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A Study on Temporal Effects of Different Types of Mobile Application Updates

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Abstract: The sustainability of market performance of mobile applications (apps) updates is a vital goal for e-commerce firms to continuously innovate for products and functions. E-commerce firms must formulate effective app update strategies and tackle the temporal uncertainties associated with different types of app updates. However, the existing literature on app updates mainly focuses on the effects of update frequency. At the same time, scant attention has been paid to clarifying the temporal effects of different types of app updates. Accordingly, based on the framework of exploration vs. exploitation, we investigate the temporal effects of different kinds of app updates on market performance in the hypercompetitive context of online travel mobile applications. We collected data on release notes and downloads of seven Chinese online travel apps available from the Android Market from April 2013 to January 2015; conducted structured content analysis to identify different types of app updates; and adopted the feasible generalized least-squares (FGLS) estimation to test our model. We found that exploitative app updates have an instant and continuous positive impact on market performance, while explorative app updates have no significant effect in the short term but will have a positive effect on market performance in the long term. Moreover, competition intensity shortens the duration of the positive effect of exploitative app updates and delays the time that explorative app updates have to take effect. By studying the different impacts that two types of app updates have on market performance from a time dimension, this study helps resolve the mixed findings on the effects of app updates and guides e-commerce firms on how to effectively formulate app update strategies in a hypercompetitive context.

Keywords: mobile application update; digital innovation; exploration and exploitation; competition intensity; time to performance impact; performance sustainability

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1. Introduction

With the increasing penetration of digital technology and the maturity of mobile shopping, mobile applications (apps) provide essential opportunities for e-commerce firms to conduct business and make profits [1]. In particular, the COVID-19 pandemic has accelerated the development of global mobile e-commerce, as users around the world spent $32 billion on in-app purchases on iOS and Google Play in Q1 of 2021, which is an all-time high and a 40% increase from the same period in 2020 (https://www.chinairn.com/news/20210608/170155917.shtml, accessed on 1 September 2021). Likewise, data also showed that the number of mobile shopping users in China, the world's largest e-commerce market, was 707.49 million, accounting for 85.3% of mobile phone users in China. Moreover, as a typical type of digital innovation, apps can be continuously updated [2,3]. With the addition of new features, app updates provide firms with opportunities to constantly create new ways of fulfilling customers' emerging needs, thereby obtaining competitive advantages [2]. For instance, initially an instant messaging app, WeChat has continuously updated to add products and services, such as content subscriptions, digital payments,

mobile e-commerce services, and games, and has become the most popular app in China, with 1.251 billion monthly active users (http://www.changchenghao.cn/n/728842.html, accessed on 15 September 2021). Thus, to pursue the unique advantages of apps in attracting and retaining customers, it is important that firms formulate effective app update strategies to ensure quick responses to environmental changes and thus achieve sustainable market performance.

However, the sustainability of market performance for firms is faced with a dilemma in terms of the temporal uncertainties of different types of app updates. In hypercompetitive app markets, to gain a sustainable market performance, firms usually have two options for continuous update strategies. Still, they require different efforts and face uncertain benefits in terms of time [4]. In the first option, firms can apply emerging technological innovation activities to improve existing markets, resulting in exploitative innovation, including the continuous improvement of existing product markets, services, and processes, and in turn achieving relatively stable and immediate returns. In the second option, they can assimilate new knowledge and experience and push out new products, services, and processes that break existing market rules and business models but may lead to significant ups and downs of success and failure, so their benefits are changeable and distant. For example, updating too quickly will lead to consumer perceptions of failure or be imitated by competitors, while by updating too slowly, firms could fail to respond to market demands and be surpassed by competitors. Therefore, a better understanding of the temporal effects of different types of app updates in hypercompetitive app markets is crucial for firms to achieve sustained market performance in app markets.

Previous literature on app updates mainly focuses on how app update frequency affects app performance. However, the findings are mixed—while some studies have found that a high rate of app updates is beneficial to improving app performance [2,5–9], other studies suggest that app updates may be costly to customers and can decrease app performance [10]. Although recent studies have started to explore the effects of update types, such as major vs. minor and feature update vs. non-feature update, the results have been far from conclusive, with the underlying theoretical mechanisms remaining unclear [11]. We posit that precisely because different types of app updates are associated with different degrees of change affecting users and competitors, the effects of different kinds of app updates can change over time and under high or low competition intensity. Therefore, our research questions are:

How do different types of app updates affect market performance over time?

How does competition intensity moderate the relationship between an app update and market performance?

We investigated the temporal effect of different types of app updates on market performance in the competitive context of online travel mobile applications. Drawing from the framework of exploration vs. exploitation, we classify app updates as explorative app updates vs. exploitative app updates. Explorative app updates refer to discovery-led updates that enter new product-market domains, while exploitative app updates refer to refinement-led updates that improve existing product-market fields [4,12]. We collected data on release notes and downloads for seven Chinese online travel apps from the Android Market. Then, we applied a structured content analysis method and a distributed time lag model to empirically investigate the temporal effects of the two types of app update on market performance, as well as the moderating effect of competition intensity. We further tested our model using feasible generalized least squares (FGLS).

The results indicated that (1) exploitative app updates have an immediate positive impact on market performance, while explorative app updates have no significant effect in the short term but have a positive impact on market performance in the long term, and (2) competition intensity shortens the duration of the positive effect of exploitative app updates and delays the time at which explorative app updates take effect. Further, the results fill in the lack of knowledge around how temporal differences relate to different types of app updates as well as the influence of competition intensity. After discussing

the results, we guide e-commerce firms to formulate effective app update strategies in competitive scenarios.

Our work contributes to the app update literature by taking a time dimension in investigating the temporal effects of different types of app updates on market performance. Furthermore, our empirical investigation of the moderating effect of competitive intensity on the effectiveness of app updates contributes to adding to empirical evidence on the effects of the competitive environment from previous studies.

2. Theoretical Background

In this section, we begin with reviewing the relevant literature on app updates to position our study and further elaborate on the framework of exploration vs. exploitation to conceptualize our core constructs.

2.1. App Updates

"Mobile app" refers to application software that allows a user to perform a specific task and can be installed and run on a particular developmental platform, such as a mobile app market (e.g., Apple's App Store or Google Play) or web browser (e.g., Firefox) [13–15]. Since digital technologies have reduced barriers to entry and made it easier to piece together business applications, hypercompetition reigns in app markets, leading to large numbers of apps that compete for users [13]. In such a hypercompetitive environment, apps are compelled to continuously update, which introduces new functionalities and features to meet user needs and achieve temporary competitive advantages [7,9]. An app update is a continuous product innovation that releases a new version of an existing app. The new version enables app providers to continuously change or improve their products via product upgrades, which is a particular kind of digital innovation [2,3,10].

Relevant studies focus on the factors and impacts of app updates from different perspectives, including the user-oriented perspective [5,16], which discusses user adoption behavior or continuous use behavior of mobile innovation; the platform perspective (e.g., Apple's App Store or Google Play), which focuses on how platforms should utilize resources and set rules to promote developer innovation and user growth, such as openness [17] and quality control [9]; and the developer perspective that investigates the update strategies of app providers to increase market performance [6,15]. This study focuses on how firms should develop different types of update strategies to achieve market performance in the context of competition, which is positioned from the developer perspective. For research that focuses on the developer perspective, the relevant literature mainly discusses the effects of update frequency. Update frequency refers to version upgrade speed, such as the number of version updates in a specific period, and explores the relationship between update rate and app performance. However, findings on the effectiveness of app updates with regard to performance are mixed (see the column of "Direction of Effects" in Table 1).

On one hand, the majority of these studies indicate that frequent updates improve the quality of an app, attract customer attention, and add value to customers, thus leading to superior market performance [2,7,9]. This stream of research views app updates as an ongoing process of incremental refinement of existing apps and holds the view that it is the frequency or rate of the update rather than the update itself that determines app performance [8]. Ghose et al. [5] proved that the number of version updates is related to the quality of a mobile application, which has a positive impact on user demand, along with price reductions, which also have a positive impact on performance.

On the other hand, recent studies have demonstrated a non-linear relationship between update frequency and app performance, as well as a negative effect on profits. Zhou et al. [2] showed that app updates increase both customers' purchase intentions and development costs, so there is a non-linear relationship between the customer agility characteristics of an application update and performance. Specifically, they found that responding to customers' demands effectively prompts customers' willingness to buy, but over-responding can generate a variety of costs to the product developer and will eventually hurt product

performance, illustrating the tension with customer agility. Foerderer et al. [10] believed that new features added through application updates positively affect consumer perceptions of product utility and lead to more downloads. In addition, app updates increase switching costs, and users have emotional behaviors, such as a sense of psychological belonging and seeking routine, that will lead to a decrease in user scores.

Table 1. Summary of the main research on effects of app updates.

Study	Research Context	Research Topic	Classification	Direction of Effects	Main Findings
[5]	Top 400 ranked apps in Apple's App Store and Google Play in the U.S.	Mobile marketing	None	Positive	1. App demand increases with an in-app purchase option, e.g., number of previous versions. 2. A price discount strategy results in a greater increase in app demand in Google Play compared with Apple's App Store.
[17]	Top 300 ranked apps in Apple's U.S. iTunes	Entrepreneurial innovation	None	Positive	The number of updates to an app (number of versions) significantly and positively affects the probability that a non-game app will enter the top-grossing killer app rankings.
[6]	Top 300 apps in Apple's App Store in the U.S.	Apps' survival	1. Quality (feature) updates 2. Price updates	Positive	App-level attributes such as free app offers, high initial ranks, investment in less-popular (less-competitive) categories, continuous quality updates, and high-volume and high-user review scores have positive effects on app sustainability.
[7]	Top 400 apps in the U.S. Google Play Store	Update strategies	None	Positive	Users rank frequently updated apps highly rather than being annoyed about frequent updates.
[10]	17,247 apps in the U.S. Google Play Store	Product (feature) updates	None	Negative	Negative reactions—updates may stimulate new demand but may also alienate existing consumers.
[2]	2865 apps in Apple's U.S. App Store	Product innovation	None	Curvilinear	Customer agility has a curvilinear relationship with product performance.
[11]	Online Chinese travel firms in Apple's App Store	App innovation	1. App core innovation 2. App support innovation	Positive and negative	Adding new business functions to provide new categories of product or service offerings increases customer evaluations, whereas adding new supporting service functionalities (SSFs) decreases customer evaluations. For followers that "imitate" innovation, the effect of adding SSFs on customer evaluations is negatively contingent on the quality of early-mover apps.

Recent studies center on app features and find that the effectiveness of different types of app updates is unclear [6,11]. While some studies found that app updates significantly

improve app performance, other studies argue that some types of app updates can decrease app performance. Lee et al. [6] found that quality updates can improve the survival rate by three times, while price updates have no significant impact on improving the survival rate. Based on the technological innovation and early-mover advantages literature, Tian et al. [11] delineated two types of app innovation and their impacts on customer evaluations. Their findings indicate that adding new business functions to provide new categories of products or service offerings increases customer evaluations, whereas adding new supporting service functionalities (SSFs) decreases customer evaluations. For followers that "imitate" innovation, the effect of adding SSFs on customer evaluations is negatively contingent on the quality of early-mover apps.

A few studies have noted that the competitive environment faced by the mobile application market can affect the effectiveness of updates. According to Kajanan et al. [18], given the hypercompetitive environment of the mobile app market and the fact that there is an alternative option to most apps, if users are not satisfied with the quality of an app's frequent updates, that app may not survive. Comino et al. [9] found that app updates on iTunes, which has strict quality control, increase the growth rate of downloads. However, due to the lack of quality control on Google Play, mobile apps are in a hypercompetitive state of excessive updates, and the effect of app updates is not obvious. Although these studies pay attention to the competitive environment faced by the mobile application market, there is a lack of empirical research to analyze the mechanisms of the competitive environment.

Therefore, related studies that focus on app updates mainly investigate the effects of update frequency and update type. The majority of these studies indicate that frequent updates improve the quality of an app and attract customer attention, thus leading to superior market performance. However, the findings are mixed, with both positive and negative conclusions in previous research [2,7,9]. Although recent studies have started to explore update types, e.g., major vs. minor or feature update vs. non-feature update, the results have been far from conclusive, and the underlying theoretical mechanisms have been unclear [6,11]. There are two research gaps in better understanding the relationship between app updates and market performance. First, previous studies have not explored the effect of app updates from the time dimension, regarding updated content as homogeneous and leading to mixed conclusions. Second, competition has become an important factor that affects mobile app updates, but current studies mainly assume competitive environment as the background condition and have not empirically revealed the mechanism of the competitive environment on app updates.

2.2. Exploration vs. Exploitation

The concept of exploration vs. exploitation has become a central theme in the organizational learning literature [19]. Its applicability has been extended to characterize how firms strategically prioritize their approach to technological innovation [4,20], from the generation of new ideas to the launch of new products [21]. In general, exploration is associated with organic structures, path-breaking, improvisation, autonomy and chaos, and emerging markets and technologies. Exploitation is associated with mechanistic structures, path dependence, routinization, control and bureaucracy, and stable markets and technologies [20].

Exploration refers to the ability of a firm to enter new product-market domains through research, discovery, and experimentation [4,20,22]. It advocates for deviating from the status quo by focusing on experimentation with new alternatives and promoting a broad search for new and alternative solutions that often generate risky and uncertain returns [19,23,24].

In contrast, exploitation refers to a firm's ability to improve its existing product-market efficiency through improvements to, and refinements of, its current skills and processes [4,20,22]. It involves the firm taking advantage of its experience-based learning curve and focusing its research on its current knowledge domains to generate "safe" returns [22,23].

In addition, it has been noted that the process of revenue generation is different between exploration and exploitation [4,12,19,25]. Prior literature has highlighted potential pitfalls in inferring which innovation strategy is more effective in terms of firm performance, as "the returns from the two options vary not only with respect to their expected values, but also with respect to their variability, their timing, and their distribution within and beyond the firm" [19]. Exploitation can lead to positive short-term performance effects by reducing variety and increasing efficiency, while exploration strategies focus on variance-increasing activities that allow the firm to create new knowledge that can lead to positive long-term performance effects [26]. He and Wong examined how exploration and exploitation can jointly influence firm performance in the context of firms' approaches to technological innovation [4]. In denoting an exploratory innovation dimension, they discussed how technological innovation activities are focused on pursuing innovation strategies that will help a firm enter new product-market fields. Moving in this direction may lead to significant ups and downs of success and failure, so the benefits are changeable and distant. In contrast, they described an exploitative innovation dimension that denotes technological innovation activities aimed at improving existing product-market positions, and their return is relatively stable and immediate. Sanders (2008) [27] has divided the application paradigm of IT into exploration and exploitation. Between them, IT exploitation aims at improving, utilizing, and incrementally refining firms' competencies, and their accomplishments are gains that can be clearly defined. As for IT exploration, it is applied to create new capabilities and design new schemes for existing problems. Thus, the corresponding outcomes are difficult to calculate in advance.

Based on the perspective of exploration vs. exploitation, this study divides app updates into two types: explorative and exploitative. Explorative app updates refer to exploring new opportunities and creating a new business model to radically change the way a firm creates and delivers business value. Their purpose is to meet new market demands, such as creating new product markets or finding a new niche in the existing market. Exploitative app updates refer to using existing resources and abilities to improve the existing business model and the efficiency of the existing processes in order to expand on the value chain of the existing products, services, or markets, without fundamentally changing the value chain structure. Their purpose is to meet the existing market demands, such as adding more products or services to an existing product line.

We then investigate the impact of these two types of app updates on performance from a time dimension. Update type refers to how a new version's upgraded content is classified, including the features of the update and the update's effects on performance. Specifically, we analyze the temporal effect from two aspects: timing and duration. Timing refers to the amount of time required for an app update to have a significant positive impact on performance. Duration refers to the period of time for which the positive impact is deemed significant. In addition, since update frequency is widely regarded to be a key factor in the update effect of mobile applications [5], we introduce the concept of update frequency and consider that explorative app updates are measured by the number of explorative app updates in a given period. Exploitative app updates are measured by the number of exploitative updates in a given period.

3. Research Model and Hypotheses

3.1. Research Model

This study investigates the temporal effect of different types of app updates on market performance in the hypercompetitive context of online travel mobile applications. We applied a structured content analysis method and distributed time lag model to explore the different effects of two types of app updates on market performance in terms of time and the moderating effect of competition intensity. The research model is constructed as shown in Figure 1, and Table 2 summarizes the definitions of the constructs in our research model. This model consists of four core constructs: exploitative app updates, explorative app updates, competition intensity, and mobile application's market performance.

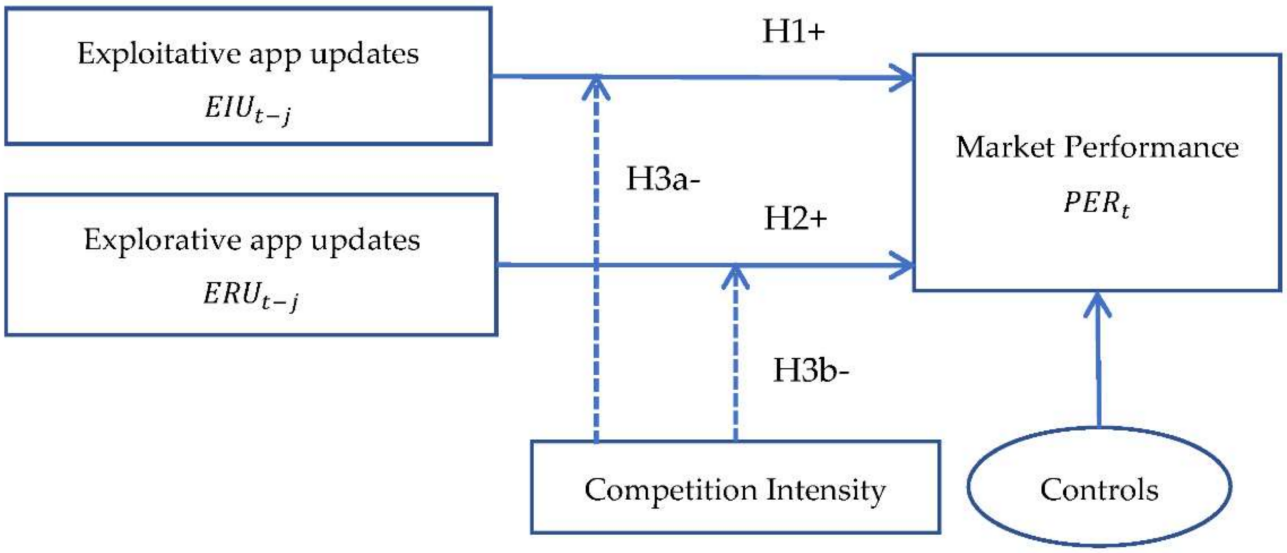


Figure 1. Research model.

Table 2. Definition of constructs.

Construct	Definition	References
Exploitative app updates	Use existing resources and abilities to improve the existing business model and the efficiency of the existing processes, as well as to expand the value chain of the existing products, services, or markets without fundamentally changing the value chain structure.	[12,19,20]
Explorative app updates	Explore new opportunities and create a new business model to radically change the way firms create and deliver business value.	
Competition intensity	The number of competitors in the field and their moves against focal firms, which is the competitive environment the focal firm faces.	[28]
Market performance	How well an app fares with its end users.	[8]

As a typical type of digital innovation, app updates provide firms with opportunities to constantly create new ways of fulfilling customers' emerging needs, thereby obtaining competitive advantages [2]. Thus, digital innovation of app updates can apply emerging technological innovation activities to improve product markets, services, and processes, thereby enhancing the competitiveness and benefiting the sustainability of the app's market performance [16]. Market performance (PER) refers to how well an app fares with its end users [8]. A sustainable market performance means that in a hypercompetitive environment, an app can constantly meet user needs, thus achieving its sustainable development. In order to gain a sustainable market performance, firms usually have two options for continuous updates, but they require different efforts and face uncertain benefits in terms of time. Therefore, based on the perspective of exploration vs. exploitation, this study divides app updates into two types: explorative app updates (ERU) and exploitative app updates (EIU). Explorative app updates (ERU) refer to discovery-led updates that enter new product-market domains, while exploitative app updates (EIU) refer to refinement-led updates that improve existing product-market domains [4,12]. We then investigate the temporal effect of these two types of app updates on market performance (PER) from a time dimension.

PER represents market performance; EIU represents exploitative app updates; ERU represents explorative app updates; CI represents competition intensity, and we introduced promotion behavior (PB) as the control variable; t represents the t phase; and t-j represents the lag j phase relative to t (j = 0, 1, 2 . . .).

3.2. Research Hypothesis

3.2.1. The Impact of Two Types of App Updates on Market Performance

Between the two types of app updates, there is a difference in the time effect that affects performance. This difference depends on the differential processes in which the two types of updates generate benefits.

Exploitative app updates refer to a firm's ability to improve its existing product-market efficiency through improvements to, and refinements of, its current skills and processes. In contrast, explorative app updates refer to the ability of a firm to enter new product-market domains through research, discovery, and experimentation [19].

As such, exploitative app updates denote technological innovation activities aimed at improving existing product-market positions based on experiential learning [4,12]. This learning process ensures appropriate and efficient utilization of a firm's current expertise and knowledge such that the firm's existing products, services, or methods can be adapted [23] to improve quality and/or cost efficiency and enhance the consumption experience of existing customers [29]. Therefore, export firms that focus on exploitative app updates can leverage their past experience [30] to fine-tune their well-defined but limited product-market solutions and benefit from improved quality and efficiency while growing export sales revenues. For instance, Ctrip, the largest online travel platform in China, launched "Flight Assistant" in version 7.2.2, which is a sub-function of the app's ticket module. It provides information services such as flight dynamics, airport weather, arrival delays, service evaluation, and destination guides to meet passenger needs. Comparing the trends in total app downloads within 30 days following the app update, Ctrip has a lead of nearly 7–8 times over Fliggy (another of China's leading online travel platforms and one of Ctrip's main competitors), as Fliggy does not provide detailed flight information services.

We believe there are two explanations for this immediate positive effect from exploitative app updates. First, experiential learning is easier to turn into incremental actions [31]. Second, the benefits of exploitative app updates from improvements in quality and efficiency can be delivered to the market in a relatively short period of time and received by target customers quickly [26]. Hence, we propose:

Hypothesis 1: *Exploitative app updates have an immediate positive impact on market performance.*

Explorative app updates pertain to search, discovery, novelty, innovation, and trial and error, which rely on experimental learning [4]. Due to their emphasis on experimentation and risk taking, explorative app updates allow firms to learn from searching for new or unrecognized customer needs, identifying novel solutions, and generating value from expansion into untapped market opportunities [32]. To respond to new market opportunities, firms engage in a learning process to develop new technologies and expand product ranges in order to create and commercialize radical new products and services that generate value.

We expect that this positive effect of explorative app updates on market performance lags in its impact but provides long-term value for two reasons. First, it takes time for firms to undertake searching and experimental learning [31]. Second, it also takes time for firms to innovate on what they learn and, for instance, develop or expand products and markets [32]. Accordingly, we suggest:

Hypothesis 2: *The significant positive impact of explorative app updates lags behind market performance.*

3.2.2. Competition Intensity and the Two Types of App Updates' Performance

Mobile applications allow firms to create and reconfigure digital capabilities for appropriate short-term competitive advantage [13]. The benefits firms obtain from a specific action are not infinite and lasting. As competitors find ways to respond to such actions, this competitive advantage will erode.

Studies have noted that the competitive environment faced in the app market will affect updates. The competition intensity will negatively adjust the relationship between update frequency and performance. Competition intensity is defined as the number of competitive actions initiated by aggressive competitors against focal firms [28].

Competition intensity will negatively regulate the relationship between exploitative app updates and performance and weaken the positive impact of progressive renewal on performance. On the one hand, although a firm can enhance user stickiness through continuous exploitative app updates, in highly intense competition, rival firms are able to decipher and imitate exploitative app updates, thereby eroding the competitive advantage of the focal applications [33]. On the other hand, the long-term positive feedback of progressive renewal can lead a firm to stay on a path of strong dependence and continuing reliance on its current focus and abilities. This, in turn, can lead to the firm's core competence becoming its core confinement. Thus, while its competitors continue to evolve and seek new opportunities, the firm will find itself in a sub-optimal trap of long-term stability and short-sighted abilities that will ultimately lead to the firm's decline.

Moreover, competition intensity will negatively regulate the relationship between explorative app updates and market performance. As mentioned earlier, explorative app updates have high trial-and-error costs and user conversion costs [8], which undoubtedly increase the cost to users in core mobile applications. When the user's perceived cost is greater than the perceived utility, the user will provide negative feedback about an update. When a user's routine costs in a core mobile application are very high, a competitor's app may reduce those routine costs for the user. The greater the competition intensity, the more likely the competitor will attract users of an app to its own platform. Therefore, due to high-intensity competition, explorative app updates can have a negative impact on performance. Therefore, these assumptions are put forward:

Hypothesis 3a: *Competition intensity has a negative effect on the relationship between exploitative app updates and market performance.*

Hypothesis 3b: *Competition intensity has a negative effect on the relationship between explorative app updates and market performance.*

4. Data and Methods

4.1. Research Context and Data Collection

We tested our hypotheses in the context of Chinese online travel mobile applications. The unit of analysis was an app of an online travel platform (OTP). China's online travel apps provide a particularly good setting in which to investigate our research questions because of the frequent digital updates and competitive interactions in the online travel industry. On average, OTPs update their apps at least once a month, or even once a week (https://www.gelonghui.com/p/296499, accessed on 20 September 2021). Online travel apps are typical digital products, enabling OTPs to constantly update and evolve by adding digital functions and features to their apps. Furthermore, with the prevalence of competitive interaction among rival online travel platforms, there are increased threats of being imitated or surpassed in the online travel industry in China. In this fierce competition, online travel platforms carry out rapid and diversified digital app update strategies, which provided abundant materials for our research.

We gathered monthly data on app updates from Android Market (Mobile Paradise (www.shouji.com.cn, accessed on 5 January 2013) is a mobile application download platform for Android apps through which one can download mobile applications and their

update records) and on performance from ctcnn.com (ctcnn.com is the authoritative tourism information media portal in China, accessed on 11 January 2013) for seven leading OTPs (Ctrip, Qunar, Fliggy, eLong, Tuniu, LY, Lvmama) in China during the period of April 2013 to January 2015, i.e., 22 months in total.

The dominance of these seven OTPs was acknowledged in the industry report and also received prominent attention in media coverage about competition in the online travel industry. Reports suggest that the seven OTPs combined had approximately 90% of the online travel industry market in 2015 [11].

Moreover, the most intense competitive interaction among the seven OTPs occurred during that period. The seven OTPs started to deploy their apps in 2013 (https://fashion.ifeng.com/travel/news/china/detail_2013_03/01/22637964_0.shtml, accessed on 20 March 2013), and customers gradually adopted them to reserve and manage their trips. Therefore, we chose April 2013 as the starting point of data collection. Frequent capital operations, such as mergers and purchases, occurred in 2015, especially when Ctrip acquired eLong and Qunar, fundamentally reshaping the industry structure and marking the end of the intensely competitive interactions among the seven OTPs. As a consequence, we terminated the data collection at the end of January 2015.

4.2. Coding of App Updates

This study applied structured content analysis to code OTPs' app updates [34], which were classified into two types which are described below. The structured content analysis uses a content analysis schedule to draw relevant information from published case materials (more generally, published text materials) and transforms the qualitative text into a quantitative matrix with variables as units so that researchers can quantitatively verify the proposed assumptions.

The coding schedule was divided into three steps. First, two doctoral students read 154 app update records carefully and then extracted key descriptions reflecting research constructs (radical updates and incremental updates). From this, the coding protocol could be formulated. The coding rules are presented in Table 3.

Second, two graduates and two doctoral students were divided into two groups for independent encoding. The first group took charge of coding Ctrip, Fliggy, Tuniu, and Lvmama, while the other group was responsible for coding Qunar, LY, and eLong. Both of them classified the OTPs' app updates into explorative or exploitative categories according to exploration–exploitation perspectives. Third, the reliability of our classification process was tested using the Q-sort method [35]. The Kappa value was 0.908, indicating a high degree of reliability.

4.3. Variables and Measurements

Dependent variables. *Market performance* reflects how well an app fulfills customer needs and is measured by the number of downloads in a month t per online travel app i. Due to the inaccessibility of actual sales data, previous literature has used publicly available data, such as estimated downloads [5,9], ranks [7,18], and average rating [8,10] to measure the market performance of an app. However, ctcnn.com (accessed on 20 October 2021) now provides reliable market performance data on mobile apps, and we were able to use their monthly download data for the seven leading OTP apps in China for this study. Considering the time lag between an app update and its effects on the market, we took the following steps: downloads from the 21st of month t-1 to the 20th of the month t were used to measure the performance in month t. We log-transformed the downloads to address the skew in distributions.

Independent variables. We had two independent variables (IV): *Explorative app updates and exploitative app updates*. We measured *explorative app updates (ERU)* through the number of new features or functionalities in app updates introduced by online travel app i in month t. According to our coding rules, this study included two types of explorative app updates. The first type of update is the launching of new products and channels.

Traditional tourism products mainly include food, hotel, transportation, tourism, shopping, entertainment, combined products, and additional products [36]. If a new product category were added, it would be regarded as an explorative update. The second type of update is the launching of new business models based on digital technology. If a new business model is added to a mobile application, it is also regarded as an explorative update.

Table 3. Coding rules of app updates.

Categories	Definitions	Coding Rules and Examples	Key Terms
Explorative app updates	Explorative app updates refer to exploring new opportunities and creating a new business model to radically change the way firms create and deliver business value. It seeks to meet new market demands, such as creating new product markets or finding a new niche in the existing market.	• Launching new products and channels (e.g., launching a new overseas hotel channel) • Launching new business models based on digital technology, accompanied by the launch of new business channels (e.g., launching the "air ticket + hotel" independent travel channel, group purchase channel, mystery hotel channel, etc.)	Launch new products, launch new channels, new launches, new additions, new support, etc.
Exploitative app updates	Exploitative app updates refer to using existing resources and abilities to improve the existing business model and the efficiency of existing processes, as well as to expand on the value chain of the existing products, services, and/or markets, without fundamentally changing the value chain structure. Its purpose is to meet the existing market demands, such as adding more products or services to an existing product line.	• Enriching the product line (e.g., adding student tickets to existing train ticket sales) • Cooperating with more suppliers to provide more product choices (e.g., access "7-day Hotel" as the hotel business supplier) • Adding new service elements to the original product business (e.g., the new "flight dynamics" function of the air ticket channel enables consumers to query flight dynamics in real-time) • Revising the original service function elements to optimize the user experience (e.g., optimizing the search function to improve the efficiency of international hotel searching)	New page revision, more products, optimizing experience, optimized details, faster, more convenient, functional upgrade, optimized layout

To measure *exploitative app updates (EIU)*, we used the exploitative app update coding rules to identify the number of features or functionalities introduced by online travel app i in month t. This study included four types of exploitative app updates: increasing product segmentation, expanding the number of products, adding service elements to the original product business, and revising the original service functionalities.

Moderator variable. *Competition intensity (CI)* is defined as the number of competitive actions initiated by aggressive competitors against focal firms [28]. Taking competition intensity as the moderator variable, this study investigated the temporal effects of different types of app updates on market performance. Therefore, in our context, the sum of the number of competitive behaviors initiated by six other mobile applications in the mobile application samples in month t, including update behavior and promotion behavior, was used as the measurement of competition intensity.

Control variables. Previous research argued that a company's promotion behavior has substantial impacts on performance [5,6,18]. Therefore, we introduced promotion behavior as the control variable. A dummy *promotion behavior (PB)* took a value of 1 for online travel app i if it exhibited promotion behavior in month t and a value of 0 if it did not.

4.4. Econometric Model

This study investigated the temporal effects of different types of app updates on market performance in hypercompetitive app markets. Based on the previous theoretical description, our theory suggests that the impact of the two types of app updates on market performance is not limited to a single period but varies with time. We studied the different effects of the two types of app updates on market performance in terms of timing and duration. Employing a distributed time lag model [37] and using alternative lag time periods as covariates allowed us to evaluate the effects of changes in independent variables on the dependent variable over multiple periods of time [38]. Specifically, our distributed time lag model included the two types of app updates, lagging by 1 to 5 months due to the impact of seasonal factors in the travel industry on user demand [36]. Thus, in our model, market performance in January 2015 may have been affected by OTPs' app updates from December and November 2014 back to August 2014. Given how turbulent the travel industry was in the period of 2013–2015, we determined that 5 months could be termed "longer term". We checked the sensitivity of the results against shorter and longer lag periods: the results were robust to changes in the number of lags included in the model.

Econometric Models. We estimated the following model to investigate the temporal effects of different types of app updates on market performance in the hypercompetitive world of online travel mobile applications. Model 1 (including 1A and 1B) tests how the time to positive impact varies across types of app updates on market performance, and Model 2 (including 2A and 2B) tests the moderator effect of different competition intensities on app updates and on market performance. To test Hypothesis 1 and Hypothesis 2, we look at the first month with significant positive market performance. To test Hypothesis 3a and Hypothesis 3b, we examine the number of months for which the significant positive market performance impact is sustained. Accordingly, we proceed to specify four models:

Model 1A: The relationship between exploitative app updates and market performance.

$$\ln Per_{it} = \beta_0 + \beta_1 EIU_{it} + \ldots + \beta_6 EIU_{i,t-5} + \beta_7 CI_{it} + \ldots + \beta_{12} CI_{i,t-5} + \beta_{13} PB_{it} + u_i + \varepsilon_{it} \quad (1)$$

Model 1B: The relationship between explorative app updates and market performance.

$$\ln Per_{it} = \beta_0 + \beta_1 ERU_{it} + \ldots + \beta_6 ERU_{i,t-5} + \beta_7 CI_{it} + \ldots + \beta_{12} CI_{i,t-5} + \beta_{13} PB_{it} + u_i + \varepsilon_{it} \quad (2)$$

Model 2A: The relationship between exploitative app updates and market performance under different competitive intensities.

$$\begin{aligned} \ln Per_{it} = {} & \beta_0 + \beta_1 EIU_{it} + \ldots + \beta_6 EIU_{i,t-5} + \beta_7 CI_{it} + \ldots + \beta_{12} CI_{i,t-5} \\ & + \beta_{13} EIU_{it} \times CI_{it} + \ldots \beta_{18} EIU_{i,t-5} \times CI_{i,t-5} + \beta_{19} PB_{it} + u_i + \varepsilon_{it} \end{aligned} \quad (3)$$

Model 2B: The relationship between explorative app updates and market performance under different competitive intensities.

$$\begin{aligned} \ln Per_{it} = {} & \beta_0 + \beta_1 ERU_{it} + \ldots + \beta_6 ERU_{i,t-5} + \beta_7 CI_{it} + \ldots + \beta_{12} CI_{i,t-5} + \beta_{13} ERU_{it} \times CI_{it} \\ & + \ldots \beta_{18} ERU_{i,t-5} \times CI_{i,t-5} + \beta_{19} PB_{it} + u_i + \varepsilon_{it} \end{aligned} \quad (4)$$

where <i, t> represent an app–month combination; $x_{i,t-5}$ is a vector of the standardized number of app updates of the two types taken by online travel app i in month t − 5; β_(0–16) are the regression model coefficients; and ε_ denotes the remaining stochastic disturbance term. We standardized $EIU_{i,t-(0-5)} \times CI_{i,t-(0-5)}$ and $ERU_{i,t-(0-5)} \times CI_{i,t-(0-5)}$ to eliminate concerns about multicollinearity in the model brought on by the high correlation between the squared term and $\ln Per_{it}$.

Our data set was a balanced panel: the data structure was pooled cross-section and time series. The time dimension t (t = 22) was greater than the section dimension n (n = 7), which belonged to long panel data. Introducing the Wooldridge test for intergroup heteroscedasticity and intragroup autocorrelation, as well as the Breusch–Pagan LM Test for intergroup contemporaneous correlation, we tested the disturbance term of the panel data [39]. The results strongly rejected the original hypothesis, indicating that the disturbance term of the sample data had intergroup heteroscedasticity, intra group autocorrelation and inter group contemporaneous correlation. Therefore, we opted for the feasible generalized least-squares (FGLS) to test our model, and ordinary least-squares regression with panel-corrected standard error (OLS-PCSE) was used to test the robustness of our findings [40].

5. Results

5.1. Descriptive Statistics

Table 4 provides descriptive statistics and Pearson correlation coefficients for the variables. Correlations among independent variables are low to moderate, and the variance inflation factors for the lags of app updates are lower than 3.14, which are all values below the commonly accepted cutoff of 10. We then proceeded to report our empirical results.

5.2. Empirical Results

The results of the data analyses are shown in Table 5. Model 1 tests how the time to positive impact varies across types of app updates in terms of market performance, and Model 2 tests the moderator effect of different competition intensities on app updates in terms of market performance. For a more intuitive display, Figure 2 illustrates that the total impact of app updates on performance is distributed over time (the lags that are statistically significant are shown in darker gray).

Model 1 reveals that the time to positive impact varies across types of app updates. Results indicate that the time to the first significant positive impact for exploitative app updates is very short, having an immediate impact. In contrast, explorative app updates take longer to have a significant positive effect on market performance: The first significant positive effect is in lag period 3. Hypothesis 1 states that the time to positive impact for exploitative app updates is short, and that of explorative app updates is longer. Our results support the proposed order in Hypothesis 1.

Hypothesis 2 is supported as well. Model 1 shows that the two types of app updates have different durations of performance impact. Figure 2a,b show that exploitative app updates have a significant positive impact on performance from the current period to lag period 5, while explorative app updates have a continuously positive impact on performance after lag period 3.

Model 2 shows that competition intensity has a negative moderator effect on the relationship between the two types of app updates and market performance. Results in Model 2 reveal that the interaction between competition intensity and explorative app updates has a significant negative correlation with performance at the level of 1% from lag period 3 to lag period 6, $\beta < 0$. It shows that competition intensity plays a negative regulatory role in the relationship between explorative app updates and market performance. Results in Model 2 reveal that the impact of the interaction between competition intensity and exploitative app update has a significant negative correlation with market performance at the level of 1% from lag period 3 to lag period 6, as well as at the level of 10% in lag period 2, $\beta < 0$. It shows that competition intensity also has a negative regulatory effect on the relationship between exploitative app updates and market performance. Hypotheses 3a and 3b are supported.

Table 4. Descriptive statistics and correlation matrix.

Variables	Mean	SD	PER	PB	ERU_t	ERU_{t-1}	ERU_{t-2}	ERU_{t-3}	ERU_{t-4}	ERU_{t-5}	EIU_t	EIU_{t-1}	EIU_{t-2}	EIU_{t-3}	EIU_{t-4}	EIU_{t-5}	CI_t	CI_{t-1}	CI_{t-2}	CI_{t-3}	CI_{t-4}	CI_{t-5}
PER	7.67	1.61	1																			
PB	0.41	0.49	0.15	1																		
ERU_t	0.18	1.12	0.18	0.05	1																	
ERU_{t-1}	0.18	1.14	0.21 *	−0.04	0.19	1																
ERU_{t-2}	0.12	1.11	0.23 *	−0.02	0.16	0.17	1															
ERU_{t-3}	0.12	1.1	0.27 *	−0.03	0.13	0.16	0.02 *	1														
ERU_{t-4}	0.11	1.1	0.28 *	0.09	0.06	0.12	0.17	0.19 *	1													
ERU_{t-5}	0.05	1.04	0.29 *	−0.06	−0.00	0.09	0.14	0.21 *	0.23 *	1												
EIU_t	−0.32	0.7	0.30 *	0.11	0.41 *	0.21 *	0.14	0.31 *	0.23 *	0.07	1											
EIU_{t-1}	−0.35	0.7	0.34 *	0.05	0.1	0.41 *	0.22 *	0.14	0.32 *	0.32 *	0.07	1										
EIU_{t-2}	−0.40	0.65	0.34 *	−0.05	0.01	0.13	0.38 *	0.29 *	0.18 *	0.27 *	0.19 *	0.11	1									
EIU_{t-3}	−0.39	0.66	0.35 *	0.05	0.17	0.04	0.1	0.37 *	0.27 *	0.20 *	0.27 *	0.18 *	0.11	1								
EIU_{t-4}	−0.41	0.64	0.36 *	0.02	0.06	0.19 *	−0.01	0.12	0.37 *	0.24 *	0.1	0.32 *	0.14	0.12	1							
EIU_{t-5}	−0.43	0.61	0.36 *	0.01	0.08	0.04	0.12	−0.00	0.14	0.37 *	0.11	0.12	0.29 *	0.14	0.05	1						
CI_t	−0.40	0.72	0.30 *	0.04	0.15	−0.04	−0.06	0.14	0.09	0.25 *	0.27 *	0.04	0.13	0.20 *	−0.06	0.26 *	1					
CI_{t-1}	−0.46	0.75	0.33 *	0.17	−0.04	0.15	−0.01	−0.03	0.16	0.13	0.12	0.29 *	0.06	0.1	0.20 *	−0.06	0.14	1				
CI_{t-2}	−0.62	0.65	0.32 *	0	0.09	−0.01	0.15	0.05	0.01	0.21 *	0.14	0.14	0.23 *	0.01	0.08	0.18 *	0.30 *	0.22 *	1			
CI_{t-3}	−0.64	0.65	0.32 *	0.04	0.05	0.08	−0.00	0.16	0.06	0.01	0.23 *	0.15	0.14	0.21 *	0	0.08	0.55 *	0.31 *	0.29 *	1		
CI_{t-4}	−0.71	0.67	0.34 *	0.20 *	−0.09	0.06	0.1	0.03	0.18	0.1	0.03	0.25 *	0.14	0.1	0.21 *	−0.00	0.06	0.58 *	0.35 *	0.30 *	1	
CI_{t-5}	−0.79	0.61	0.31 *	0.13	0.1	−0.07	0.04	0.15	0.05	0.21 *	0.23 *	0.02	0.20 *	0.12	0.09	0.22 *	0.60 *	0.08	0.48 *	0.39 *	0.29 *	1

Notes: * represents $p < 0.05$; PER represents market performance; EIU represents exploitative app updates; ERU represents explorative app updates; PB represents promotion behavior; CI represents competition intensity; t represents the t phase; and t-j represents the lag j phase relative to t (j = 0, 1, 2 . . . 5).

Table 5. FGLS estimation of market performance.

Variables	EIU		ERU	
	Model 1	**Model 2**	**Model 1**	**Model 2**
PB	−0.015	−0.015	−0.017	−0.052 ***
	(0.161)	(0.219)	(0.229)	(0.002)
AU_t	0.034 ***	0.040 ***	0.002	−0.002
	(0.001)	(0.001)	(0.800)	(0.666)
AU_{t-1}	0.058 ***	0.054 ***	0.004	−0.005
	(0.000)	(0.000)	(0.612)	(0.406)
AU_{t-2}	0.061 ***	0.003	0.008	0.001
	(0.000)	(0.868)	(0.267)	(0.838)
AU_{t-3}	0.050 ***	−0.009	0.019 **	0.003
	(0.004)	(0.626)	(0.010)	(0.643)
AU_{t-4}	0.061 ***	0.003	0.032 ***	0.018 ***
	(0.000)	(0.846)	(0.000)	(0.008)
AU_{t-5}	0.053 ***	0.026	0.018 ***	0.016 ***
	(0.000)	(0.109)	(0.007)	(0.007)
CI_t	0.101 ***	0.122 ***	0.118 ***	0.103 ***
	(0.000)	(0.000)	(0.000)	(0.001)
CI_{t-1}	0.185 ***	0.181 ***	0.203 ***	0.240 ***
	(0.000)	(0.000)	(0.000)	(0.000)
CI_{t-2}	0.238 ***	0.203 ***	0.242 ***	0.274 ***
	(0.000)	(0.000)	(0.000)	(0.000)
CI_{t-3}	0.210 ***	0.155 ***	0.236 ***	0.261 ***
	(0.000)	(0.000)	(0.000)	(0.000)
CI_{t-4}	0.216 ***	0.187 ***	0.206 ***	0.234 ***
	(0.000)	(0.000)	(0.000)	(0.000)
CI_{t-5}	0.128 ***	0.102 ***	0.096 ***	0.146 ***
	(0.000)	(0.002)	(0.000)	(0.000)
$AU \times CI_t$		−0.004(0.825)		0.006(0.358)
$AU \times CI_{t-1}$		−0.040 *		−0.011
		(0.075)		(0.122)
$AU \times CI_{t-2}$		0.127 ***		0.025 ***
		(0.000)		(0.003)
$AU \times CI_{t-3}$		0.104 ***		0.025 ***
		(0.000)		(0.005)
$AU \times CI_{t-4}$		0.104 ***		0.044 ***
		(0.000)		(0.000)
$AU \times CI_{t-5}$		0.054 ***		0.018 ***
		(0.007)		(0.009)
Constant	9.943 ***	9.710 ***	9.857 ***	9.991 ***
	(0.177)	(0.157)	(0.203)	(0.150)
Number of observations	126	126	126	126

Note: * represents $p < 0.1$, ** represents $p < 0.05$, and *** represents $p < 0.01$; robust standard errors reported in parentheses; EIU represents exploitative app updates; ERU represents explorative app updates; AU represents app update; PB represents promotion behavior; CI represents competition intensity; t represents the t phase; and t-j represents the lag j phase relative to t (j = 0, 1, 2 . . . 5).

5.3. Robustness Test

We applied alternative estimation procedures to test the robustness of our findings. The ordinary least-squares regression with panel-corrected standard error (OLS-PCSE) was used to test the robustness of our findings. The results were consistent with those estimated by FGLS, indicating the strong robustness of our research findings. The robustness test results are shown in Appendix A.

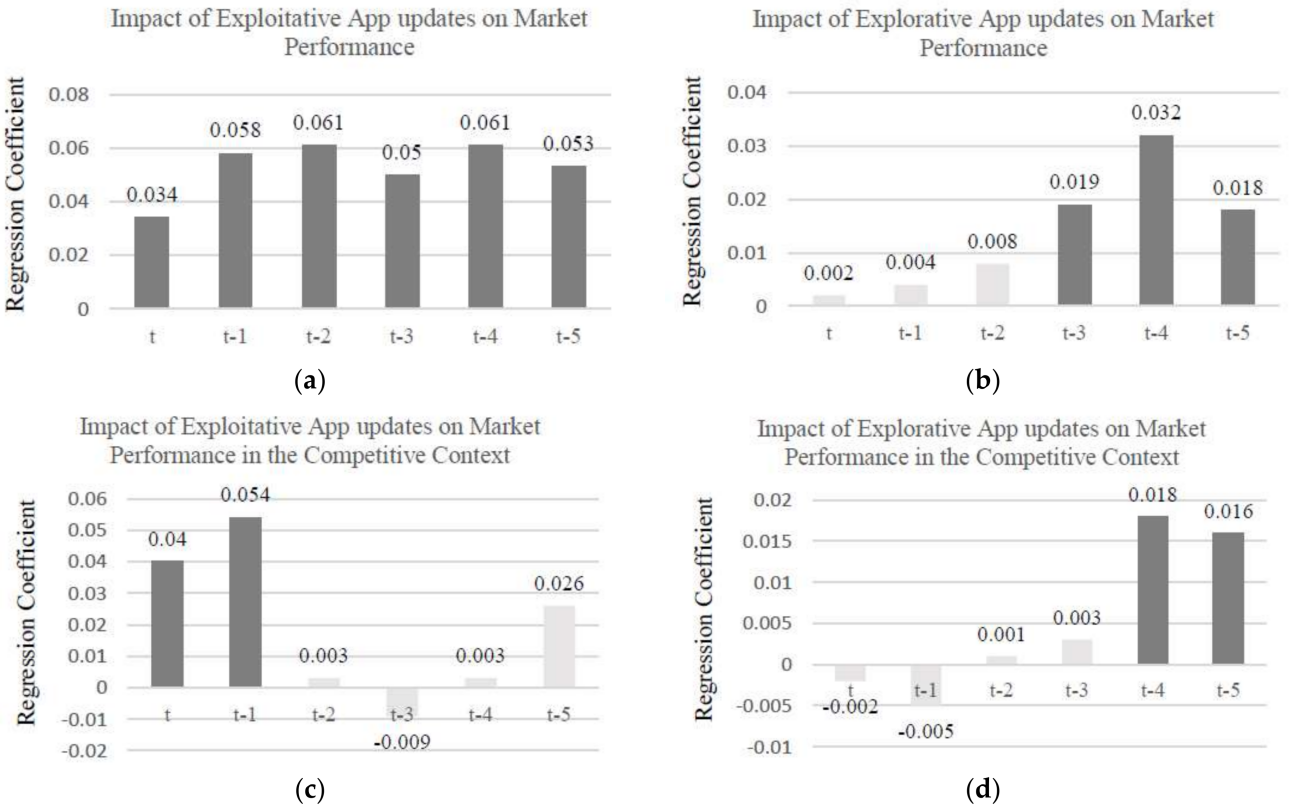


Figure 2. (**a**) Impact of exploitative app updates on market performance, (**b**) impact of explorative app updates on market performance, (**c**) impact of exploitative app updates on market performance in the competitive context, and (**d**) impact of explorative app updates on market performance in the competitive context. Note: the significant lag effect of regression results is shown in darker gray.

6. Discussion

This study investigated the temporal effect of different types of app updates on market performance in the competitive context of online travel mobile applications. Specifically, we applied a structured content analysis method and distributed time lag model to explore the different effects of two types of app updates on market performance in terms of timing and duration, as well as the moderating effect of competition intensity.

6.1. Research Findings

First, our findings indicate differences in the timing and duration of the impact of the two types of app updates on market performance. Exploitative app updates have an immediate and continuously significant positive impact on market performance, while explorative app updates have no significant positive impact on market performance in the short term but will have a positive impact on market performance in the long term (lag 3). We posit that the different temporal effects of app updates are due to the underlying tension between the process of revenue generation by digital innovation of exploration vs. exploitation. Exploitative app updates are based on existing resources and capabilities to enrich and expand the existing product and service market. Therefore, they can obtain more rapid and accurate returns [19]. However, explorative app updates include launching new tourism products and launching new business models. Such updates require OTPs to invest more resources and experience greater uncertainty in the early stages of exploration trial and error, while users face high conversion costs [8], which means that immediate strong performance is unlikely. With the ongoing accumulation of knowledge and experience of firms, the user experience improves as users perceive conversion costs to be decreasing [41], which will have a long-term positive impact on market performance.

Second, competition intensity shortens the duration of the positive effect of exploitative app updates and delays the time that explorative app updates have to take effect. More specifically, competition intensity has a negative moderator effect on the relationship between the two types of app updates and market performance, especially with its significant negative impact on exploitative app updates. In a hypercompetitive environment, competitive interaction will become predictable due to competitors' knowledge of each other. Lower technical barriers and higher visibility of exploitative app updates make it more likely that competitors will respond, thus achieving only temporary market performance [33]. Therefore, the competition intensity will have a negative, shorter impact on exploitative app updates. For explorative app updates, due to the significant resources needed for explorative app updates and the ambiguity of the innovation effect, it is difficult for competitors that lack technical capacity and resources to respond quickly [19,28]. Therefore, competition intensity will delay the effect of explorative app updates, but in the long term, explorative app updates will help OTPs capture a competitive advantage.

6.2. Theoretical Contributions

This study makes two theoretical contributions. First, this study provides theoretical guidance for classifying app updates and explaining their temporal effect on market performance, which fills research gaps by considering the role of time factor. Prior literature on the effects of app updates has largely focused on the effects of update frequency, and finding the effectiveness of app updates is unclear, while scant attention has been paid to clarifying the temporal effects of different types of app updates from the time dimension, resulting in mixed conclusions [2,7,9,11]. Therefore, we integrate exploration vs. exploitation, which focuses on the heterogeneity of updated content, to divide app updates into two types: explorative and exploitative. We confirm that there are differences in the timing and duration of the impact of the two types of digital innovation on market performance, which helps in understanding how continuous innovation of app updates affects the sustainability of market performance.

Based on the concept of competitive intensity, we provide a detailed analysis of the moderator effect on app updates and market performance, which supplements the view of the competitive environment influencing performance. Previous studies have taken the competitive environment as the research background and focused on the differential impact of mobile application updates on performance due to factors such as application quality, reputation, and positioning [9,18]. Therefore, this study empirically tests whether the intensity of competition will shorten the duration and delay the timing effect of explorative app updates, as well as expanding the relevant research on competition in the mobile application market.

6.3. Practical Implications

Our findings have important implications for firms formulating effective app update strategies for mobile applications in a competitive context. First, firms should take into account the time difference between explorative app updates and exploitative app updates when considering market performance and balance the two types of updates to maximize performance. Firms also need to be aware that using existing technologies and resources to continuously meet the needs of users brings immediate but temporary benefits. When deploying explorative app update strategies, firms also need to consider the risks of the time lag effect on performance.

Second, firms should regularly assess their competitive environment when leveraging digital innovation for app updates. When the market is relatively stable, firms can continuously improve the user experience and enhance user stickiness through exploitative app updates. When facing a hypercompetitive environment, firms need to actively explore new opportunities, develop new products and services, and constantly obtain new competitive advantages so as not to be knocked down by the innovation of competitors. If firms blindly pursue exploitative app updates, they will fall into the dilemma of innovators. In this case,

firms need to constantly update to explore new opportunities to radically change markets, while at the same time developing new products and services, so as not to be knocked down by the sudden subversive innovation of competitors.

6.4. Limitation and Further Research

This study has some limitations that could provide opportunities for future research. First, the sample is limited to app updates taken in the context of online travel mobile applications. It might prove particularly interesting to complement the present findings with data from other industries that are more innovative or less competitive than the online travel industry. Second, although exploration vs. exploitation provides a good theoretical background to classify app updates, future studies can further distinguish product and technology updates and explore their impact on the sustainability of market performance.

7. Conclusions

We have studied the temporal market performance consequences of two types of app updates in hypercompetitive app markets. We indicate that alternative types of app updates vary in terms of time needed to achieve significant positive performance impacts. We also find that different types of app updates vary in terms of the persistence of this positive effect over time due to different competitive intensities. We hope that this work will inspire more research on digital innovation and the sustainability of market performance.

In conclusion, as a typical type of digital innovation, app updates provide firms with opportunities to constantly create new ways of fulfilling customers' emerging needs, thereby obtaining competitive advantages [2]. Thus, digital innovation of app updates can apply emerging technological innovation activities to improve product markets, services, and processes, thereby enhancing the competitiveness and benefiting the sustainability of the app's market performance [16]. We posit that the different temporal effects of app updates are due to the underlying tension between the processes of revenue generation by digital innovation of exploration and exploitation. The revenue of explorative app updates may be uncertain and long-term, while the revenue of exploitative app updates may be stable and immediate. Explorative app updates refer to discovery-led updates that enter new product-market domains [4,12]; they can generate long-term excess returns and create new market performance sustainability for firms through niche markets. Exploitative app updates refer to refinement-led updates that improve existing product-market domains [4,12] and that can meet the needs of existing customers and market with low cost and high efficiency. Once the competition is fierce, it will make it difficult for firms to maintain sustainable market performance. Therefore, firms should take into account the time difference between explorative app updates and exploitative app updates when considering market performance, and they should balance the two types of updates to maximize performance.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Robustness Check Results

Table A1. Results of the robustness test.

Variable	EIU		ERU	
	Model 1	**Model 2**	**Model 1**	**Model 2**
PB	−0.006	−0.005	−0.018	−0.034
	(0.850)	(0.886)	(0.581)	(0.398)
AU_t	0.051 **	0.028	−0.012	−0.014
	(0.024)	(0.249)	(0.333)	(0.241)
AU_{t-1}	−0.091 ***	0.053	−0.005	−0.014
	(0.002)	(0.090)	(0.724)	(0.312)
AU_{t-2}	0.098 ***	0.016	0.005	−0.009
	(0.002)	(0.679)	(0.733)	(0.470)
AU_{t-3}	0.081 **	0.007	0.025	0.005
	(0.017)	(0.859)	(0.127)	(0.748)
AU_{t-4}	0.091 ***	0.004	0.045 ***	0.023
	(0.005)	(0.920)	(0.007)	(0.126)
AU_{t-5}	0.076 ***	0.037	0.023 *	0.021
	(0.004)	(0.337)	(0.093)	(0.106)
CI_t	0.144 ***	0.138 ***	0.139 ***	0.139 ***
	(0.003)	(0.002)	(0.002)	(0.005)
CI_{t-1}	0.224 ***	0.208 ***	0.233 ***	0.255 ***
	(0.000)	(0.000)	(0.000)	(0.000)
CI_{t-2}	0.265 ***	0.230 ***	0.287 ***	0.305 ***
	(0.000)	(0.000)	(0.000)	(0.000)
CI_{t-3}	0.211 ***	0.172 ***	0.227 ***	0.252 ***
	(0.000)	(0.000)	(0.000)	(0.000)
CI_{t-4}	0.238 ***	0.196 ***	0.235 ***	0.260 ***
	(0.000)	(0.000)	(0.000)	(0.000)
CI_{t-5}	0.123 **	0.095 **	0.130 **	0.153 **
	(0.039)	(0.086)	(0.024)	(0.010)
$AU \times CI_t$		−0.024		−0.004
		(0.526)		(0.790)
$AU \times CI_{t-1}$		−0.052		−0.019
		(0.258)		(0.257)
$AU \times CI_{t-2}$		−0.143 **		−0.031
		(0.011)		(0.111)
$AU \times CI_{t-3}$		−0.109 *		−0.026
		(0.069)		(0.190)
$AU \times CI_{t-4}$		−0.141 **		−0.043 **
		(0.019)		(0.043)
$AU \times CI_{t-5}$		−0.078		−0.007
		(0.119)		(0.683)
Constant	10.002 ***	9.724 ***	9.937 ***	10.053 ***
	(0.213)	(0.200)	(0.244)	(0.204)
Number of observations	126	126	126	126
R-squared	0.798	0.807	0.781	0.798

Note: * represents $p < 0.1$, ** represents $p < 0.05$, and *** represents $p < 0.01$; robust standard errors reported in parentheses; EIU represents exploitative app updates; ERU represents explorative app updates; AU represents app updates; PB represents promotional behavior; CI represents competition intensity; t represents the t phase; and t-j represents the lag j phase relative to t (j = 0, 1, 2 . . . 5).

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