An ex-post evaluation of mobile annual best tariff notifications and end-of-contract notifications

An ex-post evaluation of the impact of the introduction of ABTNs and ECNs on re-contracting and switching for mobile services

Report

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1. Overview

Background

We believe that consumers should get a fair deal on their communications services by being able to make informed choices, shop around and switch easily. For these reasons we introduced the requirement for communications providers (CPs) to send notifications to customers to inform them of their contractual status as well as the best deals available to them.

Our assessment

Using data provided by CPs from 2020, we assess the impact of our end-of-contract notification and annual best tariff notification interventions on customer engagement with the mobile market using the following measures:

The rate at which customers re-contract with their existing CP; and
The rate at which customers switch to other CPs.

In addition, we seek to identify whether there are any customer characteristics that are associated with heterogeneity in the policy impact for the mobile market.

Key findings

We find that annual best tariff notifications (ABTNs) have a positive effect on re-contracting and switching.
We find that the impact of end-of-contract notifications (ECNs) was small and generally mixed for re-contracting, and slightly negative for switching overall, although the impact varies by CP.
We find evidence that there is some heterogeneity in the impact of ABTNs on customer engagement when we consider contract type and customer age.

2. Background and approach

Introduction of policy, rationale and background

2.1 We believe customers should get a fair deal for their communications services. We want consumers to be able to make informed choices, shop around with confidence and switch easily. In May 2019, we made the decision ("the Reforms") to introduce a new requirement on communications providers (CPs) to send annual best tariff notifications (ABTNs) and end-of-contract notifications (ECNs) to their broadband, mobile, home phone and pay-TV customers.[1]

2.2 The Reforms meant that CPs must tell their customers about their best deals when their contracts are coming to an end, via ECNs. Customers who remain out of contract must be sent best tariff information by their CP at least annually via ABTNs. The aim of this policy was to inform customers, whose contracts came to an end, about their options and to encourage them to engage with the market, potentially finding better deals with their existing or other CPs. The new rules came into effect in February 2020 as part of several policies introduced to increase customer engagement.

2.3 As part of our 2019 decision, we committed to monitor and evaluate the implementation of ABTNs and ECNs to ensure they were delivering the desired outcomes for consumers.

2.4 In November 2021, we published a review of the impacts of ECNs and pricing commitments by broadband and mobile CPs, suggesting engagement among mobile customers had increased slightly between 2019 and 2020.[2]

2.5 In May 2022, we built on the findings set out in our November 2021 review by conducting an ex-post evaluation of broadband ECNs using econometric techniques, focusing on the effect of ECNs on engagement only. The May 2022 report found re-contracting had increased because of ECNs, although the size of the effect varied by CP.[3]

2.6 This report aims to build on findings set out in the November 2021 review and the May 2022 report. We focus on the impact of ABTNs and ECNs on engagement in the mobile market. We use econometric techniques to assess the direct effects of ABTNs and ECNs on customers' re-contracting and switching rates, as well as the extent to which impacts vary across customers.

[1] Ofcom, May 2019. Helping consumers get better deals - Statement on end-of-contract notifications and annual best tariff information, section 6.
https://www.ofcom.org.uk/__data/assets/pdf_file/0018/148140/statement-helping-consumers-get-better-deals.pdf

[2] Ofcom, November 2021. Helping customers get better deals - A review of the impact of end-of-contract notifications and pricing commitments by broadband and mobile providers.
https://www.ofcom.org.uk/__data/assets/pdf_file/0025/228742/helping-customers-get-better-deals-2021.pdf

[3] Ofcom, May 2022. End-of-contract notifications - An ex-post evaluation of the impact of the introduction of ECNs on re-contracting and pricing for broadband services,
https://www.ofcom.org.uk/__data/assets/pdf_file/0025/237247/ex-post-evaluation-ecn.pdf

Previous analysis on the mobile market

Key findings from the November 2021 review of the 2019 Statement

- The proportion of bundled customers who engaged in the three months prior to, or three months after, their contract ended, increased by 6 percentage points from September 2019 to September 2020.
- Except for EE, each individual CP had an increase in customer engagement in this period.
- the total percent of SIM-only customers who engaged in the market increased over the year, although SIM-only customers were generally significantly less engaged than bundled customers.
- All CPs saw an increase in engagement of their SIM-only customers from September 2019 to September 2020 with the exception of Vodafone.
- In both 2019 and 2020, most mobile customer engagement occurred during the period from 40 days before to 30 days after their contract was due to end. However, in 2020, there was an even higher proportion of customers who engaged within this period.
- Engagement among vulnerable customers increased significantly from 45% in July 2019

2.7 Against this background and in order to build on our previous analysis, we have sought to use this ex-post evaluation to:

a. Explore the impact of ABTNs on customer engagement.

b. Investigate how much of the increasing engagement in the mobile market is attributable to ECNs rather than other factors.

c. Understand how the impact of notifications varies by contract type.

d. In the absence of reliable customer vulnerability indicators, understand how the customer engagement impacts of notifications vary by customer age.[4]

2.8 We have not sought to revisit the evaluation of how CPs have chosen to implement ABTNs and ECNs which was comprehensively covered in our 2021 Review.

[4] We did not have adequate data on customer vulnerability to perform the analysis for all CPs at the contract level. Providers use customer age as one of the main attributes to classify customer vulnerability. For these reasons we include customer age as a variable in the heterogeneity analysis.

Analytical approach

Our analytical approach to assessing the impact of policy implementation

2.9 In this publication we focus on empirically establishing a causal link between ABTNs and ECNs and the observed customer engagement with the mobile market. We consider customer contract histories from six of the largest CPs and their sub-brands for the period in which ABTNs and ECNs were introduced and investigate whether they affected customer engagement. While we cover nine sub-brands in this publication, variables were missing in some cases. For this reason, some analyses are limited to a set of sub-brands.

2.10 The data covers a period of three years from 2019 to 2022. The ABTN analysis focuses on data from March 2020 to January 2022, as ABTNs are sent out on a rolling basis. The ECN analysis specifically focuses on contract data from February 2020 to May 2020, as this covers the period surrounding the introduction of ECNs. Our analysis focuses on customer engagement by looking at re-contracting and switching by customers in the mobile market. We implement distinct econometric techniques to empirically estimate the impact of ABTNs and ECNs on customer engagement.

2.11 In addition to identifying an overall causal link between the introduction of these policies and customer engagement, the analysis is also concerned with how the effect varies across customers on different contract types as this was a relevant factor identified in Ofcom's November 2021 review. Customer vulnerability was also highlighted in the November 2021 review, but we do not have access to a reliable indicator of vulnerability in the data. Instead, we have investigate the effect of customer age on the impact of the ABTN and ECN on customer engagement.

2.12 It is important to note that the introduction of these policies and the period over which we are measuring impacts coincides with the introduction of national covid lockdowns in the UK on 26 March 2020, and these measures continued throughout much of 2020 and into 2021. It's likely that the lockdown alone will have had its own impact on customer behaviour making it challenging to isolate the effect of the introduction of ABTN and ECN policies from the impact of the lockdown. Furthermore, this may also influence our findings by making it uncertain whether the policy introduction would have the same effect had lockdowns not come into force at a similar time.

2.13 The data and our assumptions are discussed in more detail in the annex.

Our re-contracting and switching definitions

2.14 Re-contracting is defined as a mobile customer renewing their contract with the same CP up to 40 days before and 30 days after the end of the customer's minimum contract period. We identify switching events as users not renewing their contract with the same CP up to 40 days before and 30 days after the end of the customer's minimum contract period. We recognise customers can re-contract and switch at any time. However, if these actions are taken significantly before or after the end of the minimum contract period, this is unlikely to be linked to ABTNs and ECNs and thus does not reveal the impact of the policies on customer engagement.

3. Impact of ABTNs and ECNs

Impact of ABTNs on customer engagement

Our empirical approach

3.1 To estimate the impact of ABTNs on customer engagement, we rely on the quasi-random assignment of ABTN timing. The ABTN policy requires that communications providers must send ABTNs at least once in every 12-month period to customers who are out of contract. They can choose at what point during the year they send the notification and whether they send one or multiple notifications during the year. For some of the CPs who provided suitable data, we observe that the timing of the ABTNs varied among customers whose contracts expired on the same date.

3.2 To determine the impact on customer engagement, we compare the difference in the rate of switching/re-contracting between customers with the same contract end-date who received their first ABTN in a given period, with those who had not received one yet. This approach allows us to control for time trends, both in absolute time and in the relative time since expiry of the contract.[5] We implement the estimation via linear regressions with month/contract end-date specific fixed effects (see A1 for details). To ensure the robustness of our results, we also control for three contract characteristics in our analysis: tariff data, length of contract and price of airtime.

3.3 We consider whether different sub-groups of customers responded differently to the Reforms. We performed the analysis separately for customers with different contract types and age profiles for each CP. We also use a causal machine learning method to check the presence of differences in responses by customer sub-groups.[6]

Customer engagement before and after receiving an ABTN

We find evidence of the positive impact of ABTNs from our econometric analysis

3.4 We find statistically significant increases in re-contracting rates in response to receiving ABTNs. The results show that ABTNs had the biggest positive effect among Three's customers. In the case of O2 and Tesco we observe small effects, with ABTNs increasing re-contracting rates by 1-2 percentage points. Sky Mobile's results show a statistically insignificant positive effect. Overall, our analysis suggests that ABTNs had a small positive impact on re-contract rates.[7]

3.5 ABTNs are drafted and sent by the CPs and provide information on their own tariffs. Therefore, it is unclear what their effect on switching rates might be. The results from the econometric analysis show that the impact of ABTNs on switching rates is also positive, but more muted than for re-contracting rates. Again, Three customers are the most responsive

[5] We implement our identification strategy via Ordinary Least Squares (OLS) and Logit regressions with month/contract end-date specific fixed effects (see Annex for details).
[6] For more detail please see the Annex.
[7] These findings are robust to the inclusion of controls for contract characteristics, as well as using a Logit regression specification (see Table A1 in the annex).

to receiving an ABTN, while the impact on Tesco and Sky Mobile customers is close to zero.[8] Overall, our analysis shows that ABTNs had a small impact on customers' switching rates.

Table 2A Econometric analysis of ABTNs: fixed effects OLS regressions. Values represent percentage-point changes in re-contracting rates.

	Re-contracting	Switching
O2	2.02%***	0.87%***
TESCO mobile	1.28%***	0.16%***
Three	4.75%***	1.47%***
sky	0.61%	-0.77%

3.6 We find evidence that sub-groups of customers were impacted differently. Table 2B reports the results of our analysis by contract type. We find that customers with SIM-only plans are most likely to re-contract in response to receiving their first ABTN across all CPs, with customers on split contracts being the least responsive. In terms of switching rates, we find considerably larger effects of ABTNs on customers with handset & airtime plans for O2 and Three, while we observe limited heterogeneity in response across Tesco customers.[9] Overall, we find that there is some heterogeneity in the effect of ABTNs across customers with different contract types which is a consistent patterns across CPs.

3.7 We also analysed the effect of age of the customer on the effect for each operator.[10] While the effect of ABTNs on re-contracting displays heterogeneity across age groups for Tesco customers, we find that older customers respond more strongly for O2 and Sky Mobile. The second and fourth age quartiles (37-48 and 57-87 years old, respectively) appear to drive most of the overall positive effect of ABTNs on re-contracting rates for Three customers.[11] [12]

[8] As we discuss in the Annex, these results are also robust to using a Logit specification and the inclusion of controls.
[9] These results are robust to using a Logit specification and the inclusion of controls (see Annex for these additional results).
[10] Note that not all customers in the data have a reported age. Therefore, this analysis is based on a subset of customer compared to the other analysis presented in this report.
[11] These results are robust to using a Logit specification and the inclusion of covariates (see A1.11 for these additional results).
[12] These results can be found in Table A3 in the annex.

3.8 We also used a machine learning algorithm to formally test for the presence of heterogeneity in effects for the CPs for which the largest number of observations are available (O2 and Tesco).[13] The test confirms that there is heterogeneity present in the responses, however our analysis does not allow us to identify clear trends with respect to any further customer's characteristics across CPs.

3.9 For switching rates, we find a more limited degree of heterogeneity in effects across age groups.[14] The machine learning algorithm again confirms the robustness of our estimates but is only able to detect statistically significant heterogeneity in effect for O2 customers. While our analysis reveals the presence of some heterogeneity in the effect of ABTNs on re-contracting rates, we are not able to detect clear patterns with respect to the age of customers when considering switching.

Table 2B: Econometric analysis of ABTNs by contract type: fixed effects OLS regressions.

	Re-contracting	Switching
O2		
SIM-only	3.12%***	0.38%***
Handset & airtime	1.63%*	4.56%***
Split contract	0.03%	1.50%***
TESCO mobile		
SIM-only	2.70%***	0.30%***
Handset & airtime	2.34%***	-0.01%
Split contract	0.23%***	0.04%*
3		
Sim-only	5.00%***	1.11%***
Handset & airtime	3.89%***	2.04%***

[13] For details of the analysis please see the Annex.
[14] See Annex for the detail.

Impact of ECNs on customer engagement

Our empirical approach

3.10 To empirically assess the impact of ECNs on customer engagement, we used regression discontinuity design (RDD) to compare customer behaviour shortly before and after the introduction of ECNs. RDD assumes that customers right before and after the introduction date of the ECNs (the cut-off date) are similar and therefore comparable. This allows for a comparison between re-contracting or switching rates of customers who received an ECN (treated) against those who did not (untreated), by looking at the rates shortly before and after the policy introduction.

3.11 We also explore whether different sub-groups of customers responded differently to ECNs as the policy may have impacted customers differently. In order to assess whether there is variation in the impact of the ECN introduction according to customer demographics, we performed this analysis separately for customers with different contract types and age profiles within each CP, in addition to using a causal machine learning method.

3.12 In this assessment, establishing the appropriate cut-off date is important as this identifies the date after which all customers coming to the end of their minimum contract received an ECN. Ofcom's guidance states that ECNs should be sent between 10 and 40 days before the end of the minimum contract period.[15] [16] To ensure the correct threshold was used, we asked CPs to provide the date they began sending ECNs to their customers.

Graphical analysis does demonstrate a clear impact form ECNs

3.13 As a first step, we plotted the engagement rate for each brand in the data to check whether there is a change in re-contracting and switching rates around the time of the introduction of ECNs. Figure 3A plots customer re-contracting over time for each CP. The vertical axis shows the rate of re-contracting and each point in the plots represents the re-contracting rate for a certain window of days.[17] The horizontal axis shows the number of days between a customer's minimum contract period and the date after which all customers received an ECN. We use the start date each provider sent out ECNs as "day 0", which is shown by the dotted vertical line in the graphs. Negative dates before "day 0" refer to the number of days before the introduction of the Reform. Therefore, if the ECNs had an impact on market engagement, we would likely see a jump in re-contracting at the cut-off.

3.14 While we see that there is an increase in re-contracting for some providers, such as Plusnet, overall, the graphical analysis indicates that the introduction of ECNs had a very small impact on re-contracting and that the impact varies by provider.

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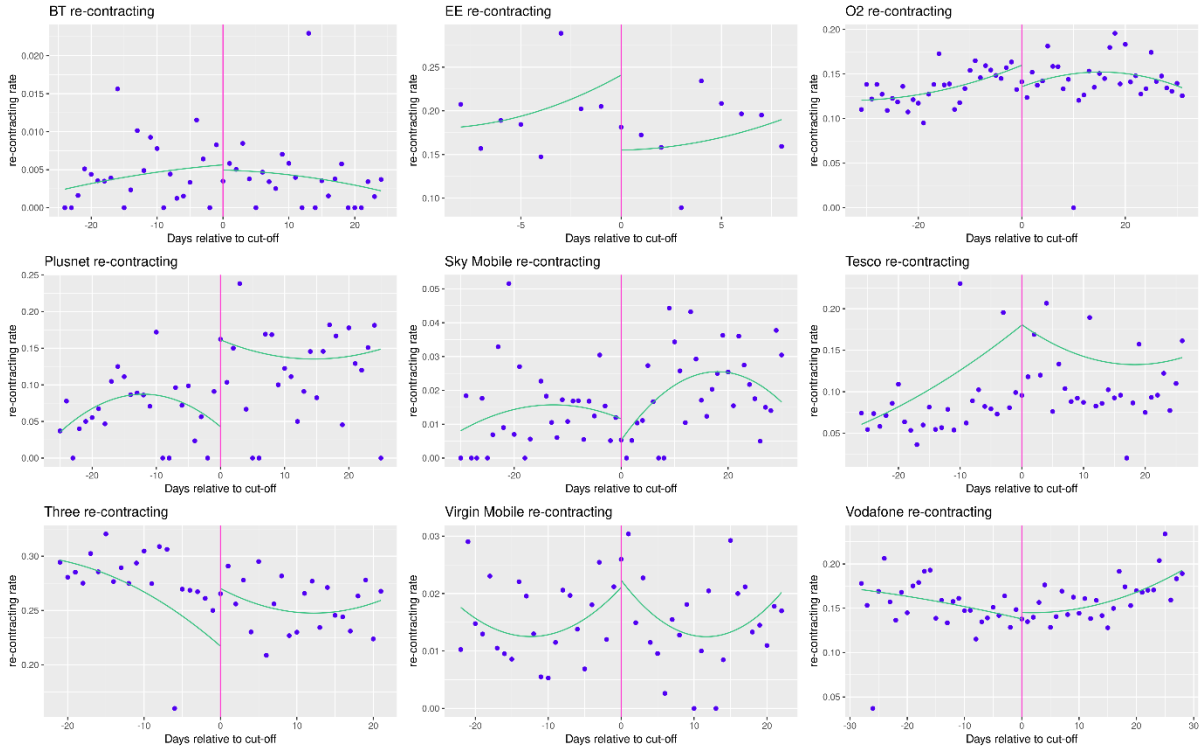
[15] Ofcom, December 2021. General Conditions of Entitlement – Unofficial Consolidated Version, C1.21-C1.29 https://www.ofcom.org.uk/__data/assets/pdf_file/0023/256343/unofficial-consolidated-general-conditions-May-2023.pdf

[16] Ofcom, December 2023. Ofcom's Guidance under General Condition C1 - contract requirements, 1.115-1.164, https://www.ofcom.org.uk/__data/assets/pdf_file/0028/229852/ofcom-guidance-general-condition-c1-contract-requirements.pdf

[17] We use a data-driven approach to deciding the number of days included in the analysis for each provider. The red line shows a quadratic function that best fits the data on either side of the cut-off. Further details on the approach are expanded on in the annex.

Figure 3A: Regression discontinuity plots for customer re-contracting over time for each CP.

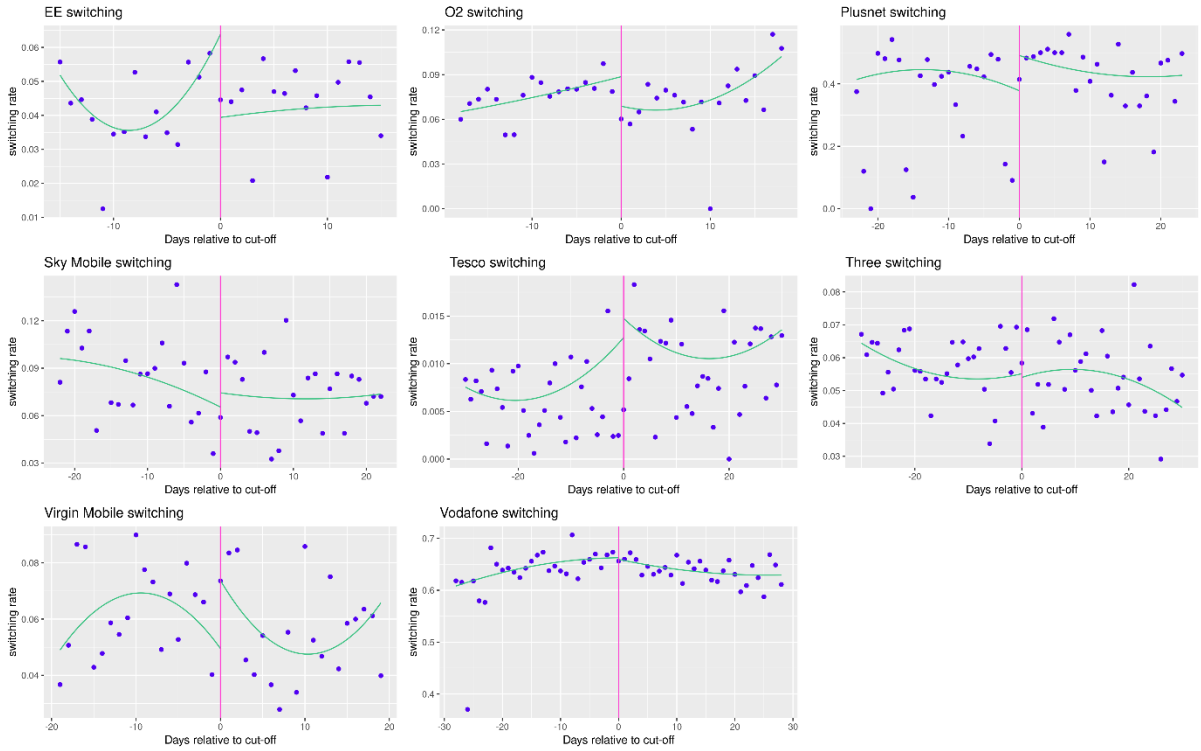


3.15 For switching, we carried out a similar graphical analysis. Figure 3B plots customer switching over time for each CP. The vertical axis shows the rate of switching and each point in the plots represents the switching rate for a certain window of days.[18]

3.16 The figure shows that for most CPs there is a negligible change in switching rates at the introduction of ECNs. For some providers, such as Virgin Mobile, we see a positive jump in the fitted trend line at the cut-off, whereas, for EE we see a decrease.

[18] The window of days for each point varies by provider depending on the number of days included in the analysis for each provider. All graphs plot 60 points.

Figure 3B Regression discontinuity plots for customer switching over time for each CP.



We find mixed results for the impact of ECNs from our econometric analysis

3.17 Our econometric estimates of the effects of ECNs on re-contracting are reported in table 3B. Our results suggest that ECNs had a positive effect on re-contracting for Plusnet and Three, and a negative impact on EE and O2.[19] These results are consistent with the graphical analysis, showing that on average impacts were small.

3.18 Overall, the results are mixed across providers and, thus, the actual impact of ECNs on the mobile market in terms of re-contracting is difficult to establish with certainty.

3.19 We also estimated the impact of ECNs on switching, which we present in the second column of table 3B. The results are similar to the re-contracting analysis on ECNs in that they show a mixed picture of the effect of ECNs on switching. Compared to re-contracting, the magnitude of impacts is lower, around 2 percentage point increase in switching rates for the statistically significant estimates. Overall, the switching results align with our expectation as ECNs provide information on the current CP of a customer but not on switching options.

[19] There may be a number of reasons why a decrease may be present. For instance, information that would have been contained in the ECN may have already been sent to customers that particularly incentivised engagement before the cut-off.

Table 3B: Re-contracting and switching treatment effect estimates for ECNs across CPs. Results are presented as percentage point changes in re-contracting/switching.

	Re-contracting	Switching
BT	-0.1%	n/a[20]
EE	-8.6%***	-2.4%***
O2	-2.4%**	-2.0%**
plusnet	11.9%***	11.3%
sky	-0.6%	0.9%
TESCO mobile	0.1%	0.2%
3	5.3%***	-0.1%
Virgin media	0.1%	2.4%***
vodafone	0.7%	-0.3%

3.20 While the results suggest a mixed picture on average, they may mask the impact on different customer groups. For example, in our previous work on evaluating ECNs we show that they

[20] We were unable to perform this analysis for BT switching as no switching events were identified during the study period for this provider.

had a differential impact by contract type.[21] Therefore, in the next section we analyse whether customer sub-groups responded differently to ECNs.

We do not find evidence that sub-groups of customers were impacted differently

3.21 To understand how the impact of the introduction of ECNs contrasts between customers on different contract types we have performed the RDD analysis separately for different customer ages, as well as contract types: SIM-only, Handset & airtime, and Split contract. In addition, we also performed a causal machine learning analysis to assess effect heterogeneity between these groups.

3.22 Overall, results are largely statistically insignificant, and we find little evidence of heterogeneity in customer engagement in response to ECNs. Results suggest that the type of contract had slight impact on engagement, which is consistent with previous findings in our report in November 2022. However, as with the average impact of the ECNs we find that the impact of ECN was mixed. A detailed analysis is outlined in annex A2.

[21] Ofcom, May 2022. End-of-contract notifications - An ex-post evaluation of the impact of the introduction of ECNs on re-contracting and pricing for broadband services, https://www.ofcom.org.uk/__data/assets/pdf_file/0025/237247/ex-post-evaluation-ecn.pdf

4. Conclusions

4.1 The Reforms were introduced to improve customer information and engagement in the mobile market. They aimed to make customers aware of the upcoming end to their contract and also to encourage them to consider different options available to them at the end of their minimum contract period. In this report, we have performed econometric analysis to study the impact of the introduction of ABTNs and ECNs for mobile customers. Our analysis builds on the 2022 broadband ex-post evaluation and indicates that these policies had a lower impact on engagement in the mobile market than the fixed broadband market.

4.2 Our findings on ABTNs suggest that sending reminders to out of contract customers had a positive effect on their engagement. The lower effect on switching is explained by messages sent containing information on re-contracting options only, but not on switching options. When we assessed heterogeneity of the impact, including considering different contract types and customer age groups, we found the presence of differences in responses to ABTNs across customers.

4.3 For ECNs, we find that they had limited impact on re-contracting and switching engagement. While re-contracting rates increased for a small number of CPs, for other CPs we found that the effect was either statistically insignificant or negative. Our findings on switching are similar in that we do not find a clear picture of an increase in engagement in response to ECNs. One possible explanation for this limited impact is that customers were already more engaged in the mobile markets than in fixed broadband markets when the policy was initially introduced.

4.4 Overall, in our previous work on the impact of the Reforms (November 2021) and an econometric evaluation of the impact on fixed broadband (May 2022) we found that customers increased engagement in response to the introduction of ECNs. The analysis outlined in this paper adds to this work with evidence on the positive impact of ABTNs on consumer behaviour in the mobile market. In the case of the mobile market, we did not however find a consistent impact from the introduction of ECNs. Therefore, taking all the evidence in the round, we conclude that the introduction of the Reforms across the telecommunications market had a positive impact on customer engagement.

A1 ABTN analysis methodology and detailed results

Overview of data

A1.1 This analysis uses contract data supplied by communications providers (CPs) from March 2020, a month after the introduction of the ABTN policy, to January 2022. Of those CPs who supplied us with suitable data, we analyse those for which we observe that the timing of the ABTNs varied among customers whose contracts expired on the same date.

A1.2 We define a re-contracting event as occurring when a customer's unique customer ID is linked to two or more contracts. Specifically, a re-contacting event occurs when a customer's next contract start date falls within -40 days and +30 days of the current tariff's end date. We use a different definition from the analysis done to study the impact of ECNs to adapt it for the ABTN data. In the ECN analysis, it was only relevant to include re-contracting events. ABTNs are received at least annually by those customers who are outside their minimum contract period and can be received at any given month each year. Given these conditions, we are interested in registering all re-contracting events, not only those which happened within a month of the end of the minimum contract period. We also disregard data from Plusnet as the provider was closing down its mobile services and migrating users to other providers in the period under consideration. As the ECN analysis is focussed on a time period covering early 2020, it is unaffected by this change.

A1.3 Within the data we cannot identify the CP the customer switched to due to differences in the recording of customer IDs between CPs. Therefore, we define a switching event where a customer's contract ends and they leave the CP, such that there is no more contract data available for this customer. One shortcoming of this assumption is that we do not know for sure that the customer chooses to contract with a different CP.

Methodology and assumptions

Fixed effects regression model

A1.4 The structure of the data led us to implement a methodology based on the quasi-random assignment of ABTN timing using OLS and logit regressions. We exploit the seemingly random variation in the month when comparable customers received their first ABTN. Comparable customers are defined as those who share their contract end date. Our identifying assumption states that comparable customers have a probability of receiving their first ABTN in a given month bounded away from 0 and 1. For this identifying assumption to work, the probability of receiving an ABTN in a given month must not depend on contract or customer characteristics. If the treatment timing was influenced by characteristics which also influence the probability of switching or re-contracting, our estimates would be biased. In order to test this assumption, we regressed the probability of receiving an ABTN on a given month on contract characteristics. We found no evidence of this connection. The detailed results are included in the following section.

A1.5 The first step in our analysis was to create repeated cross section samples for each provider. We first matched customers by their contract end date to find comparable customers. Within these groups of comparable customers, we restricted the sample to observations belonging to contract end-date/month pairs for which at least 10 customers had received an ABTN. We then had a sample where for each combination of contract end date and date of the first ABTN we had both treatment units: those who had received the ABTN, and control units, those who had not received an ABTN. The ABTN instantaneous treatment effect is estimated using the comparable groups we built. Our baseline regression specification is

$$Y_{it} = \delta D_{it} + \alpha_{j(i),t} + \varepsilon_{it},$$

A1.6 where Y_{it} is our binary outcome variables, taking the value 1 when customer i switches/ re-contracts at time t, D_{it} is a binary treatment indicator for whether customer i receives the first ABTN at time t, and $\alpha_{j(i),t}$ is a fixed effect for customer i's contract end date j at time t.

A1.7 To check the robustness of our results and improve the precision of our estimates, we also add covariates X_i to the specification to control for contract characteristics: contract length, airtime price and data included in the tariff. The regression specification with controls is

$$Y_{it} = \delta D_{it} + \alpha_{j(i),t} + \beta X_i + \varepsilon_{it}.$$

A1.8 We report both OLS and Logit estimates. For the Logit estimates we report the average marginal effect of receiving ABTNs on the probability of re-contracting/switching.

Causal machine learning

A1.9 We also employ a causal machine learning algorithm developed in Chernozhukov et al. (2023)[22] to formally test for the presence of effect heterogeneity based on observed customer characteristics (other than age and contract-type). In the evaluation of ABTNs, the algorithm also provides alternative average treatment effect estimates based on a more a flexible functional form in the controls than linear OLS and Logit specifications.[23]

A1.10 The algorithm uses a randomly selected subset of observations (training set) to compute treatment effect estimate (conditional on covariates) using random forests, which are then used to form subgroups of the population based on the magnitude of the effects. The algorithm then estimates average effects for each of these subgroups using the remaining observations (evaluation set). Differences in average effects among these subgroups are then used to test the presence of heterogeneity in effects.

[22] Chernozhukov V., Demirer M., Duflo E. and I. Fernández-Val (2023) "Fisher-Schultz Lecture: Generic Machine Learning Inference on Heterogenous Treatment Effects in Randomized Experiments, with an Application to Immunization in India". https://arxiv.org/abs/1712.04802.

[23] In the case of ECNs, the baseline RDD procedure does not involve nor require the inclusion of covariates, and it is therefore immune from concerns of robustness with respect to functional form assumptions.

Detailed results

A1.11 Tables A1-A2 present additional estimation results with inclusion of controls and using Logit specification. Tables A3-A6 present analogous additional results for the heterogeneity analysis by age and contract type.

Table A1: Econometric analysis of ABTNs – Fixed effects regression: Re-contracting. Values represent percentage-point increases in re-contracting rates.

	OLS with controls	Logit	Logit with controls
O2	2.02%***	1.36%***	0.67%***
TESCO mobile	1.28%***	1.21%***	0.82%***
3	4.64%***	3.79%***	3.83%***
sky	0.60%	0.69%***	0.69%***

Table A2: Econometric analysis of ABTNs – Fixed effects regression: Switching. Values represent percentage-point increases in re-contracting rates.

	OLS with controls	Logit	Logit with controls
O2	0.86%***	0.72%***	0.62%***
TESCO mobile	0.16%***	0.14%***	0.12%***
3	1.47%***	1.09%***	1.10%***
sky	-0.75%	-0.58%	-0.58%

Table A3: Econometric analysis of ABTNs by age quartile: Re-contracting

	OLS with controls	Logit	Logit with controls
O2			
16 – 33 years	1.69%***	1.23%***	0.51%***
33 – 44 years	1.68%***	1.16%***	0.50%***
44 – 55 years	1.81%***	1.20%***	0.55%***
55+ years	2.49%***	1.59%***	1.06%***
TESCO mobile			
17 – 44 years	1.26%***	1.13%***	0.79%***
44 – 54 years	1.30%***	1.15%***	0.79%***
54 – 65 years	1.13%***	1.07%***	0.72%***
65+ years	1.44%***	1.39%***	0.97%***
3			
20 – 37 years	-0.40%	-0.23%	-0.27%
37 – 48 years	4.62%**	2.96%*	3.15%**
48 – 57 years	0.72%	1.10%	1.30%
57+ years	2.83%*	2.47%	2.33%
sky			
17 – 38 years	0.49%	0.60%***	0.62%***
38 – 48 years	-0.97%	-1.18%	-1.27%
48 – 59 years	0.80%	0.78%***	0.75%***
59+ years	3.61%**	2.43%	2.49%

Table A4: Econometric analysis of ABTNs by age quartile: Switching

	OLS with controls	Logit	Logit with controls
O2			
16 – 33 years	1.17%***	0.90%***	0.71%***
33 – 44 years	0.99%***	0.81%***	0.66%***
44 – 55 years	0.88%***	0.74%***	0.60%***
55+ years	0.72%***	0.58 %***	0.44%***
TESCO mobile			
17 – 44 years	0.24%***	0.20%***	0.19%***
44 – 54 years	0.22%***	0.22%***	0.17%***
54 – 65 years	0.19%***	0.17%***	0.14%**
65+ years	0.12%**	0.11%*	0.09%*
3			
20 - 37 years	2.76%*	2.76%*	2.43%*
37 – 48 years	1.97%	1.97%	1.61%
48 – 57 years	2.80%*	2.80%*	2.57%*
57+ years	-0.02%	-0.02%	0.13%
sky			
17 – 38 years	-5.64%**	-4.30%	-5.90%
38 – 48 years	2.45%	-0.68%	0.53%
48 – 59 years	-0.65%	-0.76%	1.50%
59+ years	-1.34%	-1.35%	-1.11%

Table A5: Econometric analysis of ABTNs by contract type: Re-contracting.

	OLS with controls	Logit	Logit with controls
O2	2.02%***	1.36%***	0.66%***
SIM-only	3.13%***	1.70%***	1.70%***
Handset & airtime	1.65%*	1.04%***	1.21%*
Split contract	0.00%	0.02%	0.02%
TESCO mobile	1.29%***	1.21%***	0.82%***
SIM-only	2.70%***	1.45%***	1.45%***
Handset & airtime	2.34%***	1.28%***	1.29%***
Split contract	0.23%***	0.20%***	0.20%***
3	4.64%***	3.79%***	3.82%***
Sim-only	5.00%***	4.51%***	4.53%***
Handset & airtime	3.89%***	2.11%***	2.14%***

Table A6: Econometric analysis of ABTNs by contract type: Switching.

	OLS with controls	Logit	Logit with controls
O2	0.86%***	0.72%***	0.61%***
SIM-only	0.39%***	0.30%***	0.33%***
Handset & airtime	4.50%***	2.41%**	2.29%**
Split contract	1.50%***	1.17%***	1.08%***
TESCO mobile	0.16%***	1.21%***	0.00%***
SIM-only	0.30%***	0.00%***	0.00%***
Handset & airtime	-0.01%	0.00%	0.00%*
Split contract	0.03%*	0.00%*	-0.00%
3	1.48%***	1.09%***	1.10%***
Sim-only	1.07%***	0.92%***	0.88%**
Handset & airtime	2.04%***	1.21%***	1.21%***

Table A7: Heterogeneity analysis for ABTNs based on Chernozhukov et al. (2023)

	Re-contracting		Switching	
	Average Treatment Effect	Heterogeneity Test (p-value)	Average Treatment Effect	Heterogeneity Test (p-value)
O2	1.76%***	0.000***	0.80%***	0.000***
TESCO mobile	1.26%***	0.000***	0.19 %***	0.297
3	1.91%	0.413	1.95%	0.637
sky	0.47%	0.037*	-1.42%	0.263

Potential caveats to analysis

A1.12 The validity of our estimated impact of ABTNs rests on the hypothesis that, conditional on the customer's contract end-date, it is random whether a customer receives an ABTN or not in any given month. To gauge the credibility of this assumption, we run Logit regressions of a binary indicator for whether a customer receives the first ABTN on the three main contract characteristics and a fixed effect for the contract end-date/period pair. These regressions show that contract characteristics have no predictive power on the timing of the ABTN across all operators (see Table A8).

Table A8: Predictive power of contract characteristics on ABTN sending: Logit fixed effects regressions.

	Contract duration	Data tariff	Airtime price
O2	0.00%*	0.00%	0.00%
TESCO mobile	0.00%	0.00%	0.00%
3	-0.00%***	0.00%	0.00%
sky	-	0.00%	0.00%

A1.13 Another important limitation to our analysis on the impact of ABTNs is that we only measure the change in re-contracting rates in the same month when the ABTN is sent ("instantaneous effect"). As such, our estimates might be underestimating the effect of ABTNs if customers tend to respond with a large delay to the receipt of the notification.

A2 ECN methodology and detailed results

Overview of data

A2.1 For the Regression Discontinuity Design (RDD), we use data we gathered in 2022 from the six CPs. This analysis specifically focuses on contract data from December 2019 to May 2020, as this covers the period surrounding the introduction of ECNs. The data contains CPs and their brands in the UK, including BT, EE, Plusnet, O2, Virgin Mobile, Sky Mobile, Tesco, Three and Vodafone.

A2.2 A re-contracting event is defined where a contract ends and the associated customer begins another contract up to 40 days before and 30 days after the initial contract end date.

A2.3 We define a switching event where a customer's contract ends and they leave the CP, such that there is no more contract data available for this customer. Specifically, the definition includes customers who ended their mobile contract up to 40 days before and 30 days after the end of a customer's minimum contract period. One shortcoming of this assumption is that we do not know whether the customer contracted with a different CP, moved to pay-as-you-go (PAYG) SIM or has left the communications market.

Methodology and assumptions

A2.4 The introduction of the ECN policy created a discontinuity, or a cut-off, in which customers nearing the end of their minimum contract period are treated differently with respect to receiving an ECN. Generally, in these types of evaluations it is difficult to establish a counterfactual for treated customers, i.e. how would they have behaved if they have not gotten the ECN. However, for this evaluation we can leverage the introduction of the policy. Customers can be split into two groups either side of the cut-off. The untreated group is defined as those customers whose minimum contract period ended before the cut-off. Whereas the treated group are those customers whose minimum contract period ended after the cut-off, from which point all said customers received ECNs. By taking advantage of this discontinuity, we were able to compare re-contracting and switching either side of the cut-off in our econometric approach, and thus the effect of ECNs.

A2.5 For our econometric approach, we used RDD to compare customers' behaviour shortly before and after the introduction of ECNs. The intuition behind this approach is that customers just before and after the introduction of the policy are comparable thus having a quasi-randomized trial. This model was used in Ofcom's ex-post evaluation of the impact of ECNs on re-contracting and pricing for broadband services. This report identifies other papers that have successfully used RDD.

A2.6 For our analyses we contacted communication providers to report on when they began sending out ECNs, which varies by CP.

Regression discontinuity design (RDD)

Re-contracting and switching analysis

A2.7 For our market engagement analysis (re-contracting and switching), a sharp RDD is used as after the cut-off date every customer nearing the end of their minimum contract period receives an ECN.

A2.8 We use a quadratic model in our specification to improve the fit of the model. The specification used to estimate the market engagement effect is as follows:

$$y_i = \alpha + \beta_1 x_i + \beta_2 {x_i}^2 + \beta_3 x_i d_i + \beta_4 x_i^2 d_i + \delta d_i + \varepsilon_i$$

A2.9 Where y_i is the outcome variable (re-contracting/switching), x_i is the running variable centred at the cut-off (days between contract end date and cut-off date), β represents the coefficients to be estimated and δ represents the treatment effect. d_i is a binary treatment variable which denotes whether an individual received an ECN. In our model, an individual received treatment if their contract end date is after the cut-off date, such that:

$$d_i = \begin{cases} 1 \; if \; x_i \geq 0 \\ 0 \; if \; x_i < 0 \end{cases}$$

Bandwidth Selection

A2.10 Choosing an appropriate bandwidth is important within RDD as the empirical results may be sensitive to the bandwidth. For instance, a smaller bandwidth will reduce the misspecification error ("smoothing bias") of the local polynomial approximation but will simultaneously tend to increase the variance of the estimated coefficients (as fewer observations will be available for estimation)[24]. An ideal bandwidth is one that minimises this trade-off between bias and variance.

A2.11 Our approach is to minimise the mean squared error (MSE) of the local polynomial RD point estimator. The MSE of an estimator is the sum of its squared bias and its variance. This approach effectively chooses a bandwidth to optimize a bias-variance trade-off.[25]

Validity Tests

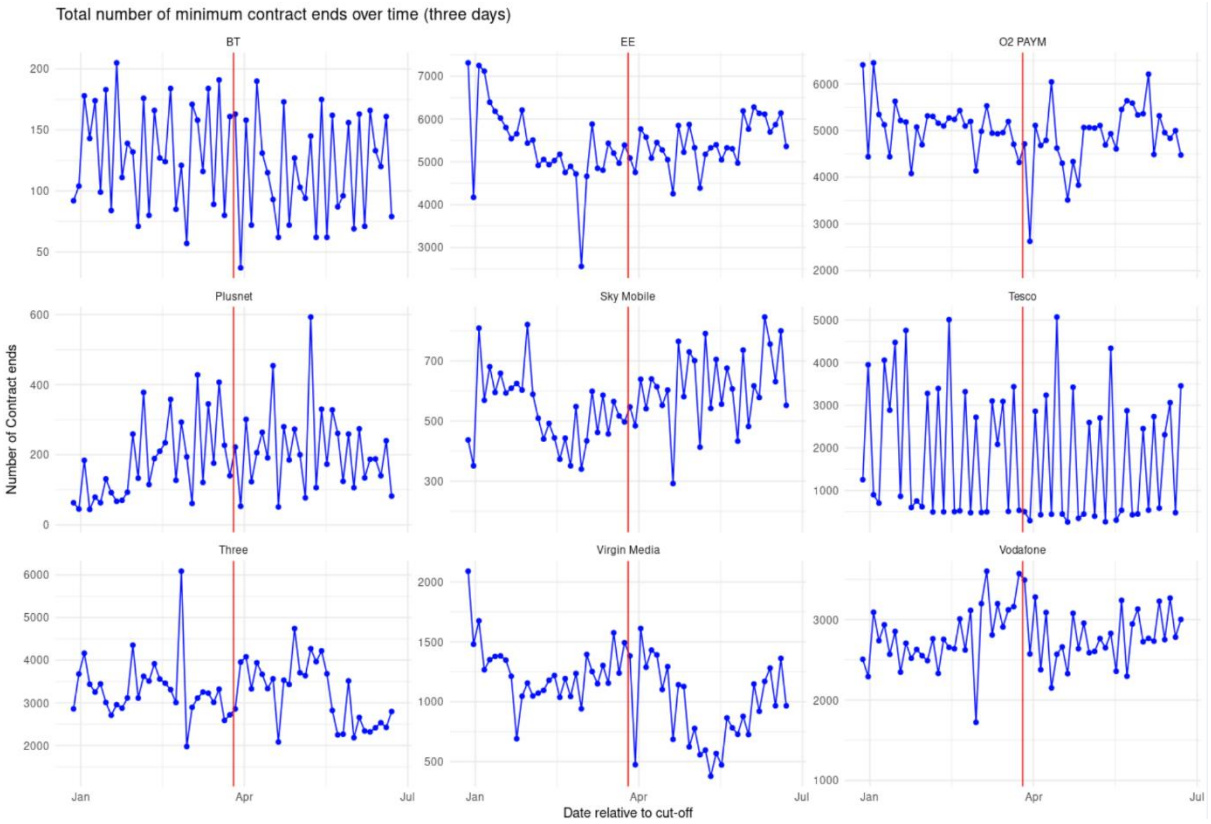
A2.12 For RDD to be an effective econometric method, individuals cannot influence whether they receive the treatment, such that there can be no self-selection into receiving the treatment. Otherwise, this would create differences in the observable and unobservable characteristics of the treated and untreated group, which would lead to an unreliable comparison and violate the continuity assumption of RDD. As most customers have a minimum contract length of 1 to 2 years, it is unlikely that customers were able to influence whether they received an ECN.

A2.13 We visualise the continuity assumption to test the validity of the RDD. Figure A1A shows the number of minimum contracts ends over time by CP split into three-day windows. To ensure the continuity assumptions holds the number of minimum contracts ends should be similar before and after the cut off, and that there is no jump at the cut-off. Figure A1A shows

[24] A Practical Introduction to Regression Discontinuity Designs: Foundations, Matias D. Cattaneo, Nicolas Idrobo, Rocıo Titiunik, November 22, 2019.
[25] A Practical Introduction to Regression Discontinuity Designs: Foundations, Matias D. Cattaneo, Nicolas Idrobo, Rocıo Titiunik, November 22, 2019.

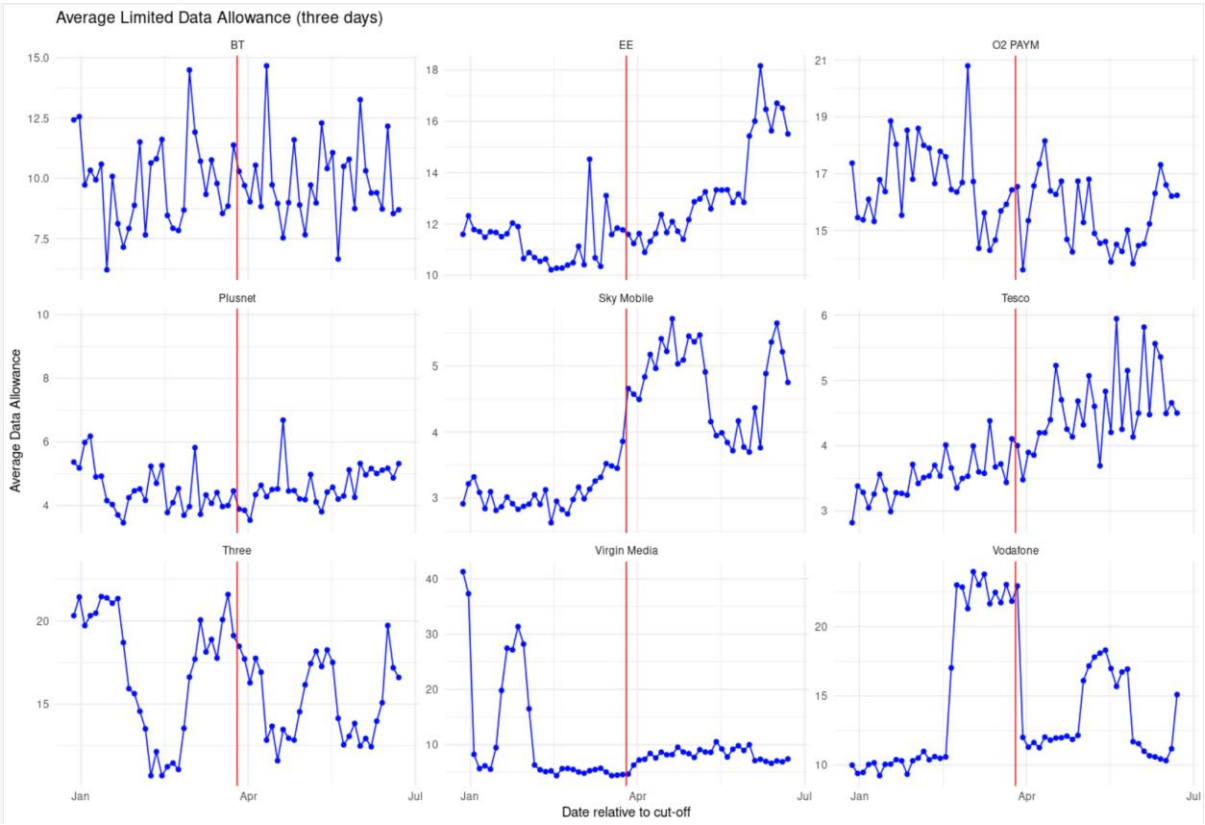
generally similar numbers before and after the cut-off although there is some volatility on both sides of the cut-off. However, for Virgin Mobile and O2 there seems to be an apparent jump. Although, these are more likely random jumps as it is unlikely that consumers might have selected their contract end date based on the introduction of the ECN, particularly as these contracts would have been set up before the introduction of ECNs. Overall, this suggests the continuity assumption holds, such that customers did not self-select into treatment group.

Figure A1A: Total number of minimum contract period ends by CP over time



A2.14 Similarly, differences in contract characteristics can be used as a continuity check to test the validity of the continuity assumption. Figure A1B shows the average limited data allowance for contracts +/- 90 days around the cut-off. Average limited data allowance should remain unaffected by the introduction of ECNs and vary little over time. Apart from Sky Mobile and Vodafone, there is not a jump in average limited data allowance for most providers around the cut-off. Although as seen in the previous figure, there is some volatility and any jumps are likely random. This supports the continuity assumption.

Figure A1B: Average limited data allowance over time



Causal machine learning

A2.15 We also employ a causal machine learning algorithm developed in Chernozhukov et al. (2023)[26] to formally test for the presence of effect heterogeneity based on observed customer characteristics (other than age and contract-type). In the evaluation of ECNs, the algorithm also provides alternative average treatment effect estimates based on a more a flexible functional form in the controls than the RDD specifications.[27]

A2.16 The algorithm uses a randomly selected subset of observations (training set) to compute treatment effect estimate (conditional on covariates) using random forests, which are then used to form subgroups of the population based on the magnitude of the effects. The algorithm then estimates average effects for each of these subgroups using the remaining observations (evaluation set). Differences in average effects among these subgroups are then used to test the presence of heterogeneity in effects. We take the same thresholds and bandwidth from the RDD approach for the causal machine learning analysis of ECNs.

[26] Chernozhukov V., Demirer M., Duflo E. and I. Fernández-Val (2023) "Fisher-Schultz Lecture: Generic Machine Learning Inference on Heterogenous Treatment Effects in Randomized Experiments, with an Application to Immunization in India". https://arxiv.org/abs/1712.04802

[27] In the case of ECNs, the baseline RDD procedure does not involve nor require the inclusion of covariates, and it is therefore immune from concerns of robustness with respect to functional form assumptions.

Detailed results

A2.17 Results of the contract type analysis for re-contracting are presented in table A9. Overall, the results for re-contracting are largely statistically insignificant with statistically significant estimates for EE Handset & airtime, and Plusnet SIM-only. This suggests that there is limited evidence for some providers that customers on different contract types responded differently to receiving an ECN.

A2.18 Heterogeneity analysis estimates can be found in Table A9. The results are largely statistically insignificant, with statistically significant results for Plusnet Handset & airtime contracts and Tesco Handset & airtime. As for re-contracting we find that there is limited evidence that customers on different contract types respond differently to receiving an ECN.

A2.19 We also analysed whether the impact of ECNs varies by customer age (Table A10). For this we calculate the quartiles for customer age for each provider and split customers into four groups based on these quartiles.[28] We then apply the RDD approach to each group of customers. The results suggest that, for both re-contracting and switching, we do not observe significant differences in effect across different age sub-groups.

A2.20 Above we explored differences in the effect for age and contract type, however other factors may contribute to heterogeneous responses to ECNs, such as other contract characteristics (e.g. contract length). We therefore used an approach that leverages Machine Learning to study heterogenous impacts of ECN on customer groups (Chernozhukov et al., 2023). For the heterogeneity analysis, we find no statistically significant results for the heterogeneity test (Table A11), indicating that we do not find evidence of heterogeneity in the re-contracting or switching based on contract characteristics.

[28] Due to data constraints, we did not have customer age data available for all providers. Furthermore, we have had to exclude observations from this analysis where the customer age was missing.

Table A9: Econometric analysis by Contract Type. Results are presented as percentage point changes with the introduction of ECNs[29]

	Re-contracting	Switching
BT		
SIM-only	0%	-
Handset & airtime	-0.6%	-
EE		
SIM-only	-0.9%	-0.2%
Handset & airtime	-2.8%**	-0.2%
O2		
SIM-only	-0.5%	-0.5%
Handset & airtime	-0.9%	-4.5%*
plusnet		
Sim-only	13.5%***	6.2%
Handset & airtime	10.7%	-0.4%
TESCO mobile		
Sim-only	8.9%	0%
Handset & airtime	-4%***	2.9%*
Split contract	0.3%	0.4%

[29] We implement automatic bandwidth selection separately for the overall and each contract type estimation, which leads to different time frames being considered in the analysis. This explains why overall estimates are not contained within contract type-specific estimates for some CPs.

Table A9 continued:

	Re-contracting	Switching
		
SIM-only	2.5%	-0.5%
Handset & airtime	2.9%	-1.2%
		
SIM-only	0.3%	0.5%
Split contract	-0.1%	2%
		
SIM-only	-1.2%	-1.5%
Handset & airtime	2%	1.8%

Table A10: RDD effect estimates for ECNs by age quartile. Values represent percentage-point changes in re-contracting and switching rates.

	Re-contracting	Switching
	-5.3%***	-1.6%**
17 – 35 years	-7%***	0.2%
35 – 46 years	-6.4%**	-0.9%
46 – 57 years	-2.9%	-3.1%**
57+ years	-5.3%***	-1.6%

Table A10 continued:

	Re-contracting	Switching
O2	-0.40%	-3.8%***
17 – 35 years	-2.9%	-1%
35 – 48 years	-2.5%	-7%***
48 – 59 years	-2.2%	-5.9%***
59+ years	-1.6%	-0.9%
plusnet	12.8%***	10.9%
17 – 44 years	19.2%***	19%
44 – 54 years	9.8%	6.4%***
54 – 65 years	17%***	6.7%
65+ years	10.9%	-4.8%
TESCO mobile	-13.0%**	0.2%
17 – 44 years	3.6%	-1.1%
44 – 54 years	-1%	-0.2%
54 – 65 years	-20%*	1.9%
65+ years	10.6%	3.2%
3	3.4%	-0.7%
18 – 34 years	1.9%	-8.7%
34 – 43 years	-0.7%	3.6%

	Re-contracting	Switching
43 – 53 years	5.6%	0.9%
53+ years	0.4%	1.2%

Table A11: Heterogeneity analysis based on Chernozhukov et al. (2023): Re-contracting and switching in response to ECNs

	Re-contracting		Switching	
	Average Treatment Effect	Heterogeneity Test (p-value)	Average Treatment Effect	Heterogeneity Test (p-value)
EE	-1.5%*	0.54	0.67%	0.01*
O2	-0.9%	0.149	-3.5%	0.099
plusnet	8%***	0.292	-8.1%***	0.522
TESCO mobile	0.8%	0.126	-0.6%	0.656
3	-2.3%	0.6	0.5%	0.797

Potential caveats to analysis

A2.21 It is important to highlight the possible effects of Covid-19 on our results. Covid-19 started to impact the UK at a very similar time to the introduction of ECNs, with the date of the first UK lockdown aligning closely with the date used for our cut-off. As a result, it is likely that the effects for re-contracting, switching and pricing is impacted somewhat by Covid-19.

A2.22 The content included within the notifications sent for ECNs and ABTNs to customers by the provider can vary by brand and may also be tailored to certain customers. As the notification identifies the best tariff available to each customer, the engagement outcome that most benefits the customer may vary. For example, it is possible that when receiving an ECN or ABTN a customer may already be on the cheapest tariff that meets their requirements. In

this instance the policy would not be expected to increase customer engagement via re-contracting or switching.