Working Paper Document

**Social Learning and diffusion over Pervasive Products:**

**An Empirical Study of an African App-store**

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**Abstract**

Fueled by the widespread smartphone adoption and an increase in the mobile internet access, the mobile app market has experienced a significant growth during the last 3 years. The mobile app market reached 64 billion downloads in 2012 up from 8.2 billion downloads in 2010, and its total revenue in 2012 was $18 billion up from $5.2 billion in 2010. In this market three types of agents operate: (1) two-sided platform owners (2) app developers/publishers and (3) consumers. As mobile phones are pervasive, the consumers’ preferences for an app in an app category can influence the peer consumers’ preferences in many ways, ranging from the psychological benefits of social identifications, social learning, and social inclusion to the utilitarian benefits of network externalities and direct network effects. Two types of forces may drive consumers’ decision to adopt an app: innovation forces, or imitation forces. World Wide Web (WWW) has enabled nations to apply each type of these forces globally, but for products that diffuse over another pervasive product, local forces may be more relevant. To optimize its marketing mix and to target heterogeneous consumers differently, an app store owner not only needs to know which type of force affects each consumer’s choices, but also needs to know heterogeneity in both consumers and app categories. Knowing the effect of each force for individual consumers, an app platform can use either viral marketing or app trial strategies. In addition, to design an optimal platform and incentive mechanisms, a platform owner needs to know the effect of the breath of app assortment in the category and the complementarity or substitution of different app categories.

Thus, given exceptional characteristics of pervasive products (e.g. mobile apps), we use hierarchical Bayesian non-linear state space and structural models[[1]](#footnote-1) to study the effects of both innovation and imitation forces, preference interdependences, mobile app category assortment breadth, and consumers and app categories heterogeneity on consumers’ individual adoption choices. In addition our model allows us to study the substitution or complementarity of different mobile app categories. We apply our model to a unique dataset of eighteen weeks of consumer’s download choices on a newly launched app store in Africa[[2]](#footnote-2). We find that local, rather than global, diffusion forces explain individual’s consumer choices on the app store. Our findings show an interesting pattern of app category heterogeneity and complementarity, yet it does not find any significant effect for app category assortment breadth. The imitation rather than the innovation force drive diffusion of mobile app categories, and consumer preference for some mobile app categories has bimodal distribution. These results have various implications for mobile app platform management and mechanisms design. Our results should be of interest to academics and business community.

Keywords: mobile app store platform, interdependence of consumer preferences, social learning, simultaneous local and global diffusion model, app category complementarity and substitution, hierarchical mixture Bayesian, state space, structural model, Markov Chain Monte Carlo, big data

**Introduction**

Smartphones are so pervasive in the telecommunication market that no matter which mobile operator anyone selects in U.S (e.g. T-Mobile, Verizon, AT&T, or Sprint), she has an option to adopt a long term contract that includes a smartphone handset. All three dominant mobile operating system (OS) companies, Google, Apple, or Microsoft, have opened their platform to third party developers to develop mobile apps, the mobile apps which help the diffusion of the OS platform. Fueled by this decision of the OS platforms, and the flood of mobile app developers to this eco-system, new intermediaries called app-stores stepped in. App stores are two sided platforms, as they match consumers and app developers, without taking the ownership of the apps.

App stores garner their revenue share either from advertisings or from paid app sales, so for them efficiency of app market translates into more revenue. Some app-store platforms show to the potential consumers the current install base of mobile apps, while others do not. For example while Google play shows the range of number of installs of an app to consumers, Apple, Microsoft, and Amazon do not do so. Showing global number of installs may only be relevant if it affects individual consumer choices at each local market. However, observing peer consumers’ choice does not have to be online. Mobile phones are pervasive, as consumers carry their smartphones in most of their social life events[[3]](#footnote-3). This pervasiveness may help the diffusion of the mobile apps in a local market. More precisely, social learning process through observing others’ choices of mobile app may play a role in the mobile apps’ diffusion in local markets. This social learning process may even be central for mobile apps to create interdependence of consumers’ preferences, as mobile phones are classified as disruptive innovations[[4]](#footnote-4). The interdependence of consumers’ preferences has long been studied in marketing in the context of the geographical or social neighborhood by Yang and Allenby (2003), Stephen and Toubia (2010), Lehmmes and Croux (2006), Nair et al. (2010), etc.

For a mobile app platform it may be important to know whether global WWW or local pervasiveness of mobile phones explains individual consumers’ choices better, because each mechanism suggest different set of marketing mix strategies. Furthermore, a platform owner may precisely be interested to know for each type of mechanism whether imitation or innovation force drives consumers’ adoption choices, because while the imitation forces suggest viral marketing strategies, the innovation forces suggest app trail strategies.

An app store platform may also be interested to know the complementarity between different mobile app categories. This knowledge may suggest a mobile app platform owner to redesign its online platform to cross sell more apps. In addition, an app platform can recommend new mobile app categories or propose trial to consumers to increase the cross selling chance. Another alternative strategy could be to use an app category as a loss leader to encourage use of apps in the other app categories. For example, the app store owner may find the app category of Book and References to be complement to the app category of Puzzle and Trivia, so she may decide to give an incentive on one to drive the diffusion on the other.

To design an optimal app store platform and optimal mechanisms, an app store platform owner may be interested to know whether an optimal assortment size exists. Scheibehenne, et al. (2010) asserts that currently there are mixed evidences about the influences of assortment breadth, or variety in product line. Many studies hinge upon search theories to argue that large assortment breath can lead to no purchase choice, including Kuksov (2010), Villas-Boas (2009), Diehl and Pynor (2010), Chernev and Hamilton (2009), Timmermans (1993), Kahn and Lehmann (1991), Sela, Berger, and Liu ([2009](http://www.jstor.org/stable/10.1086/651235#rf110)), Gourville and Soman (2005) . However, there are studies that support the idea that greater choice is always desirable, as each consumer can find a great product fit, and that  variety a brand offers serves as a quality cue (Villas-Boas 2010, Anderson [2006](http://www.jstor.org/stable/10.1086/651235#rf2), Arnold et al. 1983, Bown et al. 2003, Craig et al. 1984,  Koelemeijer and Oppewal [1999](http://www.jstor.org/stable/10.1086/651235#rf72); Oppewal and Koelemeijer [2005](http://www.jstor.org/stable/10.1086/651235#rf90), Boatwright and Nunes [2001](http://www.jstor.org/stable/10.1086/651235#rf10); Borle et al. [2005](http://www.jstor.org/stable/10.1086/651235#rf11); Drèze, Hoch, and Purk [1994](http://www.jstor.org/stable/10.1086/651235#rf29); Sloot, Fok, and Verhoef [2006](http://www.jstor.org/stable/10.1086/651235#rf116), Berger et al. 2007). On mobile apps it is not clear whether consumers also enjoy navigating in the app store or they intentionally search for specific mobile app they have heard about. Therefore, to design an optimized app store platform, and mechanisms, the owner may be interested to know the effect of assortment breath.

Individual choice data and models allow not only capturing these intricacies, but also simulating policies. Policy simulation allows the app store platform to jointly optimize its marketing mix policies. For example a given firm may find a corner or an interior solution for optimal level of imitation and innovation forces at local and global level to optimize each mobile app categories’ diffusion. This optimization has merits, especially for app store platform owner, as she can target consumers differently by their smartphones. Targeting optimization requires accounting for heterogeneity not only in app categories, but also in consumers’ responses. Therefore the model should be flexible enough to allow for any type of heavy tail distribution in consumers’ or categories’ heterogeneity.

Thus given exceptional features of the diffusion and management of an app-store platform, we consider the following substantive questions: (1) whether global or local diffusion of mobile app categories drive the individual choices of consumers? (2) Whether imitation or innovation forces drive the diffusion of an app category? (3) How can an app-store platform optimize its targeted marketing mix policies (e.g. encourage trial, or encourage sharing) to increase the choice probability of individual consumers of an app in a given app category? (4) Which mobile app categories are substitute, and which are complements? (5) What is the optimal assortment breath of each mobile app category?

To address these questions about mobile app categories’ simultaneous diffusion and their complementarities or substitutions, we cast Bass Diffusion Model (BDM) into simultaneous state-space models. Further, to address consumers’ interdependent preferences, we extract imitation and innovation forces from our simultaneous state space model, and we adopt individual choice model that uses flexible mixture of normal hierarchical Bayesian approach to model individual’s heterogeneity. To avoid multicollinearity in mobile app category characteristics, we adopt a factor model, rather than discarding the data. We capture diffusion of mobile app categories in a latent measures that evolves with parameters of innovation (p), and imitation (q), observed cumulative adoption(y), and app category market potential (M). This modeling approach allows us to capture not only direct network effect of an app and an app category in imitating parameter, but also complementarity and substitution of different apps and app categories over the app store in innovation parameter. We find that diffusion over a pervasive product (mobile phones) hypothesis fits our data better than global diffusion cross country interaction over World Wide Web. However, there is an interesting pattern of complementarity between diffusion of mobile app categories globally. Word of mouth rather than innovation forces drive the diffusion of mobile app categories and preferences of consumers on some mobile app categories have bimodal distribution. We also find that distribution of market sizes is bimodal, and that there is a significant heterogeneity in the choice response of consumers to mobile app category characteristics. Last but not least, we do not find a significant impact for assortment breath of the mobile app categories influence on the individual choice of mobile app categories.

Our study of interdependence of consumer choices is mostly related to studies by Yang and Allenby (2003), Stephen and Toubia (2010), Lehmmes and Croux (2006), Nair et al. (2010), who model the peer effect either due to geographical (distance) or social network neighborhood. In addition our study is related to study by Sriram et al. (2007) and Liu et al. (2010) on the complementarity and substitution of digital goods, and study by Putsis et al. (1997) and Dekimpe et al. (1997) on global simultaneous diffusion. Although these studies have contributed greatly to our understanding of the phenomenon, none has considered the impact of visibility of goods (e.g. mobile app) diffused over pervasive products (e.g. mobile phones) on the individual consumer decision. Given ubiquity of smart phones, it may be important to consider the influence of visibility of goods diffused over pervasive products, to understand whether global village buzz translates to global diffusion force or local diffusion force to affect individual choices. In addition, to understand complementarity or substitution of mobile app categories, it may be important to consider the joint diffusion of mobile app categories simultaneously. Needless to say, we may also expect a significant heterogeneity both in the individual consumers and in the mobile app categories parameters.

To address some of these limitations and research questions, we extended the use of the state space and the individual logit choice models to model the interdependence of consumers’ choices. To do so, we incorporated Bass Diffusion Model (BDM) to model simultaneous diffusion of the mobile app categories and their substitution and complementarity. The resulting combination of the state space and the choice models is information about dynamic, nonlinear, and heterogeneous phenomena of diffusion and choice over pervasive goods. In contrast to many studies, to allow the model to be flexible, and in order to separate state dependence from heterogeneity, we use normal mixture model for both mobile app category and individual choice parameters, as a substitute for normal model of heterogeneity. Moreover, we extract the aggregate innovation and imitation forces from a latent BDM diffusion model. For estimation, we re-cast BDM differential equations into non-linear discrete-time, state-space forms; and then estimate them using hybrid MCMC approach to jointly estimate diffusion and choice models by Extended Kalman Filter and normal mixture logit model.

This paper, thus, contributes to the emerging literature on pervasive products and mobile app store platforms in various ways. First, it introduces a choice model to investigate several factors that could affect choices of mobile app categories on the app store platforms. Although other studies in marketing have considered the dynamic choice models of digital goods, none has molded the effect of innovation and imitation forces on individual consumer choices, to account for interdependence of consumer choice preferences. Second, the paper examines the complementarity and substitution of different mobile app categories. This information can help the app store platform to optimize its promotion strategies on mobile app categories. Third, rather than selecting the mobile app characteristics, we use a factor model to summarize the variations, and then we use the factors in the choice model. Fourth, to ease the estimation rather than discarding the big data on the whole app store, we first use the whole data to recover imitation and innovation forces, and then wen select a stratified sample to get intuition about underlying mechanism of individual choice behavior. Fifth, despite mixed evidence and normative suggestions about the effect of assortment breadth, to the best of our knowledge we are the first to empirically test the predictions over app store platforms. Sixth, to estimate the resulting model, the paper employs hierarchical Bayesian mixture normal on the top of both choice and Extended Kalman Filter estimation. These approaches should be of interest to academia and a number of commercial entities interested in the performance of products diffused over pervasive products, and their relevant store platforms.

The data we used for our estimation were collected by an African telecom operator on downloads of mobile apps’ on the app store platform of its global partner. The app-store is launched within 330 days prior to our study, but we use around 190 days of daily downloads of mobile apps on the app store. We selected 10 different app categories, and within each app category we stratified a sample of individual consumers who have at least one downloaded app during the time of this study. We aggregated consumers’ daily choices and aggregate diffusion of mobile app categories at weekly level to avoid inherited scarcity in our data. In addition, we dealt with the inherited scarcity in the data using Bayesian shrinkage method for both mobile app categories and individual parameters. We investigate geographic source of interdependence of consumer preferences (i.e. within the city) versus global sources of interdependence of consumer preferences (i.e. across the globe). We create geographic neighborhood (i.e. city) by physical proximity, through mapping IP address of each consumer to the corresponding city. For this purpose we wrote a crawler and scraper in Perl to scrape the location of each corresponding IP in an IP-location mapping website. The data consists of around 20,000 consumers, with around 3,000 consumers in a local city in Africa under study. This local city has around 4,000 app downloads for duration of our study, and we draw a random stratified sample of 147 consumers’ individual choices.

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2. I would like to thank Dr. Ying Xie and Dr. Elisabeth Honka for their revision of the proposal I send out to the company. I also would like to thank Dr. Rao for making me to write a lot during his spring seminar, which allowed me to organize my mind, and to position my research paper. [↑](#footnote-ref-2)
3. This process has been so extensive that some scholars study how cell phone affects social interaction of individuals http://www.michigandaily.com/news/%E2%80%98u%E2%80%99-researchers-identify-link-between-cell-phones-and-socialization-habits [↑](#footnote-ref-3)
4. http://www.businessweek.com/articles/2014-02-20/uber-leads-taxi-industry-disruption-amid-fight-for-riders-drivers [↑](#footnote-ref-4)