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The effects of price, popularity, and technological sophistication on mobile handset replacement and unit lifetime

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ABSTRACT

Modeling the sales and replacements of technology products is typically carried out at the aggregate product category level. However, with maturing markets and especially with high-technology products, the ever-increasing variety of differentiating product features calls for more detailed analysis. This article presents evidence on the effect of price, popularity, and technological sophistication on unit replacement and lifetimes of mobile handsets. The analysis is conducted with a unique device model specific dataset from the Finnish market, with monthly mobile handset unit sales from 2003 to 2009 and annual installed bases from 2005 to 2012. The results show that median unit lifetimes decreased during the second half of the study period, indicating a structural change in the mobile handset market. Furthermore, handset models with higher technological sophistication were shown to have explanatory power on unit lifetimes. During the first half of the study period, more popular handset models were also associated with longer unit lifetimes and models with complex flip design with shorter lifetimes.

1. Introduction

In mature technology product markets a large share of product sales consists of replacement purchases (Islam and Meade, 2000), increasing the importance of tracking and modeling the lifetimes of existing units in use (Bayus and Gupta, 1992). For example, modeling and forecasting sales or diffusion patterns of product categories, product models, or product features require estimates about the unit lifetimes of the sold units. Empirical work on replacement often views products at the aggregate level of product categories, such as televisions, cars, or personal computers (PCs). In the case of technology products and services, this level of detail is often insufficient for understanding the underlying dynamics of unit replacement. If all units within a product category are essentially considered the same, it is not possible to study the effect of, for instance, product characteristics on replacement.

Owners of existing products replace or upgrade these for various reasons, often other than wear and tear (Bayus, 1991). One driver of replacement purchases is the fast pace in which new product models with improved features are introduced. As markets approach saturation, it becomes important for suppliers to innovate so that the existing owners of old units perceive increased benefits of the new product models (Okada, 2006). This is especially true with high-technology products such as mobile handsets, which is a rapidly evolving technology product category. During the early mobile phone diffusion in the 1990s, the innovation in the industry focused on optimizing the size and battery life of the device (Koski and Kretschmer, 2007). After the introduction of fast cellular data connectivity in the early 2000s—when the penetration of mobile handsets already started to reach notable shares in several markets—the innovation on mobile handsets shifted to differentiation by adding new product features, such as improved Internet access with the WLAN technology, positioning with GPS chips, as well as better media consumption and usability with larger touch screen displays.

The innovation and differentiation of such maturing technology products increases the interest to focus on differences within the product categories. From a managerial perspective, it is important to understand whether the replacement process in the market is changing, and whether there are differences in unit lifetimes based on supply-side decisions related to, for example, design and technical features. Information on unit lifetimes gives understanding for the product manufacturer, for instance, on the duration of after-sales support required by the device owners.

Abbreviations: GPS, global positioning system; WLAN, wireless local area network; PC, personal computer; GSM, global system for mobile communications; UMTS, universal mobile telecommunications system; IMEI, international mobile equipment identity; GPRS, general packet radio service; EDGE, enhanced data rates for GSM evolution; WCDMA, wideband code division multiple access; HSDPA, high-speed downlink packet access; FM, frequency modulation; LTE, long term evolution; NFC, near field communication.

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Estimates of unit lifetimes of the sold products can also be used in planning and timing of next generation product models and features. In addition, information on replacement cycles and unit or subcategory lifetimes should enable more accurate forecasts of the product category sales or the diffusion of product features. The diffusion of product features (Riikonen et al., 2013) is especially important for mobile application developers, who need to estimate the size of the potential market for their products. Product features are often enablers of the services provided by these third party developers, such as GPS technology for location-based services. In addition, mobile network operators need to estimate the demand for their network services. Information on the unit lifetimes of different devices enables better estimates of how long the existing units in use will stay active in the network. However, only a few examples of quantitative replacement studies focusing on subcategories of technology products are available (see, e.g., Gordon, 2009; Kivi et al., 2012). Similarly, few studies (e.g., Bayus, 1991; Kivi et al., 2012) have analyzed product unit lifetimes over time.

One reason for the limited number of detailed empirical studies on replacement is the difficulty of collecting suitable data. While product model level data about the sales of technology products can be obtained from retailers or market research companies, data on the actual devices in use is more difficult and expensive to collect. Often studies of the devices in use (installed base) are conducted by collecting survey data from the end users or households. This method is suitable when relatively high-level information is required, such as information on whether people use a mobile phone or not. However, collection of detailed device model information via surveys can be difficult, as the end users may not know or remember the actual device model, or the features of the device they own or regularly use.

For some technology products such as cars and mobile handsets, however, comprehensive registers about the products in active use are constantly collected and maintained, with detailed information about the product models and features. In the case of mobile handsets, it is technically possible to obtain such installed base data from mobile operators' charging and billing systems, which contain all units actively used in their networks. With survey-based methods, it is challenging to get large enough sample size for individual device models. However, collecting the data from mobile operators' registers means that one can obtain census data of all the devices in use in the network. In this article, the data collection was done over a period of almost 10 years, in collaboration with all mobile network operators of the studied market.

This article studies the effects of price, popularity, and technological sophistication on mobile handset replacement and unit lifetime. For this purpose, mobile operator-based census data on the annual installed base of mobile handset models is combined with monthly, model specific sales data. The installed base data includes information on how many units of each handset model were actively used, whereas the sales data describes the number of unit purchases for each device model. Using this data, product unit lifetime distributions are estimated for models introduced in the Finnish mobile market between 2003 and 2009 and observed in mobile operators' networks between 2005 and 2012. Then several hypotheses on product model specific characteristics—such as popularity, price, and technological features—are tested using sequential multiple regression and mediation analysis.

The article has theoretical contributions on the diffusion and replacement literature, testing explanatory variables of technology product unit lifetimes. From data collection viewpoint, the detail of collected data and large sample sizes enable the analysis of the unit lifetimes on a device model level. This is among the first articles to combine product model-specific data on the installed base (usage), and sales (acquisitions) to analyze replacement patterns and determinants. This article also suggests a way of calculating technological sophistication of technology products, and gives insights on the suitability of different replacement models for estimating mobile handset product lifetimes. From a managerial perspective, the results show the dynamics of replacements in an example market, and provide suggestions for practical market forecasts.

The article is structured as follows. After this introduction, previous replacement literature is reviewed in Section 2. Section 3 describes the conceptual model, whereas the research process, data, and methods are explained in Section 4. Section 5 presents the results of the replacement model fitting and the multiple regressions on unit lifetimes. The article closes with a summary and discussion of the results in Section 6.

2. Literature review

Sales of durable goods can be categorized based on the nature of purchase in question. In the initial stages of a product's life cycle almost all sales consist of first time purchases, but as the product matures an increasing share of sales shifts to replacement or additional purchases (e.g. Bayus, 1988, 1991; Islam and Meade, 2000; Steffens, 2001). The replacements are often discretionary and “unforced” as opposed to forced replacements due to product failures (Bayus, 1988). In the rapidly evolving technology product markets this seems to be especially true, as new, more powerful, and more functional devices continuously deem existing devices obsolete. Despite the dominant role of product replacements in determining the sales of many technology products, academic interest has mainly been on modeling diffusion rather than replacement.

The literature on diffusion of innovations has received broad academic interest since the works of Mansfield (1961), Rogers (1962), and Bass (1969). Diffusion models such as the Bass (1969) model serve the purpose of modeling and forecasting the adoptions and resulting sales of new products (Mahajan et al., 1990; Parker, 1994; Meade and Islam, 2006; Peres et al., 2010. Many traditional diffusion models are first-purchase models, and have limited value when the share of replacement sales is large. Olson and Choi (1985) proposed a decomposition of sales into adoptions and replacement sales, and modeled the replacements by using Rayleigh distribution as the probability density function of product unit lifetime. Kamakura and Balasubramanian (1987) used a similar approach and truncated normal distribution, whereas Islam and Meade (2000) compared seven different distributions together with a distribution-free approach. Steffens (2001) extended the replacement models by incorporating a time-varying mean replacement age, instead of the typical assumption of constant density function.

A complementing stream of literature has focused on modeling repeat purchases. Repeat purchases as a concept is especially important with non-durable consumer goods, such as food and fuel, which have notably faster purchase cycles. Similar models, nevertheless, can also be used for forecasting the timing of replacement purchases of durable products. Since the works of Fourt and Woodlock (1960), and Eskin (1973), many researchers have used models that divide purchases into trials and repeat purchases. Recent literature has been reviewed in Meade and Islam (2010), who suggest the use of a multistage model with copulas for repeat purchases of consumer durables. In the suggested model by Meade and Islam (2010), a consumer first makes an initial purchase, followed by a number of repeat purchases. The model consists of separate components for repurchase probability and density function of the repurchase time. The advantage of such method is the capability to include the dependencies between successive cycles into the model, which was shown to be important in the case of an example non-durable consumer good. However, with durable consumer goods, used for relatively long periods, the dependency of interpurchase times should be lower, and could be more related to the actual durability and capabilities of the product. Therefore, the analysis of this article focuses on understanding whether device features have explanatory power on unit lifetimes of technology products.

Few of the previous replacement studies have analyzed product model level—or other product sub-category level—replacement. Gordon (2009) studied different PC types by collecting survey data on