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Privacy tradeoffs in smartphone applications

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HIGHLIGHTS

- Choice experiments are used to examine privacy tradeoffs in smartphone applications.
- Plausible WTP amounts to conceal information are estimated.
- Valuations differ for different demographic groups.

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ABSTRACT

We use choice experiments to examine privacy tradeoffs in smartphone applications ("apps"). Results show that the representative consumer is willing to make a one-time payment for each app of about $2.28 to conceal their browser history, $4.05 to conceal their contacts, $1.19 to conceal their location, $1.75 to conceal their phone's identification number, and $3.58 to conceal their texts. These valuations vary for different segments of society.

1. Introduction

The concealment of personal information or "privacy" has been the subject of much recent debate. Discussion has centered on the low-cost collection of large amounts of personally identifiable data in online markets, and the sharing of these data with third-parties such as advertisers, application developers, and government agencies. The policy responses to increased privacy concerns include industry self-regulation, full disclosure of how personal information is used, laws to restrict the use of personal information, and the assignment of property rights so that market forces will allocate personal information efficiently. Despite several interesting theoretical and empirical contributions from economists, this discussion has largely evolved without relevant measures of consumer preferences for privacy (e.g., Taylor, 2004; Acquisti and Varian, 2005; Hermalin and Katz, 2006; Goldfarb and Tucker, 2010). This is surprising given that estimates of consumer valuations would help policy makers better understand the tradeoffs associated with the protection of personal information when evaluating these proposed initiatives.

We use in-person interviews of a large sample of geographically and demographically disperse individuals to examine privacy tradeoffs in smartphone applications ("apps"). Using choice experiments, while subject to hypothetical bias, allows us to obtain willingness-to-pay (WTP) estimates for the concealment of a variety of personal information contained in one's smartphone. We obtain plausible estimates of the dollar value of relinquishing a set of specific aspects of personal privacy, under the framework of a random utility model of the demand for apps. We study the apps market because it is typically necessary for the consumer to relinquish some personal information through "privacy permissions" to obtain the app and its benefits. Furthermore, there is experimentally designed variation in the required permissions across apps, allowing more accurate estimation of the individual aspects of privacy such as location, online browsing history, etc. Another aspect

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	HootSuite	Social Me	Social Me A	Social Me B	Social Me C	Social Me D
Contacts	Yes	Yes	Yes	No	No	Yes
Phone ID	Yes	Yes	Yes	No	Yes	No
Read Texts	Yes	No	No	Yes	No	No
Advertising	Yes	Yes	No	Yes	No	Yes
Cost	$0.00	$1.99	$2.99	$3.99	$5.99	$4.99

Fig. 1. Choice question for social app with three privacy permissions.

of the market is that apps are free or relatively inexpensive, making the stated-preference field experiments used in this research possible.[1]

The five privacy permissions examined in this paper are the websites the consumer has browsed on their smartphone (*BROWSER HISTORY*), the contacts in their address book (*CONTACTS*), the location of the consumer while carrying their smartphone (*LOCATION*), the unique identification number (*PHONE ID*), and the text messages the consumer has written and received on their smartphone (*READ TEXTS*). We derive the WTP for the concealment of this information from 1726 respondents. An important feature of this approach is the estimation of preferences for different demographic groups.

2. The survey and data

Data are obtained from an in-person survey employing repeated discrete-choice experiments. Respondents are shown an app on the interviewer's smartphone. It is free, but users must relinquish several permissions to download and use it, and have advertising appear on their screens. Table 1 describes the privacy permissions and other characteristics. Then the respondent is told that there is a new app available, identical in functionality to the app just demonstrated, except that it has a price but does not require revealing as much personal information, and may not come with advertising. The respondent makes a choice. He or she is then told that soon there will be available different versions of this app, and again the respondent makes a pair-wise choice. This is repeated once more so that, in total, the respondent has made three, pair-wise choices.

With ample experience thinking about prices and permissions, the respondent is now shown the complete set of six apps (see Fig. 1 for an example with an app in the social app category), and asked to indicate which app he most prefers. Respondents were informed that the new apps would soon be available in the marketplace and that they must commit to buying one app from the six alternatives or opt out and not make a purchase.

The choice experiment is repeated once more with a different app from a different category, either a shopping, social, travel, TV & movie, or utility app, and with different levels of the characteristics of the app alternatives. This is the data we analyze below in Section 3.

A potential disadvantage of survey data is hypothetical bias. This arises when the behavior of the respondent is different when making choices in an experimental versus a real market. We minimize this source of bias with protocols that assure respondents that the apps are real, are traded in markets, and that they will be making (or, not making) an actual purchase. For example, the interviewer demonstrates an actual app at the beginning of each experiment and informs the respondent that they are expected to follow through on their commitment to purchase a chosen app when the experiment is over.

Data from the various marketplaces for apps were used to choose the five app categories and the market apps used in our experiments. Apps were selected that are easy to explain and understand, can be easily demonstrated *on the interviewer's smartphone*, are potentially interesting to a wide audience, and are available on all major platforms. Information from app developer's promotional materials, industry journals, and two focus groups were used to develop the descriptions of the app characteristics. The levels for the characteristics were constructed from a statistically efficient design (Huber and Zwerina, 1996). We created the universe of all reasonable characteristic combinations (ensuring adequate variability on all characteristics) and from this chose 24 app alternatives that were grouped into four choice sets of six alternatives. The alternatives in each choice set are described by *ADVERTISING* and *PRICE*, and *three* of the five privacy permissions, *LOCATION*, *BROWSER HISTORY*, *CONTACTS*, *PHONE ID* or *READ TEXTS*. The five permissions were distributed across all choice sets so that they were equally represented in the total sample. Each of the four choice sets were assigned to interviewers so that choice questions one and two contained a different set of permissions and different levels for all characteristics. This ensured optimal variation in the data across all sample cities.

The survey was administered to consumers with smartphones at their home and in public places from July 10 to August 19, 2013. Survey locations were randomly drawn from seven cities and in-person interviews were conducted around these locations.[2] Interviewers offered a cash incentive to respondents for participating. A total of 1726 respondents from Atlanta (306), Chicago (259), Denver (316), Philadelphia (279), Portland (208), Salt Lake City (77) and San Diego (281) completed a valid survey. When compared to the general US population, our sample is younger and more educated which is expected given that smartphone adoption is more likely when the household head is young, and has relatively higher education. For example, see Hiller et al. (2015).

3. Empirical results

Columns two and three of Table 2 contain estimates of the conditional logit model (i), where utility is a linear function of *BROWSER HISTORY*, *CONTACTS*, *LOCATION*, *PHONE ID*, *READ TEXTS*,

[1] Other studies which have used experiments to value privacy are Hann et al. (2007) for financial portals, Egelman et al. (2012) for smartphone location, and Grossklags and Acquisti (2007) for information on quiz performance.

[2] See the authors for a detailed description of the cluster sampling method used to locate and recruit respondents.