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Estimating Consumer Inertia in Repeated Choices of Smartphones

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Estimating Consumer Inertia in Repeated Choices of Smartphones

Abstract

In this paper, we use a unique database on switching between mobile handsets in a sample of about 5,000 subscribers using tariffs without commitment from a single mobile operator on monthly basis between March 2012 and December 2014. We estimate discrete choice model in which we account for disutility from switching to a different operating systems and handset brands and for unobserved time-persistent preferences for operating systems and brands. Our estimation results indicate presence of significant state-dependency in the choices of operating systems and brands. We find that it is harder for consumers to switch from iOS to Android and other operating systems than from Android and other operating systems to iOS. Moreover, we find that there is significant time-persistent heterogeneity in preferences for different operating systems and brands, which also leads to state-dependent choices. We use our model to simulate market shares in the absence of switching costs and conclude that the market share of Android and smaller operating systems would increase at the expense of the market share of iOS.

Key Words: *Smartphones; Consumer Inertia; Switching Costs; Mixed Logit; iOS; Android*

JEL Classification: L13, L50, L96

1 Introduction

The total number of smartphones sold to end users worldwide reached 1,495 millions by 2016, which is an increase by more than 1200% from 122 million in 2007.¹ During this period, the market of mobile smartphones has been inherently dynamic with new market players rapidly gaining global market shares and others being driven out of the market. In particular, Apple and Samsung entered the market in 2008 and within three years by 2011 reached joint market share of about 50% globally. Since then their global market shares are in decline, but they still remain the largest global market players in this industry.² At the same time, BlackBerry which was one of the most prominent smartphone vendors early on with sales peaking at 85 million worldwide in September 2013, lost its dominant position due to the success of the Android and iOS platforms. In March 2016, the number of BlackBerry subscribers fell to 23 million.³ Since 2010, the global market shares of Asian manufacturers such as LG, Huawei, ZTE and Lenovo are on the rise pushing out of the market manufacturers such as HTC and Motorola and eroding the position of Apple and Samsung.

Smartphones are sold with pre-installed operating system (OS), thus the sales of smartphones determine global market shares of operating systems. The big winner is Android with market share growing from zero in 2009 to about 85 percent of all smartphones sold to end users globally in the first quarter of 2017. The second dominant operating system is iOS with market share of 14.7% as of first quarter 2017. The other operating systems including Microsoft, RIM, Bada and Symbian have a negligible total market share of 0.3%.⁴ The success of smartphone manufacturers is intertwined with the success of operating system.

Due to the role which smartphones started to play in our daily lives and their increasing role as a platform for distribution of products and services, there is an immense interest in what drives the evolution and success in this industry. Fierce competition for the market between iPhone and Galaxy smartphones has already led to a series of ongoing lawsuits between Apple Inc. and Samsung Electronics with respect to the design of smartphones and tablet computers. Moreover,

¹Source: www.statista.com

²Source: www.businessinsider.com

³Source: Blackberry financial statement from April 2016.

⁴Source: www.idc.com

the extremely high concentration in operating systems market and the winner-takes-all feature of this market has drawn attention of the policy makers. In 2016, the European Commission charged Google with unfairly using Android to promote its own services over those of its rivals. The Commission also looked into the relationships of Google with some of the world's biggest manufactures of mobile handsets, which have helped expand the reach of Android.⁵

In this paper, we shed light on competition between smartphone manufacturers and operating systems by revealing some facts with respect to consumer behavior in this market. We estimate consumer choices of smartphone models using a database of subscribers to a single mobile operator in a European country on monthly basis between March 2012 and December 2014. Since the choice and use of handset is inherently linked to mobile tariff and consumers tend to switch both tariff and handset at the same time, we model these two choices in parallel. However, in the estimation, we consider consumers who only use newly launched tariffs without commitment to avoid the problem of dealing with the issues of handset subsidies and possible lock-in due to commitment period.⁶ Moreover, we only focus on consumers and observations in which handset switching takes place. Thus, our estimates are conditional on the decision to switch handset.

In our model the choice set consists of a combination of all tariffs without commitment which are available to consumers in a given month and mobile handsets without subsidy which are available in handset catalogues of the operator published on quarterly basis. We focus on the dynamics of consumer decision problem and estimate consumer inertia with respect to the choice of tariff and handset. Of particular interest for us is whether consumers face frictions when switching between different brands of smartphones, especially Samsung and Apple, and between two main operating systems: Android and iOS.

Our estimation results indicate that there is significant state-dependency in the choices of operating systems and smartphone brands. In general, we observe that it is harder for consumers to switch from iOS to other operating systems, except Blackberry. These higher switching costs may be also linked to the cost of changing the whole ecosystem build by Apple around iPhone.

⁵Source: europa.eu

⁶The issue of consumer myopia when making choices of tariff plans and handset subsidies is studied by Nicolle (2017).

Switching from Android to iOS and Windows is also costly but the switching costs in this direction are lower than average. It is also easier than average to switch from Blackberry to iOS. There is no difference from average in switching from Windows to different operators systems. Smartphones made by Blackberry and Apple have proprietary operating systems and the state-dependency between operating systems and brands cannot be separated. Moreover, we find that there is significant time-persistent heterogeneity in preferences for different smartphone brands and operating systems, which also leads to state-dependent choices. Our estimation results indicate presence of significant state-dependency in the choices of tariffs without commitment. Thus, consumers who decided to switch handset tend to continue using the same tariff due to preferences or switching costs. We use our model to simulate market shares in the absence of OS and brand-specific switching costs and conclude that the market share of Android and smaller operating systems would increase at the expense of the market share of iOS.

The literature on the choice and use of smartphones is still very short and recent, which is due to the fact that the industry essentially exists only since 2007. The second reason is availability of data which is suitable for such modelling. This paper is the first empirical analysis of repeated consumer choices of smartphones and the first attempt to estimate state-dependency in choices of operating systems and handset brands.

Our paper is related to the stream of empirical literature on switching costs between mobile providers and tariffs. Among papers on switching costs between mobile providers, Cullen and Shcherbakov (2010) use U.S. survey data from 2005-2009 to estimate a model for myopic consumers and develop a framework which allows including the introduction of persistent unobserved consumer heterogeneity in tastes for handset-carrier combinations. They find that consumers have significant switching costs associated with a change of provider amounting to approximately \$230 USD. In another paper on provider-level, Weiergraeber (2017) uses survey data of U.S. consumers for years 2006-2010 to estimate dynamic demand model with both switching costs and network effects. He estimates switching costs to range from \$40 USD to \$88 USD. Switching costs are also found to lead to state-dependency in choices of tariffs. Grzybowski and Liang (2015) use consumer-level information on monthly basis for year 2013 from a single mobile provider in an European country to estimate switching costs between mobile tariffs. They

find significant switching costs which reduce consumer surplus on average by 48-55 Euros per month. To the best of our knowledge there is only one paper so far by Sinkinson (2014) which estimates a structural model of demand for smartphones and carriers at the same time. He uses monthly market-level dataset of US consumer decisions over 2008-2010 and estimates both price elasticities for smartphones and carriers in order to study the implications of exclusive contracts for smartphones. Based on counterfactual simulations he concludes that AT&T had the highest willingness to pay for exclusivity with Apple and that this exclusivity increased entry incentives for rivals. In another recent paper, Park and Koo (2016) attempt to estimate switching costs between smartphones in Korea but the analysis is based on a single cross-sectional survey data and declarations of consumers about switching smartphones in the past.

The remainder of this paper is organized as follows. Section 2 presents the data used in the estimation. Section 3 introduces the econometric framework. Section 4 presents the estimation results. Finally, Section 5 concludes.

2 Data

This analysis is based on three datasets which we combine together. The first database at the starting point consists of about 115,000 mobile subscribers to a single carrier in a European country who are observed on monthly basis between April 2011 and December 2014. This database includes only consumers with contracts, i.e., there are no prepaid users. From this sample we select subscribers to tariffs without commitment and handset subsidy. These may be either new subscribers who did not have contract with the operator before or consumers who switched from tariffs with commitment and handset subsidy during the time period of our data. There are approximately 16,000 such consumers in our database. They can quit their contracts at any time without additional charges.⁷ We focus on consumers using tariffs without commitment to avoid dealing with the issue of handset subsidies which are linked to commitment. Consumer decision problem can be greatly complicated when in addition to the

⁷Tariffs without commitment and handset subsidy were first launch in October 2011. But due to a small number of users of these tariffs and also a small number of switchings between handsets in the first months we start our analysis from March 2012.

choice of handset we would need to consider a large number of tariffs with 12 or 24 months commitment and different level of subsidy. We observe in the data that only few consumers who decide to use a tariff without commitment switch back to a tariffs with commitment (less than 1% of the sample). The vast majority of consumers either keep using initially selected tariff or switch between tariffs without commitment. We drop from the analysis consumers who switched back to tariffs with commitment. We focus therefore on consumers who make a choice between tariffs without commitment and purchase a handset at a full price.

Next, we select only months in which consumers switched handset. In the time period considered, we observe 7,146 instances of handset switching by 4,983 unique customers. We are therefore not modeling the decision of a consumer to switch handset but the choice of specific handset conditional that a consumer had already decided to switch handset. We can observe that the handset was changed because the SIM card automatically detects and registers a new device, which is recorded in the data. It is possible that a consumer uses the SIM card in a few different handsets during a single month. Handset type is registered in the information system thanks to its International Mobile Equipment Identity (IMEI) twice a week on Monday and Thursday. Our database contains the last handset used by a consumer at the end of each month.

The second database includes the characteristics of all tariffs without commitment, which were available to consumers each month between March 2012 and December 2014. These characteristics are minutes and data allowances included in the tariff price and whether DSL broadband connection is part of the offer. Fiber-to-the-Home (FttH) broadband connection was not bundled with these tariffs.

The third database consists of prices and names of handsets which were advertised by the operator in its catalogues published on quarterly basis between March 2012 and December 2014. Subscribers could purchase these handsets at listed prices without subsidy. For these handsets we have collected from online sources a long list of characteristics including the release date in the country considered. For 30.5% of observations in subscribers database, consumers switch to or from older handsets which are not listed in the catalogues. We do not have information on prices and other characteristics for these handsets and the observations on subscribers who use

them are dropped from the analysis. This leads to bias towards newer handsets and smartphones and a higher share of iPhones and Apple than in the country population.

2.1 Switching between smartphone brands and operating systems

Before moving to econometric estimation we first compute some statistics to illustrate how consumers switch between different handset brands and operating systems. Table 1 illustrates switching between feature phones and smartphones with different operating systems, where feature phones are broadly defined as handsets without operating system, i.e., not smartphones. We observe that 47% of switching takes place from Android to Android and 72% from iOS to iOS. There is therefore substantial inertia towards using the same operating system. This inertia is not present among users of Windows among whom only 19% switch to another smartphone running on Windows. Similarly, only 16% of Blackberry users switch to another Blackberry device. Users of Windows tend to switch more to iOS (36%) than to Android (28%). Also, users of Blackberry switch more to iOS (37%) than to Android (23%). Users of ‘other’ operating systems switch more to Android (32%) than to iOS (28%). Only 4.7% of them switch to a device which also relies on ‘other’ operating system. Finally, 41% of users of feature phones switch to another feature phone. The higher popularity of Android among users of feature phones may be due to a greater range of offers of Android smartphones both in terms of brands and specific models. But iPhones are also in general more expensive, hence first time smartphone users may opt for cheaper models to get their first experience. Among 59% who switch to a smartphone, 51% choose Android versus 27% opting for iOS. The adoption of smartphones is on the rise but there are still many smartphone users who switch back to feature phones. The smallest share of switchers to feature phones represent users of iOS (6.4%), followed by Windows (9.7%) and Android (13.9%). The highest share of smartphone users who switch to feature phones are among users of devices running on ‘other’ operating systems (21.9%) and Blackberry (16.5%). The observed switching patterns indicate that the operating systems market evolves rapidly towards duopoly of Android and iOS with the remaining operating systems and feature phones losing market shares.

Table 2 illustrates switching between different handset brands. As above, we observe that

72.5% of consumers switch from iPhone to iPhone. Furthermore, 37% of Blackberry users and between 17.8% to 27.7% of users of the other brands switch to iPhone. We also observe that 47% of users of Samsung switch to Samsung, where the percentage of users of other brands based on Android who switch to Samsung ranges between 27.7% for Sony to 42.3% for LG. At the same time 15.8% of iPhone users and 25.5% of Blackberry users switch to Samsung. The percentage of consumers who switch within the same brand relative to switching to the other brands is also higher for the remaining brands. This indicates that there is consumer inertia when switching between smartphone brands, which varies depending on brand and operating system.

2.2 Choice Set

We use the tariff and handset data sets to create choice set in each month. The choice set is a combination of tariffs and handsets which are available to consumers in a given month. The choice set of a particular consumer must also include tariff which he uses, even if it is not available to other consumers. Because of this, the set of tariffs which are included in the choice set in a given month may differ among consumers. On the other hand, the handsets included in the choice set in a given month are the same for all consumers. This is because we estimate the choice of handsets conditional on the decision to switch, and the continuation to use the same handset is not an option.

The choice set includes all handsets which were chosen by at least one consumer in a given month.⁸ We do not consider that consumers purchase second hand handsets, which assumption is supported by market research.⁹ The choice set ranges between 474 and 1,224 alternatives in a month, where consumers choose between 3 to 10 unique tariffs per month and between 71 to 194 unique handsets. These handsets belong to 16 different brands.

⁸In alternative model specification, we include in the choice set all handsets offered at a full price in the catalogue of the operator in a given month, even if they were not chosen by any consumer, which results in greater choice set. The estimation results are comparable.

⁹According to Technical Market Index (TEMAX) from the market research firm GfK, only 15% of handsets sold in 2012 were second hand handsets. Moreover, according to Technology, Media and Telecommunications (TMT) Predictions from consultancy firm Deloitte, in 2015 only about 10% of customers from this country considered a purchase of a second hand handset.

3 Model

We estimate a discrete choice model to analyze consumer choices of handsets and tariffs. Consumers are free to combine any non-subsidized handset with any non-commitment tariff available on the market in a given month and choose the combination which maximizes their utility. We use a standard linear utility specification which depends on tariff and handset characteristics including prices. We also account for the heterogeneity in preferences for operating systems and brands by means of random coefficients. The utility of individuals $i = 1, \dots, N$ derived from handset $j = 1, \dots, J_t$ and tariff plan $k = 1, \dots, K_t$ which are available in month t is given by:

$$U_{ijkt} = X_j \beta_h^i - \alpha_h p_{jt} + X_k \beta_p - \alpha_p p_k + s_{ijkt} \gamma + \epsilon_{ijkt} = V_{ijkt} + \epsilon_{ijkt}. \quad (1)$$

where the price of handset is denoted by p_{jt} and the price of tariff plan is denoted by p_k . The valuations of handset attributes are denoted by β_h^i and the attributes vector X_j includes the following variables: (i) brand of the handset; (ii) operating system; (iii) handset measures: height, thickness and weight; (iv) battery life; (v) screen size; and (vi) camera resolution. The valuations of tariff characteristics are denoted by β_p and the characteristics vector X_k includes the following variables: (i) voice allowance in minutes if not unlimited; (ii) a dummy for unlimited voice minutes; (iii) data allowance in Gigabytes (GB); (iv) a dummy for ADSL broadband. The characteristics and prices of tariff plans do not change over time but instead new plans are introduced and older ones are withdrawn. The characteristics of handsets also do not change over time but the catalogue price may change from one quarter to another.

The vector of switching dummies is denoted by s_{ijkt} and coefficients γ represent the disutility from switching which approximates switching costs. We consider four types of switching dummies. First, we use a dummy variable for switching tariff, which takes a value zero if consumer i in the previous month $t - 1$ used the same tariff k , and value one otherwise. Second, we use a dummy variable for switching from a feature phone to smartphone. Third, we use a dummy variable for switching from a smartphone to feature phone. Fourth, we estimate an average switching costs between operating systems and a set of dummy variables which are

specific switching costs between pairs of operating systems. In this way, we allow the disutility from switching to vary depending on the OS from which consumers switch and the OS to which they change. In the case of iPhone and Blackberry, which have proprietary operating systems, switching costs between operating systems and brands are equivalent. For smartphones which operate on Android, Windows and other smaller OS, we estimate in addition average switching costs between brands.

We use random coefficients on brand and operating system dummy variables. Our data is unbalanced panel, where for some consumers who switch more than once we have multiple observations, as shown in Table 7. This table shows the number of consumers who switched handsets once, twice, three times and more. Thus, the random coefficients account for unobserved individual time-persistent preferences for particular brands and operating systems, which may result in state-dependent choices. We can denote the random coefficient as $\beta^i = \beta + \nu^i$, where β is a vector of mean valuations and $\nu^i \sim N(0, \Sigma)$ is a randomly drawn vector from a joint normal distribution. Here, Σ represents a diagonal matrix, in which the diagonal elements are standard deviations around the mean valuations. In this analysis, we do not use any observable individual characteristics which influence valuations of handset and tariff attributes because such information is confidential.

Finally, ϵ_{ijkt} is the individual-specific valuation for handset j , tariff k at time t , i.e., the “logit error term”. It is assumed to be identically and independently distributed over tariffs and individuals according to type I extreme value distribution.

3.1 Choice Probabilities and Estimation

An individual i chooses in period t a handset m and a tariff n with the highest utility among all the available alternatives, i.e., if $U_{imnt} = \max_{jk \in C_{it}} U_{ijkt}$, where C_{it} is individual i 's choice set in month t . Hence, the probability that individual i with random coefficients β^i makes a

sequence of handset and tariff choices $mn = \{mn_1, mn_2, \dots, mn_T\}$ is given by:

$$\begin{aligned} l_{imn}(\theta_i) &= \prod_{t=1}^T \Pr\left(U_{imn_{it}} = \max_{jk \in C_{it}} U_{ijk_{it}}\right) \\ &= \prod_{t=1}^T \frac{\exp(V_{imn_{it}})}{\sum_{jk \in C_{it}} \exp(V_{ijk_{it}})} \end{aligned}$$

where the second line follows from the distributional assumptions of the logit error term $\epsilon_{ijk_{it}}$.

When selected coefficients are allowed to be individual-specific, the estimated model is mixed logit model with unobserved time-persistent heterogeneity among individuals. We need to integrate of the conditional choice probability $l_{imn}(\theta_i)$ over the joint distribution of θ_i :

$$P_{imn}(\theta, \Sigma) = \int_{\theta_i} l_{imn}(\theta_i) f(\theta_i) d\theta_i. \quad (2)$$

where θ and Σ are the parameters to be estimated. In the special case when Σ is a matrix of zeros, there is no unobserved individual heterogeneity and we estimate the conditional logit model.

The probability that each individual in the sample chooses the sequence of alternatives as observed can be written as the log-likelihood function:

$$\mathcal{L}(\theta, \Sigma) = \sum_{i=1}^N \log(P_{imn}(\theta, \Sigma)) \quad (3)$$

To approximate the integral entering the choice probabilities $P_{imn}(\theta, \Sigma)$ in (2), we use simulation method, where following Train (2003) we take R draws for vector ν from the joint normal distribution to obtain the average choice probability per individual:

$$\hat{P}_{imn}(\theta, \Sigma) = \frac{1}{R} \sum_{r=1}^R \prod_{t=1}^T \frac{\exp(V_{imn_{it}}^r)}{\sum_{jk \in C_{it}} \exp(V_{ijk_{it}}^r)} \quad (4)$$

The maximum simulated likelihood estimator are the values of parameters θ and Σ which maximizes the likelihood function \mathcal{L} given by equation (3) after substituting into it probability function (4).¹⁰

¹⁰The algorithm for estimating a mixed logit model is explained in detail in Train (2003). We estimate the

4 Estimation results

The estimation results for conditional and mixed logit models are shown in Table 8. In Model I, we estimate average switching costs between brands and operating systems. In Model II switching costs are allowed to vary between pairs of OS. In Model III, in addition we estimate random coefficients on handset brands and OS, which account for unobserved time-persistent preferences of consumers. The coefficient estimates in all three regressions are comparable. The log-likelihood values indicate that the model with OS-specific switching costs is preferred to the model with average switching costs between OS and brands. Moreover, the model with unobserved brand and OS preferences is preferred to the other two models. We therefore interpret the estimates of Model III below. We must stress again that we estimate the models for a sample of consumers who decided to switch handsets, and hence our estimates are interpreted conditional on handset switching.

The coefficient estimates can be divided into tariff characteristics, handset characteristics, switching costs and unobserved heterogeneity. The estimates of tariff characteristics and tariff price are highly significant. The price coefficient is estimated at -0.132. The coefficients of tariff characteristics are easier to interpret in terms of willingness to pay (WTP), i.e., by dividing the coefficients on particular tariff characteristic by tariff price. The willingness to pay for DSL broadband as part of the tariff plan is about $1.851/0.132=14.0\text{€}$, the willingness to pay for unlimited calls rather than for standard 2 hours allowance is 7.5€ . Each gigabyte of data is valued at 4.2€ . There is also a substantial switching costs between tariffs without commitment for consumers who had decided to switch handsets which cost can be approximated at about 38.6€ .

The estimate of handset price is highly significant at -0.001, which yields a lower price elasticity of demand for handsets than for tariffs in our sample of consumers. Only some handset characteristics are significant and can be interpreted in terms of willingness to pay, i.e., by dividing their estimated coefficients by the coefficient on handset price.

Height is significant and positive with consumer willingness to pay of 8€ per millimeter.

mixed logit model using Stata procedure `mixlogit` with 50 Halton draws. See Hole (2007) for estimation details.

Consumers do not like thick handsets since the coefficient on thickness is significant and negative at -0.029. The coefficient on weight is also significant and negative at -0.003, which implies that consumers are willing to pay 3€ for each additional gram less. The coefficients on camera quality in pixels and battery talk time are not significant. Similarly, the coefficient on screen size is insignificant but it is correlated with the other handset measurements.

There are significant differences in the valuation of main brands relative to less popular brands which are not included in the model.¹¹ The most valued brand is Apple, followed by Blackberry, Samsung and Nokia. At the same time, HTC, Sony and LG are less valued than other smaller base brands. Since Apple and Blackberry have exclusive operating systems, their valuation also includes the value of their OS. Furthermore, the operating systems which are used by more than one brand, Android and Windows, are valued more than other less popular and older operating systems such as Symbian, Bada and Linux, as reflected by significant dummy variables for Android and Windows. Still the combined value of say Samsung and Android of $1.223+0.743$ is less than the value of iPhone and iOS represented by 3.680. We can also use the estimates of coefficients on brands and operating systems to approximate how much consumers are willing to pay for these brands and their OS, as shown in Figure 5.

We find that there are significant switching costs between operating systems and brands, which vary across OS pairs. The average switching costs between different operating systems are estimated at -0.966. The disutility from switching between brands on the same operating system is estimated on average at -0.287. In terms of willingness to pay, these numbers translate to approximately 966€ ($=-0.966/-0.001$) and 287€, which are substantial monetary switching costs. Switching costs from feature phone to smartphone and from smartphone to feature phone are not significant.

The cost of switching varies greatly between operating systems and brands. In particular, switching from iOS to other operating systems and brands is much harder. The highest cost of switching is estimated from iOS to other operating systems such as Symbian, Bada and Linux followed by the cost of switching to Windows and Android. Surprisingly, it is not much harder than average to switch from iOS to Blackberry.

¹¹The other brands include Acer, Huawei, Icelphone, Motorola, Sagem and some country-specific brands.

It is also harder to switch from Android to other smaller operating systems: Symbian, Bada and Linux. The cost of switching from Android to Windows and Blackberry is close to average. On the other hand, the cost of switching from Android to iOS is below average at $(-0.966+0.400)=-0.566$. For the other two larger operating systems, Windows and Blackberry, the cost of switching to other operating systems is close to average, except that it seems to be easier to switch from Blackberry to iOS, as reflected by significant and positive coefficient estimated at 0.392.

There is therefore asymmetry in the cost of switching from iOS to Android and from Android to iOS. The higher cost of switching from iOS may be due to the fact that iPhone users may have other devices from Apple, such as tablets and laptops, which are incompatible with other brands. Thus, the higher switching cost for iPhone may be the cost of switching the whole ecosystem. Figure 6 compares switching costs between pairs of operating systems in monetary terms based on willingness to pay calculation.

Finally, we estimate significant heterogeneity in consumer preferences for brands and operating systems, as reflected by significant standard deviations on all brand coefficients, except Apple. The estimates of heterogeneity vary across brands with the highest estimates of standard deviations for Sony and HTC, and the lowest for Sony Ericsson and Blackberry (apart from Apple with insignificant standard deviation). There is also significant unobserved heterogeneity for Android, as reflected by significant estimate of standard deviation on the dummy variable for Android.

We use the model to simulate market shares of brands and operating systems in the absence of switching costs. To do this we set the estimates of switching costs between brands and OS to zero, but keep non-zero switching costs between tariffs. The simulated market shares of operating systems for the whole time period are shown on Figure 7. Since we estimated the highest disutility from switching from iOS to other operating systems, in the absence of switching costs iOS and Apple lose market share, while Android's market share increases, as shown on Figure 8. As of December 2014, in the absence of switching costs the market share of iOS in our sample would drop from 56% to 42.1%. At the same time, the market share of Android would increase from 28.5% to 38.2%, with the smaller OS gaining market shares as well (see Figure 7).

Our sample is highly skewed towards iOS but we can expect a similar change in market shares at the country-level. We can therefore conclude that the market position of Android would be even stronger towards monopoly in the absence of switching costs between operating systems and brands.

5 Conclusions

This is the first paper which relies on detailed consumer-level data on choices of handsets over time to shed light on consumer inertia in choices of smartphone brands and operating systems. Our analysis contributes to understanding the role which state-dependency plays in the evolution of shares of market players and competition between iOS and Android.

We estimate consumer choices of smartphone models using a database of subscribers to a single mobile operator in a European country on monthly basis between March 2012 and December 2014. In the estimation, we only consider consumers who use newly launched tariffs without commitment to avoid the problem of dealing with the issues of handset subsidies and possible lock-in due to commitment period. Moreover, we only focus on consumers and time events in which handset switching takes place. Thus, our estimates are conditional on the decision to switch handset.

Our estimation results indicate that there is significant state-dependency in the choices of operating systems and smartphone brands. In general, we observe that it is harder for consumers to switch from iOS to other operating systems, except Blackberry. These higher switching costs may be also linked to the cost of changing the whole ecosystem build by Apple around iPhone. Switching from Android to iOS and Windows is also costly but the switching costs in this direction are lower than average. It is also easier than average to switch from Blackberry to iOS. There is no difference from the average in switching from Windows to different operators systems. Smartphones made by Blackberry and Apple have proprietary operating systems and the state-dependency between operating systems and brands cannot be separated. Moreover, we find that there is significant time-persistent heterogeneity in preferences for different smartphone brands and operating systems, which also leads to state-dependency of choices.

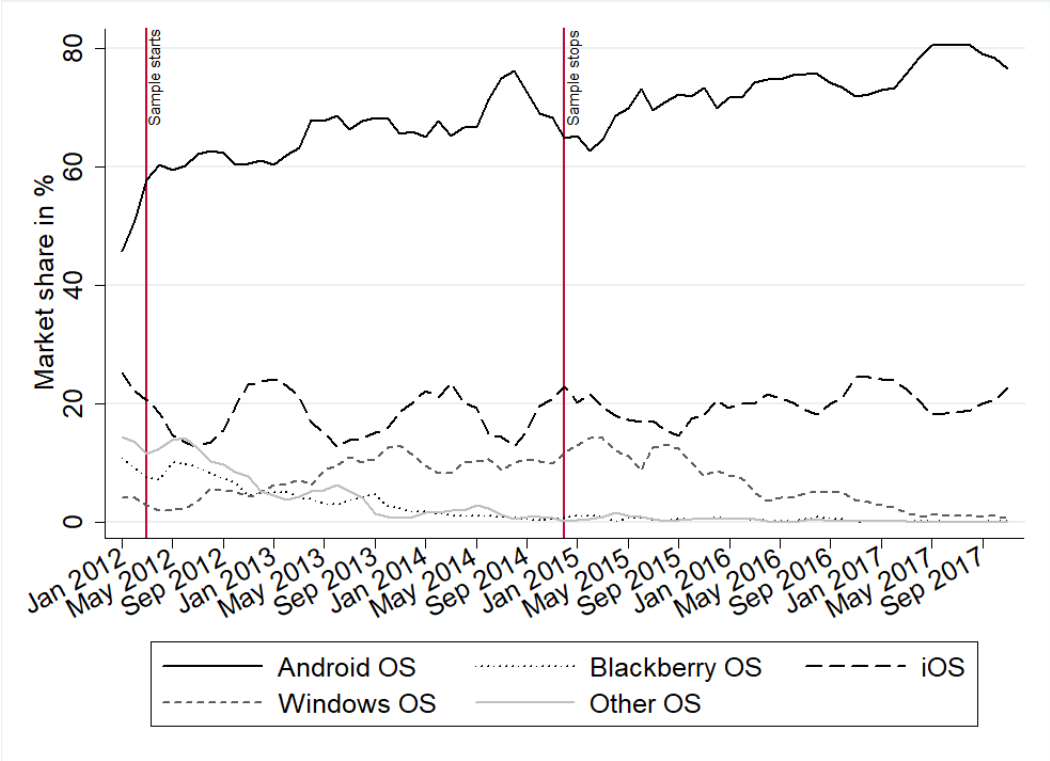
We use our model to simulate market shares of brands and operating systems in the absence of switching costs. Since we estimated the highest disutility from switching from iOS to other operating systems, in the absence of switching costs iOS and Apple lose market share, while Android's market share increases. We can conclude that the market position of Android would be even stronger towards monopoly in the absence of switching costs between operating systems and brands.

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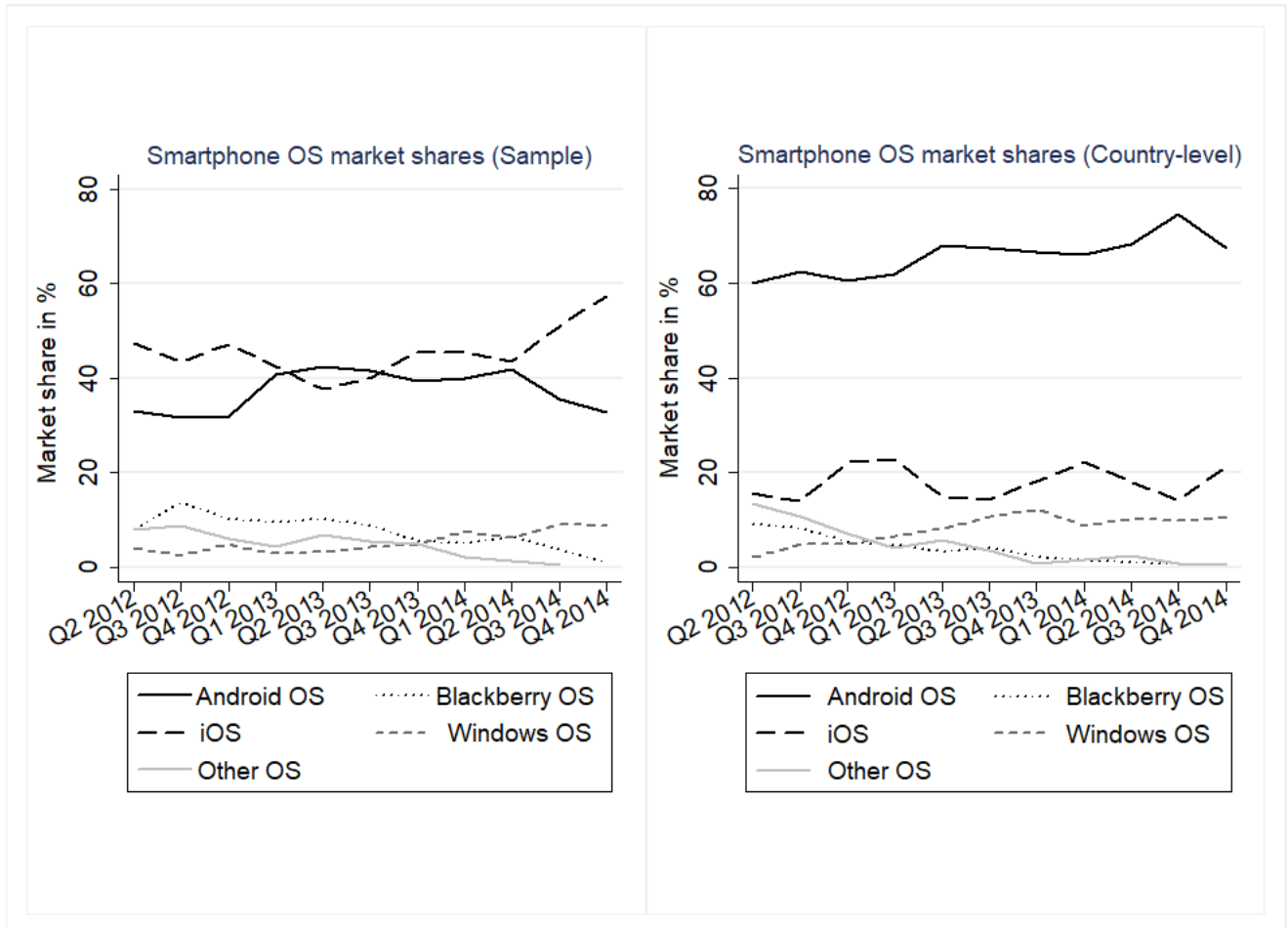
6 Appendix

Figure 1: Smartphone OS market shares at the country-level



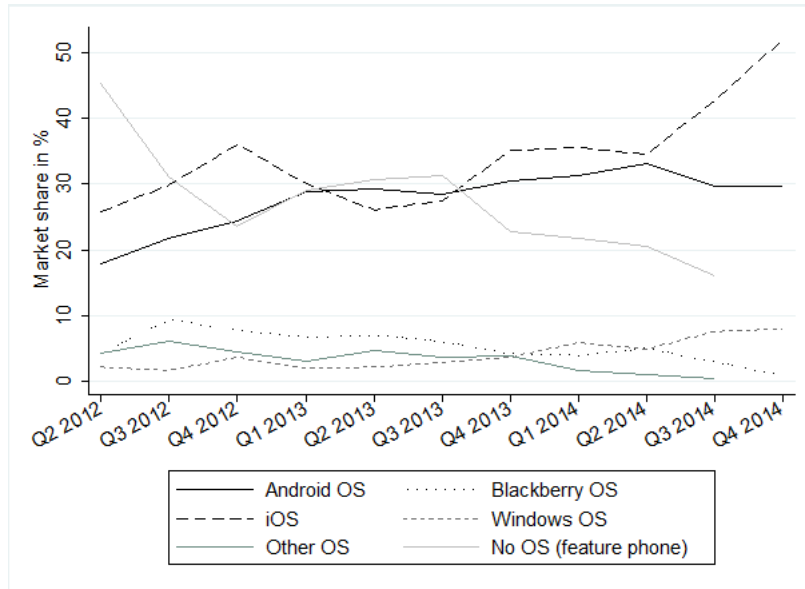
Source: Kantar Worldwide Panel

Figure 2: Smartphone OS market shares in the sample and at the country-level March 2012 and December 2014



See Figure 3 for market shares including feature phones. Source for country-level data: Kantar Worldwide Panel

Figure 3: Handset market shares between March 2012 and December 2014 (smartphones and feature phones)



See Figure 2 for smartphones market shares.

Figure 4: Main brands in the sample between March 2012 and December 2014 (smartphones and feature phones)

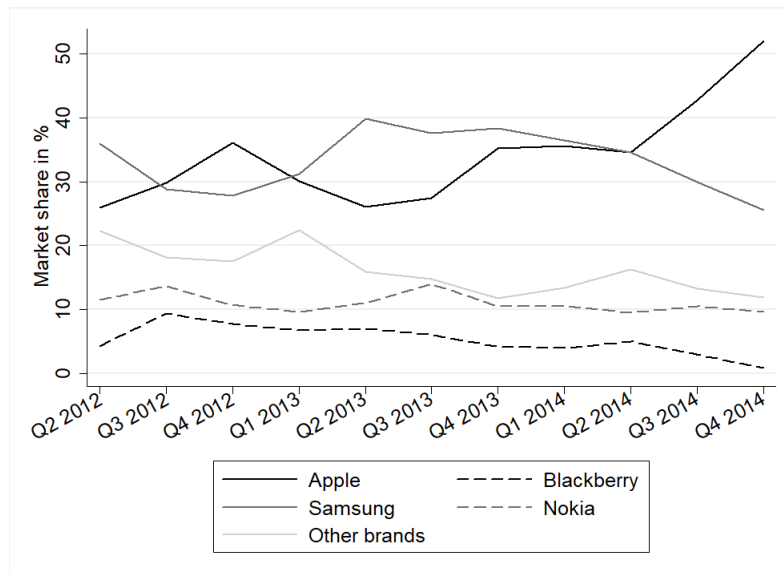


Table 1: Operating system before and after switching handset (% of observations of individuals)

		OS after switching						Total
		Android	Blackberry	Windows	iOS	Other	Feature phone	
OS before	Android	46.94	4.02	5.99	27.55	1.59	13.9	100
	Blackberry	23.17	16.28	4.59	37.16	2.29	16.51	100
	Windows	28.41	4.55	18.75	35.8	2.84	9.66	100
	iOS	15.13	2.91	2.1	72.46	0.97	6.44	100
	Other	32.38	4.7	7.83	28.46	4.7	21.93	100
	Feature phone	29.97	4.53	4.65	15.96	4	40.9	100
	Total	29.3	4.7	4.76	36.43	2.55	22.26	100

Table 2: Brand before and after switching handset (% of observations of individuals)

		After switching								Total	
		Apple	BBerry	HTC	LG	Nokia	Samsung	Sony	Son.Eric.		Other brands
Before switching	Apple	72.46	2.91	0.97	0.87	3.47	15.79	1.94	0.72	0.87	100
	BlackBerry	37.16	16.28	1.38	3.44	9.4	25.46	2.98	1.61	2.29	100
	HTC	25.25	4.04	8.59	2.02	9.6	40.91	5.56	2.02	2.02	100
	LG	17.79	5.53	3.95	4.74	13.83	42.29	3.56	1.98	6.32	100
	Nokia	20.12	4.36	2.18	3.37	22.79	35.08	3.07	1.59	7.43	100
	Samsung	22.73	3.66	1.38	4.02	10.76	46.76	4.02	1.25	5.4	100
	Sony	27.66	2.13	1.06	1.06	10.64	27.66	26.6	1.06	2.13	100
	Sony-Ericsson	19.14	5.12	1.89	4.58	12.94	35.85	9.16	7.55	3.77	100
	Other brands	20.2	6.62	1.36	5.26	13.92	34.63	4.07	1.87	12.05	100
	Total	36.43	4.7	1.69	3.09	10.83	33.19	3.85	1.6	4.62	100

Table 3: Operating system before and after switching handset (observations of individuals)

		OS after switching						Total
		Android	Blackberry	Windows	iOS	Other	Feature phone	
OS before	Android	736	63	94	432	25	218	1568
	Blackberry	101	71	20	162	10	72	436
	Windows	50	8	33	63	5	17	176
	iOS	296	57	41	1418	19	126	1957
	Other	124	18	30	109	18	84	383
	Feature phone	787	119	122	419	105	1074	2626
	Total	2094	336	340	2603	182	1591	7146

Table 4: Brand before and after switching handset (observations of individuals)

		After switching									
		Apple	BBerry	HTC	LG	Nokia	Samsung	Sony	Son. Eric.	Other brands	Total
Before switching	Apple	1418	57	19	17	68	309	38	14	17	1957
	BlackBerry	162	71	6	15	41	111	13	7	10	436
	HTC	50	8	17	4	19	81	11	4	4	198
	LG	45	14	10	12	35	107	9	5	16	253
	Nokia	203	44	22	34	230	354	31	16	75	1009
	Samsung	509	82	31	90	241	1047	90	28	121	2239
	Sony	26	2	1	1	10	26	25	1	2	94
	Sony-Ericsson	71	19	7	17	48	133	34	28	14	371
	Other brands	119	39	8	31	82	204	24	11	71	589
	Total	2603	336	121	221	774	2372	275	114	330	7146

Table 5: Average prices of handsets and tariffs, and share of smartphones/iPhone per quarter between Q1 2012 and Q4 2014

Quarter	Handset price	Tariff price	Smartphone (%)	iPhone (%)
Q1 2012	300.73	14.16	0.67	0.11
Q2 2012	334.34	17.17	0.55	0.26
Q3 2012	373.86	17.58	0.69	0.30
Q4 2012	419.73	17.40	0.76	0.36
Q1 2013	384.79	17.51	0.71	0.30
Q2 2013	364.25	16.70	0.69	0.26
Q3 2013	330.50	15.37	0.69	0.27
Q4 2013	357.17	15.99	0.77	0.35
Q1 2014	352.28	16.44	0.78	0.36
Q2 2014	343.72	16.32	0.79	0.35
Q3 2014	369.03	17.40	0.84	0.43
Q4 2014	408.13	18.31	0.91	0.52
Total	368.15	16.87	0.78	0.36

Table 6: Tariff and handset characteristics

Variable	Mean	Std. Dev.	Min.	Max.	N
Unlimited calls (0/1)	0.78	0.42	0	1	7146
Data allowance (GB)	1.65	1.4	0	5	7146
Quad. with DSL fixed line (0/1)	0.03	0.17	0	1	7146
Height (mm)	117.97	13.55	67	172	7146
Width (mm)	59.69	7.25	26	85.90	7146
Thickness (mm)	10.94	3.09	6.7	40	7146
Screen size (inch)	3.5	1	1	10.1	7146
Battery life: Talk time (hrs)	8.87	3.61	2.8	24	7146
Battery life: Stand by (hrs)	413.52	176.26	150	920	7137
Camera quality (mpixels)	5.38	3.59	0	41	7146

Table 7: Switching per individual

Switchings	Freq.	Percent	Cum.
1	3,637	72.99	72.99
2	902	18.1	91.09
3	267	5.36	96.45
4	98	1.97	98.41
5	32	0.64	99.06
6	24	0.48	99.54
7	8	0.16	99.7
8	2	0.04	99.74
9	5	0.1	99.84
10	2	0.04	99.88
11	2	0.04	99.92
12	3	0.06	99.98
13	1	0.02	100
Total	4,983	100	

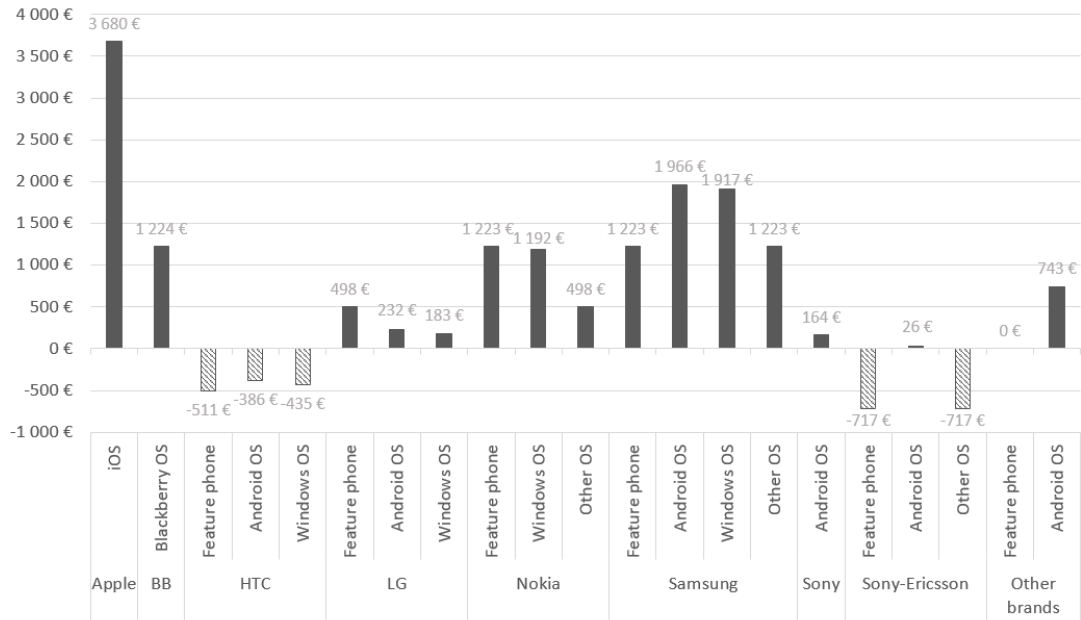
Table 8: Estimation results

	(1)		(2)		(3)	
	Clogit		Clogit		Mixlogit	
Main						
<i>Tariff characteristics</i>						
Tariff price	-0.132***	(0.02)	-0.132***	(0.02)	-0.132***	(0.02)
Unlimited calls	0.993***	(0.13)	0.993***	(0.13)	0.993***	(0.13)
Data allowance in GB	0.563***	(0.09)	0.563***	(0.09)	0.563***	(0.09)
Quad. with DSL fixed line	1.851***	(0.50)	1.851***	(0.50)	1.851***	(0.50)
<i>Handset characteristics</i>						
Handset price	-0.001***	(0.00)	-0.001***	(0.00)	-0.001***	(0.00)
Apple	4.067***	(0.11)	3.637***	(0.13)	3.680***	(0.14)
BlackBerry	1.694***	(0.11)	1.459***	(0.14)	1.224***	(0.19)
HTC	-0.473***	(0.11)	-0.472***	(0.11)	-1.129***	(0.29)
LG	0.165	(0.09)	0.165	(0.09)	-0.511*	(0.24)
Nokia	0.912***	(0.07)	0.923***	(0.07)	0.498***	(0.12)
Samsung	1.209***	(0.06)	1.227***	(0.06)	1.223***	(0.07)
Sony	0.191*	(0.09)	0.194*	(0.09)	-0.579*	(0.23)
Sony Ericsson	0.127	(0.11)	0.127	(0.11)	-0.717*	(0.33)
Other brands	0.000	(.)	0.000	(.)		
Battery life: Talk time	0.007	(0.00)	0.007	(0.00)	0.007	(0.00)
Screen size	-0.031	(0.04)	-0.031	(0.04)	-0.033	(0.04)
Height	0.008***	(0.00)	0.008***	(0.00)	0.008***	(0.00)
Weight	-0.003***	(0.00)	-0.003***	(0.00)	-0.003***	(0.00)
Thickness	-0.027**	(0.01)	-0.028**	(0.01)	-0.029**	(0.01)
Camera quality in mpixels	-0.009	(0.01)	-0.009	(0.01)	-0.009	(0.01)
Android Os	0.892***	(0.09)	0.784***	(0.11)	0.743***	(0.11)
Windows Os	0.923***	(0.10)	0.754***	(0.13)	0.694***	(0.15)
<i>Switching costs</i>						
Switching from feature phone to smartphone	-0.273**	(0.10)	-0.116	(0.14)	-0.140	(0.15)
Switching from smartphone to feature phone	0.021	(0.09)	-0.339	(0.18)	-0.377*	(0.19)
Switching cost for changing o.s.	-1.212***	(0.04)	-1.097***	(0.13)	-0.966***	(0.14)
Switching cost for changing brand	-0.513***	(0.05)	-0.457***	(0.05)	-0.287***	(0.06)
Switching cost for changing tariff	-5.098***	(0.07)	-5.098***	(0.07)	-5.098***	(0.07)
Switching from Android to iOS			0.435**	(0.15)	0.400*	(0.16)
Switching from Android to Blackberry OS			0.186	(0.20)	0.184	(0.21)
Switching from Android to other os			-0.389	(0.28)	-0.406	(0.28)
Switching from Android to Windows OS			0.325	(0.19)	0.331	(0.20)
Switching from iOS to Android			-0.621***	(0.15)	-0.742***	(0.16)
Switching from iOS to Blackberry OS			-0.340	(0.20)	-0.414	(0.21)
Switching from iOS to other os			-1.122***	(0.30)	-1.183***	(0.30)
Switching from iOS to Windows OS			-0.969***	(0.22)	-1.031***	(0.23)
Switching from Blackberry OS to Android			-0.376*	(0.19)	-0.338	(0.20)
Switching from Blackberry OS to iOS			0.421*	(0.18)	0.392*	(0.19)
Switching from Blackberry OS to other			-0.642	(0.38)	-0.622	(0.38)
Switching from Blackberry OS to Windows OS			-0.330	(0.28)	-0.285	(0.30)
Switching from Windows OS to Android			-0.125	(0.24)	0.003	(0.27)
Switching from Windows OS to iOS			0.309	(0.24)	0.394	(0.26)
Switching from Windows OS to Blackberry OS			0.002	(0.41)	0.151	(0.44)
Switching from Windows OS to other			-0.117	(0.51)	-0.108	(0.51)
SD						
Apple					-0.185	(0.27)
BlackBerry					0.750***	(0.18)
HTC					1.192***	(0.25)
LG					-1.265***	(0.22)
Nokia					1.172***	(0.14)
Samsung					0.576***	(0.12)
Sony					1.400***	(0.21)
Sony Ericsson					1.393***	(0.28)
Android Os					0.554***	(0.14)
Windows Os					0.282	(0.27)
Observations	6169592		6169592		6169592	
Log Likelihood	-30062.6		-29996.5		29909.5	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 5: Estimated willingness to pay for brands and operating systems



The estimates are relative to the base which are other smaller brands and operating systems. The negative values indicates that the base brands and operating systems are valued more.

Figure 6: Estimated switching costs between operating systems (in terms of WTP)

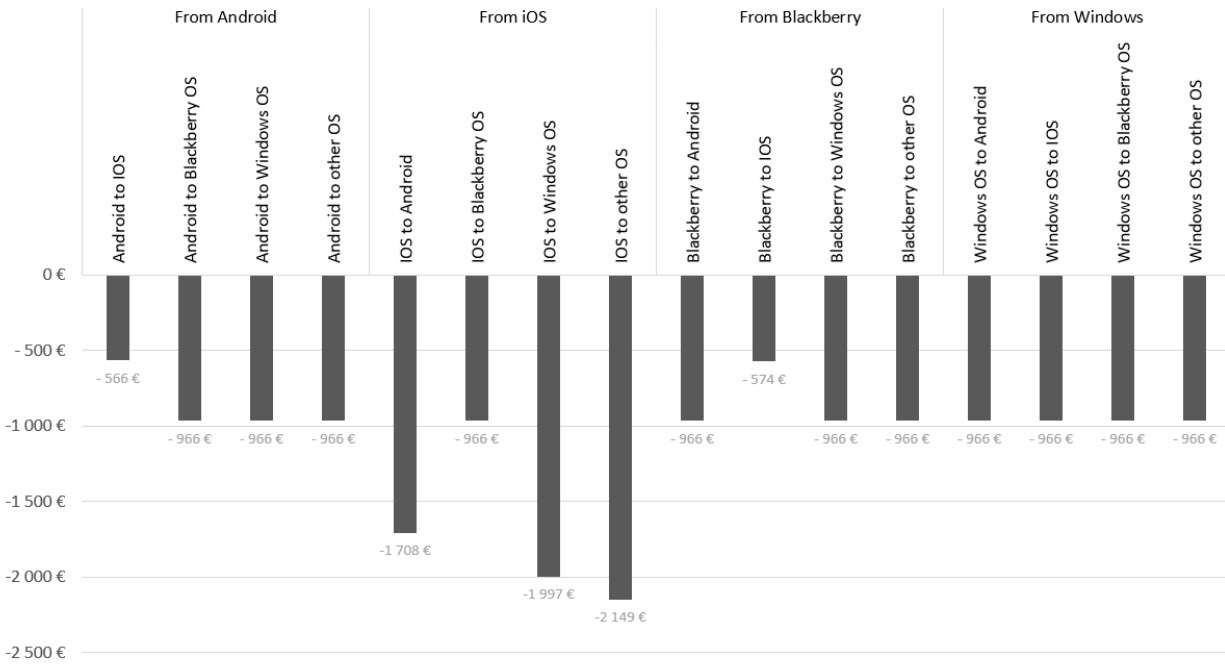


Figure 7: Simulation results for iOS in December 2014

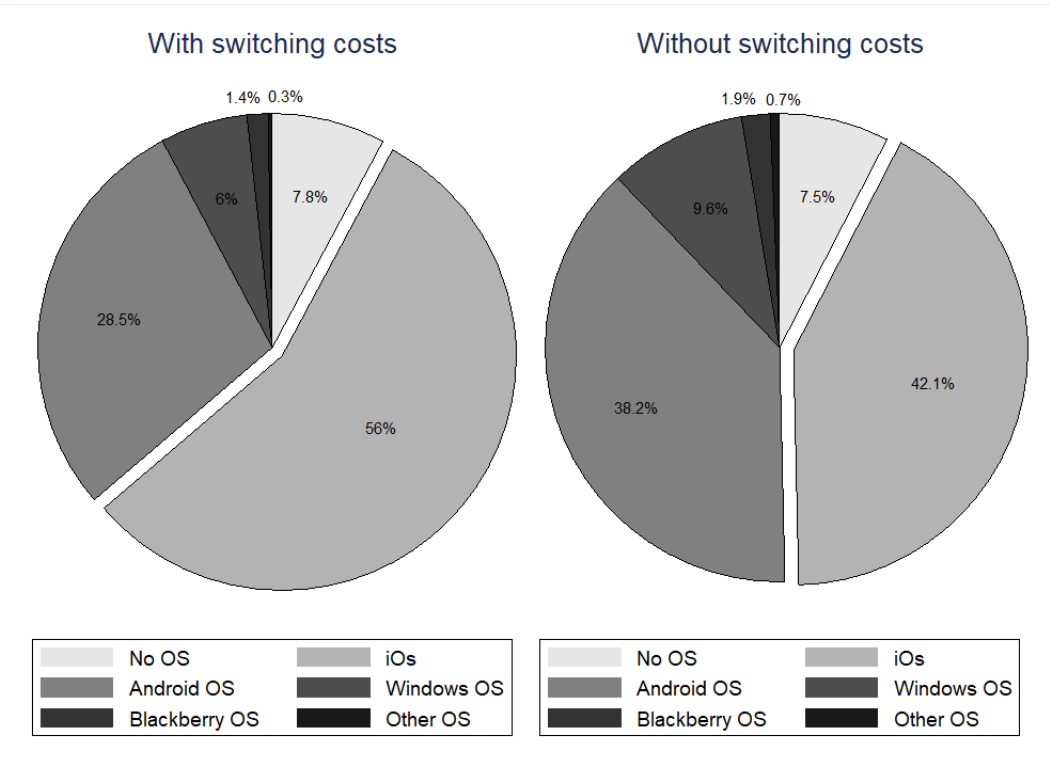


Figure 8: Simulation results for iOS and Android between March 2012 and December 2014

