Can Mobile App Usage Help Predict Firm-Level Stock Returns?

Short Paper

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Abstract

Mobile app market is one of the fast-growing segments of the mobile industry. With the increasing app users, mobile app market provides a new source of information that could potentially help predict a firm's future financial performance. This paper investigates the relationship between mobile app usage and future stock returns. We utilize a panel data set of 326 public firms that have released mobile apps on the Apple iOS App Store or Google Play Store. Our results show that monthly abnormal app downloads and abnormal daily users are positively associated with the next-month abnormal stock returns, suggesting that mobile app usage can help predict firm-level future stock returns. The findings are robust to the inclusion of different sets of controls. Collectively, this study provides new insights for investors with respect to the predictive value of mobile app usage data.

Keywords: Mobile app usage, stock return predictability, abnormal return, app downloads, app daily users

Introduction

There has been considerable academic and practical interest in stock market prediction. A rich stream of literature demonstrates stock return predictability based on various kinds of information, such as product-related information (Chen et al. 2011), consumers' product reviews (Huang 2018), information from social media platforms (Luo et al. 2013), employer reviews (Green et al. 2019) and so on. Aggregating such information reveals the assessment of a firm's financial or operating performance from the perspective of some important stakeholders, such as customers and employees. Thus, these information sources may provide useful signals for predicting a firm's future stock returns.

The past decade has witnessed the prospect of the mobile app market. Nearly 70% of the world population is mobile-enabled (GSMA 2019), and there has been an increasing trend in global app downloads, app usage and consumer spending over the years. In 2018, app downloads on the iOS App Store and Google Play Store were over 113 billion, a 20% increase from 2017 (AppAnnie 2018). With the increasing number of mobile app users, mobile app becomes an important channel for a firm to interact with its customers, employees, investors or partners. In this regard, mobile app users are important stakeholders of a firm, and the level of mobile app usage reflects mobile users' satisfaction with the firm's products and services, which may have important implications for the firm's future operating and financial performances.

If the mobile app market provides useful information on firm performance, it is ex-ante unclear whether the stock market has already incorporated this information into the stock prices. On one hand, mobile app usage level can directly reflect the opinions of those app users, who can be the firm's customers, suppliers

or employees. Prior research has shown that information aggregated from main participants of a business is value-relevant to financial markets (e.g., Chen et al. 2014, Bartov et al. 2018, and Huang 2018). Thus, it is possible that the performance of a firm in the app market conveys value-relevant information to financial markets. In addition, mobile app usage also demonstrates a firm's IT capability in the mobile domain. As IT capability is usually associated with important organizational capabilities that can have an influence on financial results (Mithas et al. 2011), mobile app usage can provide signals for investors to access the future performance of a firm. On the other hand, the performance of a firm in the app market may be uninformative or correlated with the firm's other events. It is unclear if app performance provides new information beyond what has already been incorporated in the stock prices because the success of a mobile app is often related to a firm's various resources. In addition, not all firms release mobile apps, and the importance of mobile apps varies across different firms. Thus, it may be biased to use app performance to predict future stock returns. In this study, we address these issues and explore the relationship between mobile app usage and stock returns.

To examine the investment value of mobile app usage data, we construct a firm-month panel data set from July 2015 to December 2017. We measure mobile app usage by both abnormal mobile app downloads and abnormal daily average users. The app-level data is obtained from the mobile data provider Apptopia, which develops proprietary algorithms to produce estimated downloads, revenue, and the number of active users based on actual data shared by various mobile app publishers. The financial-market and financial-statement data are collected from the Center for Research in Security Prices (CRSP) and Compustat, respectively. The merged data set contains 7805 observations for 326 public firms. Our analyses show that mobile app usage is value relevant information to the stock market. Both abnormal app downloads and abnormal daily users are positively associated with future stock returns, and the results are robust to the inclusion of different sets of controls. Our findings suggest that the performance of a firm in the mobile app market can help predict future stock returns.

The remainder of this paper is organized as follows. In the next section, we provide a brief review of the research streams closely related to this study. We then introduce our dataset and present the preliminary empirical model and analysis. The last section concludes and discusses our follow-up work.

Literature Review

The literature on mobile apps is growing fast (e.g., Garg and Telang 2013, Ghose and Han 2011, Ghose et al. 2013, Ghose and Han 2014, Lee and Raghu 2014, to name a few). A large amount of research has investigated the usage behavior in the mobile app channel (e.g., Ghose and Han 2011, Ghose and Han 2013). Other studies have examined the economic consequences of mobile app introduction (Xu et al. 2014, Kim et al. 2015, Xu et al. 2017, etc,). In addition, prior studies have investigated the potential determinants of mobile apps' success (Lee and Ragu 2014, Ghose and Han 2014). Our study differs from previous studies on mobile apps by focusing on the stock return predictability of mobile app usage.

This study is closely related with the broad literature on stock return prediction. A growing stream of studies examines the informational role of the collective opinions from Internet search engines, financial forums, online product reviews, social media platforms in financial markets, and so on. For instance, Antweiler and Frank (2004) investigate how information posted on Yahoo! Finance affects financial markets, and one of their main findings is that messages from Internet stock message broads can help predict market volatility. Bollen et al. (2011) find that public mood measured by sentiment generated from Twitter activity is correlated with economic indicators. Luo et al. (2013) compare the stock return predictability of social media-based information (e.g., Web blogs) and conventional online behavioral information (e.g., Google Search), and find that information from both sources can predict firm market value but social media-based information has a stronger predictive relationship than the conventional one. Chen et al. (2014) find that investor opinions from articles and comments submitted by amateur analysts on social media can help predict future stock returns and earnings surprises. Bartov et al. (2018) find that the aggregate information from individual tweets before a firm's earnings announcement can help predict firms' forthcoming earnings and returns. Another important strand of this literature investigates the value of customer opinions in the stock market. As customers are the main source of a firm's revenue, their opinions reveal the product or service quality, which directly influences the firm's future sales and performance. Anderson et al. (2004) find that customer satisfaction is positively associated with long-term financial performance, measured by Tobin's q. Fornell et al. (2006) test how customer satisfaction affects the abnormal returns and stock market

risk by using the American Customer Satisfaction Index, and they provide evidence for a positive association between customer satisfaction and market value. Tuli and Bharadway (2009) demonstrate that the improvement of customer satisfaction decreases the systematic and idiosyncratic risks of stock returns. Huang (2018) makes use of the online product review data on Amazon.com and finds that the abnormal customer rating is positively associated with future revenue surprise, earnings surprise, and abnormal returns. In addition, some early studies suggested that website traffic helps predict a firm's value (e.g., Keating et al. 2003), because more site visitors represent a higher brand name recognition in acquiring new users and retaining existing users (Bucklin 2008). The new source of information from the mobile app market makes this study different from all prior studies in the literature. We contribute to the literature by identifying a new value-relevant information source for financial markets.

Data

We obtain data on every mobile app published on the iOS App Store and Google Play Store by the end of 2017 from Apptopia.com. Apptopia specializes in mobile app analytics and serves many of the largest companies in the world. Until 2017, Apptopia has data coverage on over 3 million mobile apps on the iOS App Store and 5 million mobile apps on the Google Play Store. In addition to the basic mobile app information, Apptopia offers mobile app performance estimates by collaborating with mobile app developers and gathering real data on app performance directly from these collaborators' app developer accounts, including app downloads, revenue, daily average users, and so on.

To identify all the app developers who are either public firms themselves or the subsidiaries of public firms on the iOS App Store and Google Play Store, we first retrieve a list of public firms listed on AMEX, NASDAQ, and NYSE with ordinary common shares between 2007 and 2017 from Compustat. By comparing website URLs and firm names between Apptopia and Compustat, we identify 1,382 public firms with over twenty-two thousand apps on the two app stores. Because not all apps on Apptopia have app performance estimates and Apptopia started providing the app performance estimates from July 1, 2014, 318 firms are dropped from our sample. To reduce noises, firms in our sample are limited to those with at least one year of daily app performance data on a continuous basis. Therefore, our initial sample consists of 539 public firms with 2,656 mobile apps. To construct the firm-month panel data set, we collect financial-market and financial-statement data from CRSP and Compustat, respectively. 213 firms are excluded due to missing data. Our final sample has 326 public firms with 7805 monthly observations from July 2015 to December 2017.

Abnormal returns

In the literature of IS, marketing, and finance, abnormal return is a common measure for the change in a firm's market value (e.g., Dewan and Ren 2007, Luo et al. 2013, Chen et al. 2014, Homburg et al. 2014, Huang 2018). This change implies the anticipated decrease or increase in a firms' future cash flow. Following prior studies, we compute the monthly abnormal returns as the difference between raw returns minus one-month T-bill rate (Huang 2018). Table 1 presents the summary statistics of the main variables.

App Usage

The mobile app performance measures include *App downloads* and *Average daily users*. *App downloads* is the total number of downloads of all apps belonging to a firm in a month, and *Average daily users* is the average number of daily active users across all apps of a firm in a month. These two performance measures capture two different types of information about mobile apps. *App downloads* represents the new users' opinions or interests in a mobile app, while *Average daily users* reveals the interest level of existing users.

$$AbnApp_{i,t} = log\left(\frac{AppUsage_{i,t}}{\sum_{j=t-1}^{j=t-12} AppUsage_{i,j}/12}\right) \quad (1)$$

To capture new information in app downloads and average daily users, we calculate *Abnormal app downloads* (*Abnormal daily users*) by using the average of the app downloads (average daily users) in the previous 12 months as the benchmark for the expected app usage level as shown in Equation (1). The $AbnApp_{i,t}$ can be either *Abnormal app downloads* or *Abnormal daily users*, while $AppUsage_{i,t}$ can be either *App downloads* or *Average daily users* The advantage of using a long-window average as a benchmark is to reduce the impact of transitory fluctuation (Huang 2018). Specifically, *Abnormal app*

downloads (*Abnormal daily users*) is the natural log transformation of the ratio of *App downloads* (*Average daily users*) to the prior-12-month average. We use the natural log transformation to reduce the influence of outliers and improve model fit. As Table 1 shows, the mean of app downloads (and average daily users) is much larger than the median, indicating the app usage data are right-skewed. To mitigate the influence of outliers, it is better to take the log transformation. In our sample, the mean of abnormal app downloads is -0.106 and the mean of abnormal daily users is 0.004.

Table 1. Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Median	Max
Abnormal return	7805	0.010	0.096	-0.663	0.007	1.298
App downloads	7805	335410.221	1682324.768	0	21507	26450647
Abnormal app downloads	7805	-0.127	0.818	-10.803	-0.051	4.167
Average daily users	7805	55218.211	309852.065	0	5420.467	5153050
Abnormal daily users	7805	0.007	0.528	-6.542	0.022	3.936
Market cap (millions of dollars)	7805	21430.175	60102.524	2.364	2735.241	691740.250
Book-to-market	7805	-0.790	16.810	-401.009	0.274	6.388
Gross profitability	7805	-0.065	14.964	-639.717	0.027	413
Stock Return$_{-12,-1}$	7805	0.010	0.025	-0.161	0.011	0.138
Dollar volume (millions of dollars)	7805	3014.998	7726.138	0.026	539.586	181314.844
CV of dollar volume	7805	0.327	0.197	0.081	0.281	3.105
Ad expense (millions of dollars)	7805	261.077	30.500	714.676	0	6300

Table 1. Summary Statistics

Control Variables

Other variables used in our analysis include *Market cap, Book-to-market, Gross profitability, Stock Return$_{-12,-1}$, Dollar volume, CV of dollar volume*, and *Ad expense*. *Market cap* is the market capitalization of the firm, calculated as the number of outstanding shares times the stock price at the end of each month. *Book-to-market* is the ratio of book value to market value of the equity. Gross profitability is the gross profit divided by total assets. *Stock Return$_{-12,-1}$* is the average stock return during the past 12 months. *Dollar volume* and *CV of dollar volume* are the average dollar trading volume and coefficient of variation of dollar trading volume, respectively, during the past 12 months, skipping the two most recent months. These variables are commonly used to control for other influences on stock return in the literature (e.g., Huang 2018). *Ad expense* is the advertising expenditure of a firm. Table 1 shows that the firms in our sample on average have a market capitalization of 21.430 billion dollars, a book-to-market ratio of -0.790, gross profitability of -0.065, a past stock return of 0.010, a dollar trading volume of 3.015 billion, a CV of dollar trading volume of 0.327, and an Ad expense of 261.077 million dollars.

Table 2 shows the correlations between the main variables. *Abnormal return* is positively correlated with *Gross profitability*. *Abnormal app downloads* is positively correlated with *Abnormal daily users*. This is consistent with the fact that the more users have installed an app, the more actual users the app could have. In addition, the firm's expenditure on advertisement is positively related to both *Abnormal app downloads* and *Abnormal daily users*, suggesting that advertising helps increase both app downloads and app usage.

Table 2. Correlations

	1	2	3	4	5	6	7	8	9
1. Abnormal return	1								
2. Abnormal app downloads	0.01	1							
3. Abnormal daily users	0.01	0.64 [a]	1						
4. Market cap	0.01	0.46 [a]	0.24 [a]	1					
5. Book-to-market	-0.01	0.01	0.01	0.02	1				
6. Gross profitability	0.04 [a]	0.00	0.00	0.00	-0.00	1			
7. Stock $Return_{-12,-1}$	-0.03 [c]	0.06 [a]	0.07 [a]	0.06 [a]	0.01	-0.03 [b]	1		
8. Dollar volume	0.01	0.46 [a]	0.39 [a]	0.82 [a]	0.02	0.00	0.08 [a]	1	
9. CV of dollar volume	-0.00	-0.06 [a]	-0.05 [a]	-0.21 [a]	-0.12 [a]	-0.02	0.04 [a]	-0.16 [a]	1
10. Ad expense	0.00	0.46 [a]	0.32 [a]	0.68 [a]	0.02	0.01	-0.00	0.61 [a]	-0.19 [a]

Notes: [a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.10$

Table 2. Correlations

Empirical Analysis

To further investigate whether mobile app performance is value-relevant information for the stock market, we run a fixed effects regression in the following specification:

$$AbnRet_{i,t+1} = \alpha + \beta_1 AbnApp_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t} \quad (2)$$

The dependent variable $AbnRet_{i,t+1}$in Equation (2) is the abnormal return of stock i in month $t + 1$. The main variable of interest is $AbnApp_{i,t}$, which is either the abnormal app downloads or abnormal daily users of stock i in month t. $X_{i,t}$ is a vector of control variables, including market capitalization, book-to-market ratio, past stock performance, gross profitability, dollar trading volume, the coefficient of variation of dollar trading volume, and the advertising expenses. Year-month dummies are included to control for time effects. Standard errors are clustered by stocks to account for the residual correlation across different observations related to the same stock.

Table3. Abnormal App Download and Abnormal Return					
	One-month-ahead abnormal return				
	(1)	(2)	(3)	(4)	(5)
Abnormal app downloads		0.003[c] (1.86)	0.003[b] (2.41)	0.003[b] (2.32)	0.003[b] (2.33)
Log(Market cap)	-0.080[a] (-7.92)		-0.072[a] (-7.63)	-0.075[a] (-7.74)	-0.081[a] (-7.92)
Book-to-market	-0.001[a] (-8.67)		-0.001[a] (-8.41)	-0.001[a] (-8.35)	-0.001[a] (-8.65)
Stock Return$_{-12,-1}$	-0.212[b] (-2.32)		-0.219[b] (-2.46)	-0.199[b] (-2.16)	-0.210[b] (-2.30)
Gross profitability	0.000[c] (1.87)		0.000[c] (1.82)	0.000[c] (1.93)	0.000[c] (1.89)
Log(Dollar volume)	0.009[b] (2.08)				0.009[b] (2.07)
Log(CV of dollar volume)	0.003 (0.67)				0.003 (0.69)
Log(Ad expense)	0.015 (1.56)			0.016[c] (1.54)	0.014 (1.54)
Cons	0.502[a] (6.56)	-0.044[a] (-7.45)	0.534[a] (7.08)	0.503[a] (6.65)	0.507[a] (6.61)
Firm fixed effects	included	included	included	included	included
Time fixed effects	included	included	included	included	included
R-squared	0.184	0.146	0.182	0.183	0.184
Obs.	7805	7805	7805	7805	7805

Notes: t statistics in parentheses
[a] $p < 0.01$,[b] $p < 0.05$, [c] $p < 0.10$

Table3. Abnormal App Download and Abnormal Return

Table 3 presents the regression results when abnormal app downloads is the key independent variable of interest. Without including the abnormal app downloads variable, Column (1) presents the coefficients of all the control variables in our regression model. In Column (2), the coefficient estimate on $AbnRet_{i,t+1}$ is 0.003 and statistically significant at the 1% level when abnormal app downloads is the only independent variable, indicating that the following month abnormal return is 0.3% higher when abnormal app downloads increase by one unit. A one-unit increase in abnormal app downloads is equivalent to an increase of 2.7 times (i.e., the base of the natural logarithm, *e*) in the ratio of monthly app downloads to the past 12-month average. In Columns (3) to (5), different sets of control variables are added into the model. The coefficient estimate on $AbnRet_{i,t+1}$ remains 0.003 and consistently significant at the 5% level.

Table 4. Abnormal Daily Users and Abnormal Return					
	One-month-ahead abnormal return				
	(1)	(2)	(3)	(4)	(5)
Abnormal daily users		0.006[a] (2.64)	0.007[a] (3.02)	0.007[a] (2.96)	0.007[a] (2.99)
Log(Market cap)	-0.080[a] (-7.92)		-0.072[a] (-7.67)	-0.075[a] (-7.77)	-0.081[a] (-7.97)
Book-to-market	-0.001[a] (-8.67)		-0.001[a] (-8.75)	-0.001[a] (-8.68)	-0.001[a] (-9.00)
Stock Return$_{-12,-1}$	-0.212[b] (-2.32)		-0.219b (-2.45)	-0.199[b] (-2.15)	-0.209[b] (-2.29)
Gross profitability	0.000[c] (1.87)		0.000[c] (1.77)	0.000[c] (1.86)	0.000[c] (1.82)
Log(Dollar volume)	0.009[b] (2.08)				0.009[b] (2.08)
Log(CV of dollar volume)	0.003 (0.67)				0.003 (0.70)
Log(Ad expense)	0.015 (1.56)			0.017[c] (1.77)	0.014 (1.54)
Cons	0.502[a] (6.56)	-0.045[a] (-7.74)	0.824*** (20.47)	0.808*** (19.85)	0.808*** (19.86)
Firm fixed effects	included	included	included	included	included
Time fixed effects	included	included	included	included	included
R-squared	0.184	0.146	0.182	0.183	0.185
Obs.	7805	7805	7805	7805	7805

Notes: t statistics in parentheses

[a] $p < 0.01$,[b] $p < 0.05$, [c] $p < 0.10$

Table4. Abnormal Daily Users and Abnormal Return

Our results in Table 4 reveal consistent patterns when using abnormal daily users as the key independent variable. In Column (2), the coefficient estimate on $AbnRet_{i,t+1}$ is 0.006 and statistically significant at the 1% level, suggesting that a one-unit increase in abnormal daily users is associated with an increase of 0.6% in the abnormal return in the following month. Similarly, the one-unit increase in abnormal daily users implies that the average daily app users should be 2.7 times of the past 12-month average. With different sets of control variables, the coefficient estimate on abnormal daily users stays at 0.007 ($p < 0.01$) across different specifications. In other words, after controlling other influential factors, an increase in abnormal average app users is associated with an increase of 0.7% in the following-month abnormal return.

These results demonstrate the predictive value of mobile app usage. Both abnormal app downloads and abnormal daily users convey value-relevant information to the stock market. This information is likely to be new and cannot be derived from other sources of information, such as past stock returns or other firm

characteristics, so controlling for other information does not affect the association between mobile app usage and future stock returns.

In addition, the coefficient estimates on the control variables are generally consistent with expectations in Table 3 and Table 4. In general, the market capitalization, book-to-market ratio, and the past stock return are negatively correlated with future abnormal returns. The gross profitability and dollar trading volume positively affect the following-month abnormal return.

Summary and Future Research

This study contributes to the literature by providing the first empirical evidence that mobile app performance contains value-relevant information for the stock market. Our findings suggest that abnormal app downloads and abnormal daily users are positively associated with the following-month stock return, and this association is robust after controlling for other factors. There are several ways to extend the analyses reported here. First, we have not controlled for the influence of analyst recommendation and earnings forecasts yet. Second, it is possible to construct the panel dataset at different levels of granularity, such as daily or weekly, to validate the results we have obtained so far. Finally, it is also interesting to investigate how mobile app performance affects revenue surprise and earnings surprise. To conclude, our study provides important managerial implications for investors by documenting the investment value of mobile app performance data in the stock market.

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