothesis of the platform can make the results more practical. This section considers the extended case that platform 1 is more advantageous than platform 2 in the basic utility of developers, i.e., $v_{d1} = v_d + \delta, v_{d2} = v_d - \delta$, and $\delta \geq 0$ is satisfied. We use subscript $E$ to represent the extended model.

5.1. Equilibrium outcome under given strategy profile. Based on the similar reasoning process of subsection 4.1, Table 5 summarizes the equilibrium results under three given preannouncement strategy combinations with non-identical platform competition, where

$$F(i) = \begin{cases} 1, & \text{if } i = 1, \\ -1, & \text{if } i = 2. \end{cases}$$

We can draw some basic results by comparing the homogeneous platforms with non-homogeneous platforms. The specific contents can be described as follows.

The related abbreviation notations are given by Table 1A in Appendix.

Firstly, from Table 5, we see that $p_{d1,E}^k \leq p_{d2,E}^k, p_{d1,E}^k \geq p_{d2,E}^k, n_{d1,E}^k \geq n_{d2,E}^k$, $u_{d1,E}^k \geq u_{d2,E}^k$, and $\Pi_{d,E}^k \geq \Pi_{d,E}^k$ are true, where $k \in \{M, M, MT, TT\}$. It means that a lower consumers’ price will be provided by the platform with a larger developers’ basic utility. The platform that provides smaller developer’s basic utility has a higher consumers’ selling price, lower developers’ price, lower consumers’ number, lower developers’ number, and lower platforms’ profits.

In addition, platform heterogeneity also changes the effects of strategy $T$ and strategy $M$ on platform profit, as showed in Proposition 4.
Table 5. Nash equilibrium of non-identical platforms

\[
\begin{array}{c|c}
(M, M) & (T, T) \\
\hline
p_{1M}^* = p_{1M}^{TT} & p_{1T}^* = p_{1T}^{TT} = \frac{3\beta_1(v_{1d} - v_{1g})}{(12 gc_1)} \\
F_1^*(v_{1g}) = \frac{E_1 + E_2}{2(24 gc_1 W_1)} - E_3(12 gc_1) & F_1^*(v_{1g}) = \frac{E_1 + E_2}{2(24 gc_1 W_2)} - E_3(12 gc_1) \\
\rho_{1M}^* = \rho_{1M}^{TT} & \rho_{1T}^* = \rho_{1T}^{TT} = (v_{1d} - v_{1g})/2 \\
\alpha_{1M}^* = \alpha_{1M}^{TT} & \alpha_{1T}^* = \alpha_{1T}^{TT} = (v_{1d} - v_{1g})/2 \\
\Pi_{1M}^{TT} = \Pi_{1M}^T + E_1^2/(24 gc_1 W_1) + E_2/(24 gc_1 W_1) + E_3/(12 gc_1) & \Pi_{1T}^{TT} = \Pi_{1T}^T + E_1^2/(24 gc_1 W_2) + E_2/(24 gc_1 W_2) + E_3/(12 gc_1) \\
& + (v_{1d} + v_{1g}) - 2E_1 + 2gc_1(v_{1d} - v_{1g})/(8 gc_1) \\
\Pi_{2M}^{TT} = \Pi_{2M}^T + E_1^2/(24 gc_1 W_1) + E_2/(24 gc_1 W_1) + E_3/(12 gc_1) & \Pi_{2T}^{TT} = \Pi_{2T}^T + E_1^2/(24 gc_1 W_2) + E_2/(24 gc_1 W_2) + E_3/(12 gc_1) \\
& + (v_{2d} + v_{2g}) - 2E_1 + 2gc_1(v_{2d} - v_{2g})/(8 gc_1) \\
\end{array}
\]

Proposition 4.

(i) Under \((T, T)\), \(\frac{\partial \Pi_{1T}^{TT}}{\partial f_e} \geq \frac{\partial \Pi_{1T}^{TT}}{\partial f_e} \geq \frac{\partial \Pi_{1M}^{TT}}{\partial f_e};\)

(ii) Under \((M, M)\), \(\frac{\partial \Pi_{1M}^{TT}}{\partial v_d} \geq \frac{\partial \Pi_{1M}^{TT}}{\partial v_d} \geq \frac{\partial \Pi_{1T}^{TT}}{\partial v_d}.\)

Part (i) of Proposition 4 shows that under \((T, T)\), platform heterogeneity leads to an increase in profit when strategy \(T\) is adopted by platform 1 and a decrease in profit when strategy \(T\) is adopted by platform 2. In other words, platform heterogeneity increases the incentive for advantage platforms to adopt strategy \(T\). At the same time, platform heterogeneity also reduces the incentive for platforms without advantages to adopt strategy \(T\). Part (ii) of Proposition 4 suggests that under \((M, M)\), platform heterogeneity leads to a corresponding decrease in profit when platform 1 and platform 2 adopt strategy \(M\). In other words, platform heterogeneity weakens the incentive of platform to adopt strategy \(M\).

The results also imply that disadvantage platforms are harder to adopt strategy \(T\) and win over more consumers and developers accessing platform. They sometimes need to make bigger sacrifices if they want to turn this around.

Finally, in order to study the impact of platform heterogeneity on consumer and developer pricing, a numerical analysis is showed in Fig. 4. The default values setting is the same as that in Fig. 2, except \(v_d = 2.5, f_e = 1, t_e = 8, \) and \(t = 2.\)

From Fig. 4, we see that the consumer price of platform 1 and the developer price of platform 1 gradually increase with platform heterogeneity under all scenarios because platform heterogeneity gives more power to platform 1 to extract more profit. In other words, higher heterogeneity of the platforms is beneficial to platform 1, the prices of both developers and consumers in platform 1 increase, and the price of developers in platform 1 increase more obvious. If we make a further reasoning, it shows that the platform heterogeneity will reduce the price of consumers and developers in platform 2, and the price of developers in platform 2 will decrease more obvious. Just because the platform is a coordinator, it needs to continually
coordinate the benefits of bilateral users through pricing, in order to ensure that all users have the basic profit incentive to join the platform.

5.2. **Sub game perfect Nash equilibrium.** There are some different results between non-identical platforms and identical scenario. Its specific contents can be described as follows.

**Proposition 5.**

(i) When platform heterogeneity is small and satisfied \( \hat{f}_{e3} > \hat{f}_{e4} > \hat{f}_{e5} > \hat{f}_{e6} \) and \( t_{e3} > t_{e4} > t_{e5} > t_{e6} \), we have

(a) \( (T,T) \) is a SPNE if \( f_{e,E} > \hat{f}_{e3}; (M,T) \) is a SPNE if \( \hat{f}_{e3} > f_{e,E} > \hat{f}_{e4} \); \( (T,M) \) or \( (M,T) \) is a SPNE if \( f_{e4} > \hat{f}_{e,E} > \hat{f}_{e5}; (T,M) \) is a SPNE if \( \hat{f}_{e5} > \hat{f}_{e,E} > \hat{f}_{e6} \); and \( (M,M) \) is a SPNE when \( \hat{f}_{e,E} < \hat{f}_{e6} \);

(b) \( (M,M) \) is a SPNE if \( t_{e,E} > \hat{t}_{e3}; (T,M) \) is a SPNE if \( \hat{t}_{e3} > t_{e,E} > \hat{t}_{e4} \); \( (T,M) \) or \( (M,T) \) is a SPNE if \( t_{e4} > t_{e,E} > t_{e5}; (M,T) \) is a SPNE if \( \hat{t}_{e5} > t_{e,E} > \hat{t}_{e6} \); and \( (T,T) \) is a SPNE when \( t_{e,E} < \hat{t}_{e6} \);

(ii) When platform heterogeneity is medium and satisfied \( \hat{f}_{e3} = \hat{f}_{e4} = \hat{f}_{e5} = \hat{f}_{e6} \) and \( t_{e3} = t_{e4} = \hat{t}_{e5} = \hat{t}_{e6} \), we have

(a) \( (T,T) \) is a SPNE if \( f_{e,E} > \hat{f}_{e3}; (M,T) \) is a SPNE if \( \hat{f}_{e3} > f_{e,E} > \hat{f}_{e4} \); \( (T,M) \) or \( (M,T) \) is a SPNE if \( f_{e4} > t_{e,E} > \hat{t}_{e5} \), and \( (M,M) \) is a SPNE when \( \hat{f}_{e,E} < \hat{f}_{e6} \);

(b) \( (M,M) \) is a SPNE if \( t_{e,E} > \hat{t}_{e3}; (T,M) \) is a SPNE if \( \hat{t}_{e3} > t_{e,E} > \hat{t}_{e4} \); \( (T,M) \) or \( (M,T) \) is a SPNE if \( t_{e4} > t_{e,E} > \hat{t}_{e5} \); and \( (T,T) \) is a SPNE when \( t_{e,E} < \hat{t}_{e6} \).

Proposition 5 shows that with the increase of cost-saving brought by strategy \( T \), the SPNE of preannouncement strategy changes from \( (M,M) \) to \( (T,M) \), from \( (T,M) \) to \( (M,T) \), and then from \( (M,T) \) to \( (T,T) \). The SPNE of preannouncement strategy changed from \( (T,T) \) to \( (M,T) \), from \( (M,M) \) to \( (T,M) \), and then from \( (T,M) \) to \( (M,M) \) with the increase of consumer lock-in effect brought by strategy \( M \). That is to say, platform heterogeneity is the main reason for change \( (M,T) \) and \( (T,M) \) from unstable strategy profile to a SPNE. However, it is worthy to note that Proposition 5 is valid when platform heterogeneity is moderately large. It is not difficult to infer that the result of SPNE distribution is the same as that of SPNE distribution when the platform heterogeneity is small. Interestingly, when platform heterogeneity is very large, the competitive risk of mutual substitution is small due to the great difference between the two platforms, then \( (T,T) \) will be a SPNE.
In general, although platform heterogeneity to some extent changes the new product forecast strategy equilibrium of the two platforms. However, the overall result is similar to that of Proposition 2. More importantly, it shows that heterogeneity makes asymmetric strategy combination be an equilibrium, and shows that platforms with different strength choose different strategies.

To study how $f_e$ and $\delta$ affect the platforms’ strategy, a numerical analysis is shown in Fig. 5. The default values set are the same as those in Fig.2, except $\delta$.

**Figure 5.** (a)SPNE changes with $f_e$ when $\delta = 0.2$ and (b)SPNE changes with $f_e$ when $\delta = 1.2$

Figure 5 shows that the SPNE changes with the increase in developer cost-savings. $(M, M)$ is a SPNE when cost-saving is smaller than a threshold, asymmetric strategy combination is a SPNE when cost-saving is medium,$(T, T)$ is a SPNE when cost-saving is larger than a threshold. The reason is that the increase of cost-savings will compress the profit platform brought by strategy $M$, then forces the platform change strategy $M$ to strategy $T$.

From Fig.5, we also see that the range of $\hat{f}_{e5} - \hat{f}_{e4}$ in Fig.5(a) is larger than that in Fig.5(b), the range of $\hat{f}_{e6} - \hat{f}_{e5}$ and $\hat{f}_{e4} - \hat{f}_{e3}$ in Fig.5(a) is smaller than that in Fig.5(b), and the range of $\hat{f}_{e6}$ and $1 - \hat{f}_{e3}$in Fig.5(a) is larger than that in Fig.5(b). It means that the probability of $(M, T)$ and $(T, M)$ becoming a SPNE increases with platform heterogeneity. Meanwhile, the probability of $(M, M)$ and $(T, T)$ becoming a SPNE decreases, and the probability of asymmetric strategies combination is unstable decreases too. In other words, if platform heterogeneity is relatively small (or even negligible), the key factors of SPNE are consumer’s lock-in effect and developer’s cost-saving effect. However, if platform heterogeneity is relatively large, the SPNE depends on platform heterogeneity mainly.

To study how platform heterogeneity affects the SPNE, a numerical analysis of SPNE changes with platform heterogeneity is depicted by Fig.6. The default values are the same as those in Fig.2 except $v_d = 9.5$, $f_e = 13$, $t_e = 8$, and $t = 3$.

As can be observed from Fig.6, increase of platform heterogeneity will change the SPNE. When the heterogeneity is small, both platforms may take the same strategy, $(T, T)$ or $(M, M)$. Then one of the platforms will change its strategy in order to extract a higher profit, an unstable asymmetric strategy combination $(T, M)$ or $(M, T)$ may emerge. However, when the heterogeneity is larger than a threshold, $(T, M)$ may be a SPNE. The platform with the competitive advantage will choose strategy $T$, while the platform with competitive disadvantage will choose strategy $M$. In general, heterogeneity decreases the pressure of the competition between two platforms and stimulates both platforms to choose the same preannouncement strategy, thus making the asymmetric strategies possible to become a SPNE.
6. Strategic choice path and social welfare.

6.1. Strategic path. This part mainly studies the impact of platforms’ heterogeneity on the transformation path of preannouncement strategy, and the specific results are shown in Proposition 6.

Proposition 6. When equilibrium solution exists,

(i) Platforms tend to choose strategy $T$ under $(T, M)$ and $(M, T)$ scenario of identical platform competition;

(ii) Platforms with higher developers’ basic utility tends to choose strategy $T$ and the platform with lower developers’ basic utility tends to choose strategy $M$ under $(T, M)$ and $(M, T)$ of non-identical platform competition.

Proposition 6 suggests that in an identical platform competition scenario, both platforms are more likely to choose strategy $T$ under homogeneity competition. This tendency of strategy selection will inevitably lead to $(T, T)$ becoming a SPNE more easily when the potential risk costs of different types of preannouncement strategy are not significantly different in an identical platform competition scenario. Proposition 6 also implies that under a non-identical platform competition scenario, the platform with higher developers’ basic utility tends to choose strategy $T$ and the platform with lower developers’ basic utility tends to choose strategy $M$ under $(T, M)$ and $(M, T)$. In other words, the platform with a competitive advantage (a platform that can provide a higher basic utility for developers) is willing to adopt strategy $T$. Those platforms that are temporarily at a competitive disadvantage will decide their new product forecast strategies based on the competitiveness difference between them and their competitors (heterogeneity degree), and choose strategy $M$ when the heterogeneity difference is large, and choose strategy $T$ when the heterogeneity is small. That is to say, as long as there is a competition platform, the platforms with a competitive advantage always adopt strategy $T$, the platforms with competitive disadvantage change their strategies dynamically. Platform heterogeneity weakens competition between two platforms, and it affects the path of preannouncement strategy.

6.2. Social welfare. In the new platform-type products preannouncement, the platforms’ benefits pursuit and the total society welfare pursuit are not always consistent. This subsection will study the impact of different strategy combinations on total social welfare, hoping to provide some suggestions for social public policy. The relevant results are presented in Proposition 7.
Proposition 7.

(i) The total social welfare increases with $f_e$ under $(T,T)$, but decreases with $t_e$ under $(M,M)$;
(ii) In identical platform competition, the order of the total social welfare is $S_{TT} \geq S_{MM}$ when $f_e > \hat{f}_T$; otherwise, the order of the total social welfare is $S_{TT} < S_{MM}$;
(iii) In identical platform competition, the order of the total social welfare is $S_{TT} \geq S_{MM}$ when $t_e \leq \hat{t}_T$; otherwise, the order of the total social welfare is $S_{TT} < S_{MM}$ in identical competition.

Part (i) of Proposition 7 shows that the total social welfare of $(T,T)$ increases with the cost-saving effect of developers, while the total social welfare of $(M,M)$ decreases with the lock-in effect of consumers. However, the profit of platform under $(T,T)$ increases with developer cost-saving effect and platform profit under $(M,M)$ decreases with the consumer lock-in effect.

Secondly, Part(ii) and Part(iii) of Proposition 7 show that the total social welfare of $(T,T)$ is not always greater than that of $(M,M)$. If strategy $M$ can bring a large consumer lock-in effect, the total social welfare of $(M,M)$ is greater than that of $(T,T)$. On the contrary, the total social welfare of $(M,M)$ is less than that of $(T,T)$. Similarly, if strategy $T$ can bring a large developer cost-saving effect, the total social welfare of $(M,M)$ is less than that of $(T,T)$.

On the contrary, the total social welfare of $(M,M)$ will be greater than that of $(T,T)$. It means that the formulation of policies that pursue the maximization of the total social welfare cannot be one-size-fits-all, and comprehensive judgment should be made based on the response intensity of consumers and developers to preannouncement strategy.

In order to depict vividly the impact of platforms’ heterogeneity on total social welfare, a numerical analysis is shown in Fig.7. The default values are the same as that in Fig.2, except $v_d = 9.5, c_M = c_T = 0, t_e = 1, \hat{t}_T = 1$ and $f_e = 13$.

Figure 7 shows that the total social welfare under $(T,T)$ and $(M,M)$ increase with platform heterogeneity. Secondly, the higher platform heterogeneity does not always lead to higher total social welfare under $(M,T)$. The total social welfare under $(M,M)$ increases first and then increases with platform heterogeneity. The reason is that when two platforms choose different preannouncement strategies, a small increase in platform heterogeneity may enhance the competition between the platforms, thus reducing the total social welfare. However, as the heterogeneity of platforms increases to a certain extent, the continuous growth of the heterogeneity between platforms will decrease the competitive intensity and thus increase the total social welfare. It is worthy to point out that with the increase of heterogeneity, the increase of total social welfare brought by symmetric strategy combination is better than that brought by asymmetric strategy profiles. It means that compared with the asymmetric strategy combination, the increase of platform heterogeneity contributes more to the increase of overall social welfare under the symmetric strategy combination.

7. Conclusions. How to choose the message of preannouncement strategy is directly related to the success or failure of new product preannouncement. We develop a new game model of two-sided market for investigating the preannouncement strategy under the competition between platforms from the perspective of information
receiver. It allows us to more accurately assess the impact of new product announcements on stakeholders. The results of this paper can be applied to NPP under a two-sided market. Some key findings are as follows:

Strategy $T$ is beneficial to all participations under $(T, T)$, but the profits of platforms may be less than that under $(M, M)$ because of the potential risk cost of strategy $T$ is too large. Strategy $M$ is beneficial only to platforms and at the expense of consumers’ benefit under $(M, M)$. Therefore, in the process of strategy selection of preannouncement strategy, the potential risk costs of strategy $M$ and strategy $T$ need to consider firstly, followed by the lock-in effect and development cost-saving effect brought by strategy $M$ and strategy $T$, other factors such as network effects need to consider finally. We find that $(M, M)$ is a SPNE when the developers’ capability heterogeneity is smaller than a threshold. $(T, T)$ is adopted by both platforms when the developers’ capability heterogeneity is larger than a threshold. That is, why the platform with higher developers’ capability heterogeneity always adopts some technical innovation and implementation of high-tech products preannouncement and platform with lower developers’ capability heterogeneity adopts marketing preannouncements.

The asymmetric strategy may be a SPNE even if the two platforms are identical (which believes that only the symmetric equilibrium can exist for the case with symmetric platforms). For instance, when the consumer lock-in effect and developer cost savings effect of the new smartphone preview are roughly equal, the asymmetric strategy will likely be an equilibrium. This usually happens in the middle of a smartphone’s life cycle, not the early or late stages. However, it is an unstable strategy. The stability of the asymmetric strategy combination to be a SPNE increases with the platform heterogeneity. Besides, the platform with high competitive advantages tends to choose strategy $T$ and adjust it to strategy $M$ dynamically to extract more profits when platform heterogeneity is large. The platform with a competitive disadvantage tends to choose strategy $M$ and adjust it to strategy $T$ dynamically. The preannouncement strategy of disadvantages platforms will be the same as that of the advantageous platform when platform heterogeneity is small. That is to say, the preannouncement strategy of platforms is not always symmetrical when both platforms have different competitive strengths, especially, when platform heterogeneity is strong.

Strategy $M$ decreases the overall welfare of society under $(M, M)$ in completely homogeneous competition because it is only the reallocation of benefits, and it is at the expense of total social welfare under intense competition. Strategy $T$ increases the overall welfare of society under $(T, T)$ in completely homogeneous
competition, because it brings a cost-saving effect of APP developers, and the cost-saving effects can pass from developers to consumers and platforms. However, platforms are not always willing to adopt strategy \( T \), because the potential risk cost of strategy \( T \) may be too high, and the heterogeneity of the two platforms may be too large. In other words, there are some inconsistencies and conflicts that need to coordinate platforms’ interest and total social welfare, especially in the case of identical platforms. Therefore, in reality, it is particularly important to avoid excessive competition and the dilemma through the coordination of industry associations and other authoritative organizations.

The shortcomings of this study are as follows. Firstly, this paper strictly distinguishes the types of new product preannouncement information. As you know, it is just an idealization. In reality, the message of preannouncement is often mixed, including both marketing and technical information. Therefore, how to improve the effect of preannouncement strategy by controlling the proportional relationship of different types of information in the case of mixed information is interesting. Besides, the paper assumes that consumers only belong to one platform and the market is completely covered, which makes it difficult to describe the entry of new consumers and the exit of old consumers. Therefore, when the market is no longer a bottleneck competitive market, but an oligopoly or an open market structure with incomplete coverage on both sides, the platforms on how to choose the new product preannouncement information is also our future research direction. Finally, the paper assumes that the decisions of consumers, developers, and platforms are synchronous and the information is symmetric. The reality is that decisions between these players may be sequential. The information may be asymmetric and the market is uncertain. Therefore, in this case, how to make decisions for the platform is an outlet.

**Appendix. Mathematical abbreviation and threshold.**

| Table 1A. Mathematical abbreviation and threshold |
|------------------------------------------------|
| \( V_1 = v_d - c_d(1 - g) \) | \( B_0 = \beta_3^2 + \beta_4^2 + 4\beta_0\beta_d \) |
| \( B_1 = \beta_3^2 + \beta_4^2 + 6\beta_0\beta_d \) | \( \phi = c_d(1 - g) \) |
| \( R_1 = \beta_3^2 - 2\beta_4^2 + 3\beta_0\beta_d \) | \( R_2 = f_r(\beta_d + \beta_d) + 2g c_d t_e \) |
| \( R_3 = 24gc_d(c_d^2 - c_d(1 - g)) + 2f c_d t_e - f_r(3\beta_d + 2\beta_0 + 2\beta_0) \) | \( R_4 = f_r(\beta_d + \beta_d) + 5g c_d t_e \) |
| \( R_5 = (\beta_d + \beta_d)(2c_d + 2c_g(1 - 2g) + f_r) + 4g c_d v_c + 2\beta_3^2 + 8\beta_0\beta_d + \beta_4^2 \) | \( R_6 = 2v_d - 2c_d(1 - g) + f_r + \beta_d \) |
| \( R_7 = f_r(\beta_d + \beta_d) + 8g c_d t_e \) | \( E_2 = 2(\beta_3^2 - \beta_4^2) \) |
| \( E_3 = 2(\beta_d + \beta_d) \) | \( E_4 = 2(\beta_d + \beta_d)^2/(8g c_d) \) |
| \( E_5 = 2v_d + \beta_d + \beta_d \) | \( W_1 = 12gc_d(1 + t_e) - (\beta_3^2 + \beta_4^2 + 4\beta_0\beta_d) \) |
| \( W_2 = 12gc_d - (\beta_3^2 + \beta_4^2 + 4\beta_0\beta_d) \) | \( W_3 = 6gc_d(2t_e + t_e) - (\beta_3^2 + \beta_4^2 + 4\beta_0\beta_d) \) |
| \( H_1 = (6f c_d + 3\beta_3^2 + 4f r(\beta_d + \beta_d) \) | \( H_2 = f_r(4gc_d t_e - (\beta_d + \beta_d)^2 + 2f_r(\beta_d + \beta_d))/(48gc_d W_3) \) |
| \( H_3 = f_r(4gc_d t_e + (\beta_d + \beta_d)^2 + 2f_r(\beta_d + \beta_d))/(48gc_d W_3) \) | \( H_4 = R_2^2(\beta_d - \beta_d)^2/(96gc_d W_3^2) \) |
| **Threshold** | **Threshold** |
| \( t^{1g} = \beta_0\beta_d/(2gc_d) - t_e \) | \( t^{1g} = \beta_0\beta_d/(2gc_d) - t_e/2 \) |
| \( t^{2g} = \beta_0\beta_d/(2gc_d) \) | \( t_g = -((1 - g) f_r(2\phi + f_r + Er_e)/(gc_d) \) |
| \( f_c = (2\phi - 2v_d - \beta_d + \sqrt{(1 + g)(1 + g)})(1 + g)/2 + 2g c_d t_e - 4g c_d t_e/(1 + g))/2 \) | |
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