Offense or Defense? Digital Innovation Strategy to Face Competitive Position Shifting in Mobile App Platform

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Abstract

Changes in competitive positions within digital platforms, such as transitioning from a challenger to a leader, are common occurrences. However, how achieved competitive positions can be sustained is a critical yet understudied issue. To address this gap, this study examines the effects of competitive position shift on development strategy change in the context of digital innovation. Using data collected from the Apple App Store for over six months and a PSM-DID design, our study reveals that the likelihood of incremental innovation decreases when a challenger's competitive position rises to a "gradual catch-up" stage, and the probability of radical innovation reduces in the "forging ahead" stage. Additionally, a drop in the competitive position to a "falling behind" stage decreases the possibility of radical innovation. Our study contributes to the literature on competitive dynamics and platform innovation and provides practical guidance to mobile app developers.

Keywords: Competitive position shift, competition dynamics, radical innovation, incremental innovation, mobile application

1. Introduction

With the rapid development of the digital economy, network effects have made "winner takes all" a common phenomenon (Church, 1992; Farrell, 1992). However, changes in competitive position (e.g., from a challenger to a leader) are often observed in digital platforms (Cusumano, 2008). An exemplar is that, in mobile app platform, which is a typical manifestation of the competition landscape of digital products (Basole & Karla, 2012), some apps grow from the beginners to the top-download products in the mobile app platform, such as WeChat, Tiktok, etc. (Chan, 2015). The dynamic shift of the position is evident as the result of fierce competition (Cennamo, 2021). Thus, to achieve and particularly sustain a superior competitive position is thus an essential task for developers to survive in the competition, especially for the challengers who need to hold their newly achieved position.

Competitive position, as reflected by the rank in the digital platform, has substantially been the primary driver for firms' strategy design. Prior research has identified several strategic antecedents to improve competitive position of mobile apps, ranging from prototype design to absorbing customers' knowledge (Kazanjian, 1988; Chen et al., 2021). While this previous research has significantly increased our understanding of which mechanisms impact achieving a temporal success, the literature does not well examine in depth how the achieved competitive position can be sustained via adapting their development strategy. A study revealed that 9,999 out of 10,000 apps fail to withdraw from the market (D'aveni, 2010). One possible explanation is that the apps do not well adapt their strategy for the competitive position shift.

Competitive position shift implies that challengers enter a new market segment where they compete with different incumbents (Srivastava, 2013). Their strategic options must be adjusted to achieve advantages in the new competition environment. For instance, when challenging apps newly enter the top-100 list, they may trigger reactive behaviors from higher-level challengers. This suggests that a competitive position shift is likely to make developers change their development strategy for sustainable development.

In fact, how to adjust strategy to sustain advantages has become a major issue for digital platform challengers. This has been documented across a range of industries, including financial (Gorodnichenko and Schnitzer, 2013), manufacturing

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(Awate et al., 2012), semiconductor (Kim, 2011) and IT service industries (Madden, Savage, 1999).

We apply the catch-up cycle theory to explain how a significant change in the status of a mobile app - often referred to as opening a window of opportunity - affects their innovation decisions (Lee & Malerba, 2014). Previous work divides catch-up cycle into four stages: "*entry*" stage, "*gradual catch-up*" stage, "*forging ahead*" stage and "*falling behind*" stage, being in different stages means the shift of position (Lee et al., 2001). For mobile app challengers, the process of catching up with the market leader covers four stages in the cycle (Kim et al., 2021). The fierce competition environment provides the challenger with an unpredictable "window of opportunity" (Lee, Keun, Franco, 2017), and the challenger needs to open it by adjusting innovation actions. Previous studies have explored it in a wide range of industries (i.e., Silva et al., 2016; Suarez et al., 2015), but the mechanism in digital product platforms remain elusive.

For digital product industries with evidence such as ranking lists, the shift of competitive position is mainly manifested in two forms: (1) the continuous improvement of market ranking; (2) the continuous decline of market ranking. A large number of studies have shown that market rankings are highly correlated with market demand (Ragaglia et al., 2014). We define (1) "*gradual catch-up*" stage – when a challenger enters the ranking list, as the challenger gains more visibility (Jung et al., 2012) and attains a narrow gap with the market leader (Satyanarayanan, Mahadev, 1996). (2) "*forging ahead*" stage – when a challenger gains leadership (Lee et al., 2014; Wang et al., 2019). For challengers, being the top apps significantly improves market performance but may also encounter competitors' resistance (Garg et al., 2013; Giachetti et al., 2022). (3) "*falling behind*" stage – when the challenger falls off the ranking list. We miss examining the "*entry*" stage because it is not visible.

We examine the influence of competitive position shift on a challenger's innovation strategy adjustment. We tested these predictions in the context of the Apple App Store. We observe the differences in innovation outcomes between apps that enter the App Store's ranking lists and others on a 6-month cycle. The total observation period is from August 2019 to August 2021. Our empirical framework follows a PSM-DID design. Our study passed two robustness tests: one test replaced the outcome variable with using the version number method; the other one verified the reliability of control variables selection by changing the PSM-matched control variable.

This paper makes two theoretical contributions. First, it extends the competitive dynamics literature to the context of digital platforms by discussing how players shall compete in the mobile app platform. Second, while how market challengers compete through innovation in different competitive environments is still underexplored (Tian et al., 2020; Tian et al., 2022), this study addresses this research gap by identifying different innovation strategies adopted for digital products. Our findings also provide valuable insights for practitioners.

2. Theoretical foundation

2.1 Overview of research on competition positions in the mobile app market

Simmonds defines competitive position as one aggregate indicator which presents the relative position against each competitor (Simmonds, 1986). McCarthy et al. (1999) defines competitive position as a kind of competitive advantage measured by consumer's responses (McCarthy et al., 1999). Following the resource-based view, Hooley (2005) stressed the importance of competitive position, since it could be a critical firm resource that need to be constantly reviewed (Hooley, 2005). Aligned with the literature, we define competitive position as the relative position of a product in the market relative to its competitors.

Considerable empirical research has investigated actions to gain competitive positions on digital platforms. Studies show that new entrants and established participants on digital platforms tend to follow different strategies, which means new entrants may be more offensive and prioritize cost-leadership strategies (Hedman, 2015). Wen and Zhu (2019) find that after platform-owner entry threat increases, the other developers in the market reduce effort of innovation and raise their prices (Wen and Zhu, 2019).

Although existing research has focused on the current competitive position, there lacks examination of competitive dynamic features, which has been widely recorded in industries such as airlines, banking, education, motion picture, network, etc. (Baum and Korn, 1996; Marcel and Barr, 2011). The existing literature on technology industries provides preliminary evidence for studies of mobile platforms' competitive dynamics (Kushida et al., 2010). Hoelck (2015) suggests that platform companies have strategic potential to benefit from platformized markets, and it is necessary for the partners to trace their market positions (Hoelck, 2015). Giachetti and Marchi (2017) find the greater potential for leadership changes for firms that undertake 'aggressive' competitive strategies when having 'significant'

windows of opportunity for mobile phone industry (Giachetti and Marchi, 2017).

2.2 Mobile app's innovation strategy and the competitive dynamics

Baregheh et al. (2009) define innovation as a multi-stage process, in which an organization turns ideas into new products, services or processes, in order to stand out in the marketplace (Baregheh, 2009). The technological innovation literature dedicates to distinguishing types of innovation into radical and incremental innovation (Christensen and Rosenbloom,1995; Schumpeter, 2003; Dewar and Dutton, 1986). Veryzer (1998) defines product's radical innovation as a new product or service that makes a huge leap in customer familiarity and usage. In contrast, incremental innovation is the ability to improve existing performance according to its established customers (Veryzer, 1998).

Consistent with previous work, we define innovation in the mobile app market as app update behavior, which means adding new features to an existing app (Wen and Zhu, 2019; Tian et al., 2020). Tian et al. (2022) define updates that improve existing features as incremental innovations (Tian et al., 2020). In contrast, radical innovation refers to the updates that add noticeable new features (Kesler et al., 2017; Lin et al., 2022). We define every user-aware update as radical innovation, whereas other improving updates as incremental innovations.

Considerable studies have shown the close relationship between innovation and competitive dynamics (Hunt and Morgan, 1996; Kim et al., 1999). Chen et al. (2017) demonstrate that rival's innovation motivates firms to take competitive reaction (Chen et al., 2017). In addition, the type of innovation can significantly change the competitive dynamics. Ansari and Krop (2012) investigate the influence of radical innovations on incumbent-challenger dynamics (Ansari and Krop, 2012). This research attempts to address an important but non-answered issue – why and how the dynamics of app challengers' competitive positions affect their innovation strategy (radical or incremental), which in turn will affect established competitive dynamics, as innovation efforts may trigger different competitive responses from the rivals.

This work is done by adopting the catch-up cycle theory from competitive dynamic literature streams (i.e., Giachetti et al., 2017; Perez et al., 1988). The catch-up cycle describes the evolution of industry leadership (Loury and Glenn, 1979). Giachetti et al. (2017) conclude four stages in every industry catch-up cycle (Giachetti et al., 2017). We find the same stages in the mobile app industry. We suppose that the challenger tends to take different innovative actions after its competitive position enters different stages.

We suggest that when the challenger's competitive position shifts to different catch-up stages, varied conditions are created for opening the "window of opportunity", which can also play as a competition signal. Specifically, when the app's competitive position rises to a key position, we suppose that it ushered in a "window of opportunity".

2.3 Mobile app's competitive position shift and innovation strategy adjustment

We suggest that changes in app rankings serve as a proxy for the shift in competitive position of mobile app challengers. On the supply side, market rankings provide mobile apps with the competence to continuously perceive dynamically changing competitors continuously (Lin et al., 2022). On the demand side, since discovering and evaluating apps is a daunting task for consumers, market rankings provide them with visibility into successful apps (Zhu et al., 2014). In addition, Oh and Min (2015) demonstrate that app's popularity rank fully mediates the arise of mobile advertising effect on its purchase (Oh and Min, 2015). Another piece of evidence is that Garg found that the top iPhone paid app was downloaded 150 times more than the top 200 paid apps (Garg et al., 2013). The Apple App Store offers listings of apps in the top 200 of the market to iOS users, suggesting a unique opportunity to observe a gradual shift in the app's competitive position to take off.

Furthermore, we suppose that when the mobile app enters the ranking list, it marks the entry of "*gradual catch-up*" stage for the challenger. The reason is that this represents the app closing the gap with market leaders, thus competing on a market scale with the same user visibility conditions (Giachetti et al., 2017).

To win the fleeting "window of opportunity", challengers are more likely to adopt radical innovation strategy. To catching up with market leaders, challengers must strive to provide fundamentally innovative services to tap new markets (Meyer et al., 1990). Secondly, changing the industry landscape by reconfiguring leadership is a fundamental driver of radical innovation (Abernathy et al., 1985). To catch up with market leaders, challengers must reposition their organizational strategies and revolutionize the competitive industry environment in which they operate (Koberg et al., 2003). Thirdly, entering the market rankings means being perceived by more consumers, which implies the New Customer Acquisition Cost is less than the Old User Learning Cost (Mugge et al., 2013).

When the mobile app gains its leadership, it enters the "*forging ahead*" stage (Landini et al., 2017). Becoming a leader signifies the achievement of a successful app, presenting app developers with a valuable "window of opportunity" to catch up with market leaders (Ali et al., 2017). At this stage, challengers are more likely to adopt a less radical innovation strategy. Firstly, from the perspective of competition, emerging challengers may be subject to competitor resistance and peer imitation, leading to an organizational response of less radical innovation strategy (Markides et al., 2004). Secondly, from the user's perspective, the market users accumulated by the app need time to adapt to the product functions, which motivates the challenger to innovate less radically (Riggins et al., 1994). We hypothesize:

H1a: *After the position rising to the "gradual catch-up" stage, the mobile app challenger tends to take a radical innovation strategy.*

H1b: *After rising to the "forging ahead" stage, the mobile app challenger tends to decrease radical innovation strategy.*

3. Research Method

3.1 Empirical context, research design and data collection

3.1.1. Empirical Context. To empirically examine how competitive position shift influences the innovation activities of market challengers in digital innovation systems, this study uses the data from the Apple App Store for iOS.

Apple's app store provides the lists of top apps rankings in the market, which facilitates the investigation of competitive position shift. The lists are visible for challengers, incumbents, and users in the market. For challengers, an essential motivation of their innovation is to enter the list and reach more users. If an app does not enter the list, its low discoverability results in fewer impressions and limited growth. Otherwise, if an app enters the list, its competitive position shifts as listed apps that enable them to get significantly higher visibility for users. In Apple's app store, top-200 apps and top-100 apps are two essential lists. Apps entering the top 100 are widely recognized as top apps (Ali et al., 2017), which signifies increased opportunities to attract and engage consumers. 200 is the maximum limit of the lists and marks whether an app enters the ranking.

To identify the samples in our study, the apps were selected from the top 1,500 consistently online apps in each genre list, which alleviates the concern about the heterogeneity between apps with shifted competitive positions and apps online but without shifting positions. Among them, we focus on the apps which shift their competitive position. Generally, this study identifies two groups of apps that are in the top-200 list or the top-100 list. Specifically, switching from no-rank apps to keeping its position in the top-200 is a sign that the challenger is entering "gradual catch-up" stage; and entering into and keeping its position in the top-100 is a sign that the challenger is entering a "forging ahead" stage.

3.1.2. Research Design. To empirically test our hypotheses, the unit of analysis is at the app-month level. The main reason for choosing monthly panel data is that apps are usually updated at least once a month (Foerderer, Jens, 2020), while mobile apps companies usually adjust the direction of innovation in the longer term (Foerderer, et al., 2018), such as quarterly.

PSM-DID. To account for the self-selection issue, we use the propensity-score matching (PSM) method (Rosenbaum and Rubin, 1983) to match the treatment apps – those shift their competitive position either into top-200 or top-100 – with control apps – those do not change their competitive position in the investigation. In our case, the treatment apps and control apps are matched based on their similar latent probabilities of shifting the competitive position in the investigation window. Our PSM process passed the parallel trend test. After employing the PSM technique to create the matching groups of apps, we use the difference-in-differences (DID) estimator to examine the innovation strategies of two groups before and after the apps change their competitive position.

Figure 1-2 shows the research design. The shift of competitive position is an external event of market competition. Firm's innovation strategies are operationalized as radical innovation and incremental innovation. For the "*gradual catch-up*" stage and "*forging ahead*" stage, we compare the differences between the app's innovation strategy A and the innovation strategy B before and after the competitive position shift event. PSM method enables to compare the treatment and control apps.

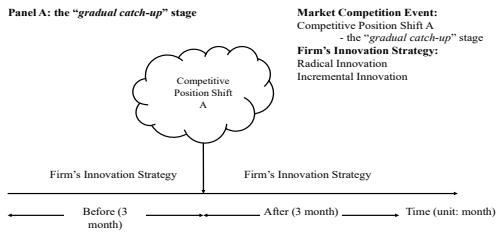

Figure 1. Research design of the "gradual catch-up" stage

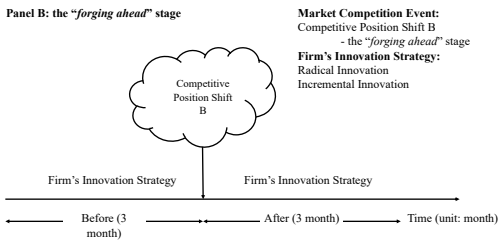

Figure 2. Research design of the "forging ahead" stage

3.1.3. Data collection. We collected data on apps that were ranked in the top 1,500 at least once in the Apple App Store on the iPhone between August 2019 and August 2021 in Mainland China. The initial dataset contains 50,088 unique apps. Apps were dropped from the sample if data were erroneous or invalid. We also excluded the apps whose release notes are not in Chinese and English version; 43,656 apps were finally selected. To measure the competitive position shift of these apps, we capture ranking data, and aggregate it on a monthly level.

We track the monthly average rank of each app in 6 consecutive months. If an app ranks larger than 200 in 3 consecutive months, and swiftly entered top-200 list in the following 3 consecutive months, this app is recognized as a member in our panel A, which includes the apps in the "*gradual catch-up*" stage. Similarly, the study also identifies the apps in Panel B (top-100), that includes apps enter into "*forging ahead*" stage.

We identified a total of 1,061 mobile apps that entered the "*gradual catch-up*" stage, including 20,149 apps that did not shift their competitive position; 532 mobile apps that entered the "*forging ahead*" stage, and a full sample of 20,678 other apps. The number of observations across groups is not balanced. Likewise, there are significant differences in innovation behavior between the two groups. Table shows the distribution of app innovation strategy that shifted and did not shift competitive positions during the "*gradual catch-up*" and "*forging ahead*" stages. However, for each competitive position shift sample, the time for improvement is independent, and the majority of samples in the market cannot meet the requirements of parallel trends and control group selection. Therefore, the full sample is an insufficient control group.

For each member in Panel A and B, we follow prior PSM literature (Caliendo et al., 2008). We set the control conditions based on apps, firms and updates. First, we control price $Price_i$. We control average rating of apps $ratingAverage_i$ and the installation package size $Size_i$. This paper controls the age limitation $ContentLevel_i$, which refers to the minimum age value for content-restricted users (divided into 4+, 9 +, 12+, 17+). We also control the number of regions $CountryCnt_i$ and supported languages $LanguageCnt_i$. Meanwhile, we control the number of apps developed by the firm $FirmApps_i$. Finally, we control app's update frequency $UpdateCnt_i$, the cumulative number of description words $WordCount_i$, the cumulative number of pictures $Pics_i$, Age_i and the maximum update interval $MaxInterval_i$, to reduce the possible differences between the treatment group and the control group.

Theoretically, propensity scores are the latent probabilities of getting competitive position shift given the covariates (Stuart, 2011). We obtain the propensity scores to (pair-)match and control apps which resemble the treatment group apps on the basis of propensity score similarity, using 1:1 nearest-neighbor matching technique (Abadie, 2004). As prior research has noted, this analysis enables us to avoid bias that may occur when linking multiple, potentially dissimilar treatment and control group apps (i.e., Jalan, 2003). The final sample is an unbalanced panel of 26,895 app-months. Table 1 shows the panel data used in our research.

	Panel A	Panel B
Treatment group	1,061 Apps	532 Apps
Control group	1,061 Apps	532 Apps

Table 1. The description of data sample

3.2 Variables

3.2.1. Dependent variable. We develop a text analysis method to better perform the estimation. A machine learning approach can analyze large-volume release notes and accurately identify their update types. Generally, we train a text-based classification algorithm to classify each update item in the release notes into a category, and then measure the innovation strategy of each update based on the identified categories (CHEN, 2021). The coding reliability reaches 0.764.

After construct the training set, test set and validation set at the ratio of 4:1:1, we adopt ERINE model to predict the updated category code to which the update item text belongs after 16 epochs of training. The result was shown to be satisfactory with 0.0029 training loss and 82.6% accuracy on the validation set. We constructed the ratio of innovation frequency as a percentage of total frequency $RadicalImprovement_{it}$ and $IncrementalImprovement_{it}$ as measures of the firm's innovation strategy.

3.2.2. Independent variable. As mentioned above, the competitive position shift is captured in the DID research design. Up_Top200_i refers to the mobile apps

which enter into "*gradual catch-up*" stage. If an app ranks outside the top 200 of the ranking lists for 3 consecutive months, and then enters the top 200 for 3 consecutive months, the app's competitive position shifts to "*gradual catch-up*" stage. The variable Up_Top100_i refers to the mobile apps which enter into "*forging ahead*" stage. If an app ranks outside the 100 for 3 consecutive months, and enters the 100 for 3 consecutive months, then the app's competitive position in the current period is shifted to the "*forging ahead*" stage. $After_t$ is 1 if month t is in the month or after the app's competitive position has shifted.

3.2.3. Control variables. In the DID stage, we control the monthly update frequency $UpdateFreq_{it}$. The app with a higher update frequency in this month usually indicates that the firm invests more resources in it. We control the number of pictures $PictureCnt_{it}$ and the number of videos $VideoCnt_{it}$ in month t, which presents the richness of update release notes. We also control the tenure $Tenure_{it}$ and the maximum update interval $UpdInterval_{it}$ in month t. We control the cumulative number of release notes $AccReleaseNote_{it}$ in month t. Table 2 shows the Variance Inflation Factor for the control variables, confirming that there is no multicollinearity between the control variables.

Variable	VIF	1/VIF
$PictureCnt_{it}$	2.17	0.46
$UpdateFreq_{it}$	1.96	0.51
$VideoCnt_{it}$	1.20	0.84
$UpdInterval_{it}$	1.04	0.96
$Tenure_{it}$	1.02	0.98
Mean VIF	1.48	

Table 2. The Variance Inflation Factor for the control variables

4. Results

4.1 Main findings

4.1.1. Descriptive analysis. Figure 3 below compares the distribution of incremental improvement between "*gradual catch-up*" apps (increased competitive position to top-200) and their PSM matching twins. The plot shows that the innovation strategy of the treatment group after entering the "*gradual catch-up*" stage tends to have a greater possibility of radical updates. The possibility of radical innovation in the month after the shift of competitive position increased by 0.8%, the possibility of radical innovation after 3 months increased by 1.1%, the possibility of radical innovation decreased by 10%.

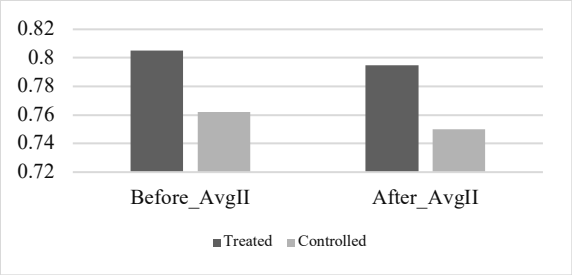

Figure 3. The distribution of incremental improvement between "gradual catch-up" apps

During the "*forging ahead*" stage (increased competitive position to top-100), after the competitive position shift, the treatment group continued to reduce the possibility of radical updates (down 3%), compared with control group.

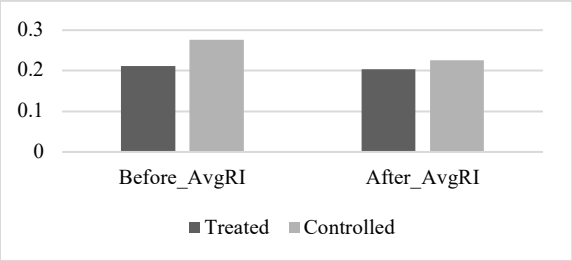

Figure 4. The distribution of radical improvement between "forging ahead" apps

	(1) *RI*	(2) *RI*	(3) *RI*
Up×After		-.085***	-.089***
		(.032)	(.032)
After		.077***	.047
		(.024)	(.054)
UpdateFreq	-.01		-.021
	(.033)		(.031)
PictureCnt	-.002		-.001
	(.003)		(.003)
VideoCnt	-.003		-.001
	(.032)		(.029)
Tenure	.009*		.01
	(.005)		(.015)
UpdInterval	0.003		0.004
	(.002)		(.002)
_cons	-.113	.234***	-.15
	(.212)	(.008)	(.621)
Observations	450	450	450
R-squared	.025	.041	.056

Standard errors are in parentheses; Controls include $UpdateFreq_{it}$, $PictureCnt_{it}$, $VideoCnt_{it}$, $Tenure_{it}$, $UpdInterval_{it}$

**** p<.01, ** p<.05, * p<.1*

Table 3. The DID results of panel A

4.1.2. Empirical Results and Heterogeneity Test. To investigate whether app's entry into panel A would lead radical innovation strategy, we examine the difference of $IncrementalImprovement_{it}$ between the treatment and control groups.

Table 3 shows the results estimated by the main effects model, where Model 1 adds control variables to the fixed panel effects regression model. Model 2 added the independent variables Up_i and $After_t$ to the fixed panel effects regression model. Model 3 added the independent variables Up_i , $After_t$ and control variables at the same time. In Model 3, we observed that the hypothesis test of the negative coefficient of the two-dimensional cross term $After_t \times Up_i$ is significant, which indicates that after the competitive position of the treatment group improving, the incremental innovation is more effective than the control group with likelihood decreased by 11.2%. The reduced likelihood of incremental innovation suggests that entering a "*gradual catch-up*" stage has a positive impact on firms adopting a radical innovation strategy.

	(1)	(2)	(3)
	II	*II*	*II*
Up×After		-.104*	-.112**
		(.053)	(.052)
After		.08*	-.03
		(.044)	(.135)
UpdateFreq	.031		.041
	(.044)		(.046)
PictureCnt	-.004		-.005
	(.007)		(.007)
VideoCnt	.034		.047
	(.044)		(.045)
Tenure	.011		.038
	(.011)		(.044)
UpdInterval	.001		-.003
	(.008)		(.006)
_cons	.063	.468***	-.916
	(.416)	(.013)	(1.597)
Observations	584	584	584
R-squared	.009	.016	.029

Standard errors are in parentheses; Controls include $UpdateFreq_{it}$, $PictureCnt_{it}$, $VideoCnt_{it}$, $Tenure_{it}$, $UpdInterval_{it}$
**** p<.01, ** p<.05, * p<.1*

Table 4. The DID results of panel B

We further estimate the main effect when the competitive position shifted to panel B. The results are shown in Table 4. The results show that firms are 8.9% less likely to adopt a radical innovation strategy. The reduced likelihood of radical innovation strategy suggests that a shift in competitive position to within 100 of the ranking lists has a negative impact on firms taking radical strategy.

4.3 Robustness test

4.3.1. Dependent variable substitution test. In order to make up for the biased conclusions of innovation actions that may be caused by the text analysis measurement method, we supplement the use of the version number method to define the $MajorRatio_i$ as the measurement of firm's innovation strategy. Table 5 shows the model estimation results for the treatment group and the control group that entered the "*gradual catch-up*" stage.

	Major Ratio
After	-.029
	(.036)
Up×After	.041**
	(.018)
_cons	.227
	(.434)
Observations	782
R-squared	.035

Table 5. The result of DV substitution

4.3.2. Control variable substitution test. We also consider that the selection of the control group sample set may cause bias, because the variables controlled in this research are a subset of all observable application data control variables. Control variables (such as application online tenure, security risks and compatibility) may affect firms' innovation strategy. Due to the possible deviation, the selected subset of the control samples was changed. Similar estimation results were obtained. The multi-group estimation results are detailed in Table 6.

	Radical Improvement	*Radical Improvement*	*Radical Improvement*
After		-.027	-.05
		(.02)	(.032)
Up×After		.06**	.056**
		(.027)	(.027)
_cons	.051	.265***	-.131
	(.172)	(.007)	(.357)
Observations	720	720	720
R-squared	.028	.015	.04

Table 6. The result of CV substitution

5. Discussion

5.1 Main findings

Our research objective was to understand the competitive dynamics of the mobile app market based on shifting competitive positions and the innovative consequences of this effect for app challengers. We assessed the consequences of app's competitive position shift by exploiting a quasi-experiment in the context of the Apple App Store, which provides the list of the top 200 apps rankings in the market.

We find that the periodic shift of the competitive position triggered a subsequent adjustment in the app challenger's innovation strategy. We estimate a 11.2% decrease in the likelihood of an update for incremental improvement for app challengers affected by entry into the "*gradual catch-up*" stage, compared to those not affected by entry. We estimate an 8.9% decrease in the likelihood of radical improvements for app challengers affected by entry into the "*forging ahead*" stage, compared to those not affected by entry. These effects are robust to alternative measures of innovation strategy and differential sets of the control group.

5.2 Implications

We make several theoretical implications. First, this study extends the competitive dynamics literature to the context of digital platforms. While prior literature on competitive dynamics have largely overlooked relevant situations that are characterized in the context of digital platform, we examine the challenger's catch-up behavior and innovation outcomes in the mobile app market, and finds out that a mobile app challenger entering a "gradual catch-up" stage reduces the possibility of incremental innovation, while the challenger reduces radical innovation when it becomes a leader. These conclusions provide new insights on the strategic decision making in the competitive dynamics, thus extending recent works on this topic (i.e., Chen et al., 2021; Guo et al., 2019).

Second, this study contributes to the platform innovation literature by unpacking how the market challengers innovate on the competition of digital platforms. While existing research has extensively investigated how innovation affects the market performance of mobile apps by concluding an inverted U-shaped relationship (Tian et al., 2020; Tian et al., 2022), how the market followers shall innovate in the platform competition is still understudied. This study fills this research gap by identifying the strategic innovative actions and explaining the corresponding mechanisms from the perspective of market challenger in a platform, thereby enriching recent literature on innovation in response to competitor threats (Wen, Zhu, 2019) and how challengers use the platform's innovation diffusion to gain competitive advantages (Carreiro et al., 2019).

Our findings also provide valuable insights for practitioners regarding how to choose innovation strategies according to the different stages of an app's development.

5.3 Limitations and future research

This paper focuses on the types of the market challenger's innovative capabilities in the catch-up stage, including radical or incremental innovation (Subramaniam et al., 2005). It is not enough to analyze the radicalness of technological innovation, as innovation actions in mobile apps involve different decisions, such as organizational innovation or product innovation. It is still necessary to examine more dimensions of challengers' innovation actions, such as innovation extensiveness. Future research can explore the effect of competitive dynamics on mobile app innovation from a more diversified perspective. In addition, we suggest future research including more evaluable competitive actions, such as development competitions and information sharing (Derfus et al., 2008).

Our research considers the widest range of players in the mobile app market - market challengers in different catch-up cycles, but it is also interesting to examine the defensive strategies of market leaders. Future research should include more contributions on market leaders' response strategy - to resist or maintain established innovation strategy? This issue is very important for market leaders, as their competitive position is often threatened by the rivals.

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