Institution: University of Oxford

Unit of Assessment: 10: Mathematical Sciences

Title of case study: *Billmonitor*: predicting the best mobile phone contract for businesses and individual users

Period when the underpinning research was undertaken: 2004 – 2013

Details of staff conducting the underpinning research from the submitting unit:

Names:	Roles:	Periods employed by submitting HEI:
Chris Holmes	Professor of Statistics	2004 – present
Nicolai Meinshausen	University Lecturer	2007 – 2013

Period when the claimed impact occurred: 1st January 2014 – 31st July 2020

Is this case study continued from a case study submitted in 2014? Y

1. Summary of the impact

Exploiting techniques that had been created for applications in finance and genetics, University of Oxford researchers Holmes and Meinshausen developed the algorithms underpinning the mobile phone package price comparison tool *Billmonitor*, which uses simulation-based inference and careful statistical modelling to analyse users' mobile phone bill data. Around 2,000,000 available packages are searched to identify the best mobile phone deal for each user's particular pattern of usage.

In 2009, *Billmonitor* became the first mobile phone contract price comparison tool to be accredited by Ofcom, and it has been regularly re-accredited, most recently in 2019. In the period 2014-2019, *Billmonitor* identified a total of GBP31,000,000 worth of savings for more than 104,000 private mobile phone users. Starting in 2015, the same *Billmonitor* technology and expertise has been applied to help UK businesses and public sector bodies, and by the end of 2019 nearly 700 business accounts with nearly 25,000 connections had been analysed, identifying total savings of over GBP6,000,000.

2. Underpinning research

Finding a model to predict future mobile phone usage based on a user's past phone bills was itself a research problem in applied statistics. For mobile phone users, the greatest costs are incurred in the months when they exceed their monthly allowances. This could be because of a longer term change in behaviour (a regime shift), or an occasional 'one-off' (large deviation). To reliably forecast the expected cost of a tariff, a tool like *Billmonitor* must rest on a model that accurately identifies regime shifts and approximates the tails of the distribution that describes user behaviour. Oxford University researchers Chris Holmes and Nicolai Meinshausen were able to create such a model by combining insights they had gained through their research in two apparently unrelated fields, genetics and finance. This enabled them to create a bespoke bootstrap algorithm for the predictions which are at the heart of *Billmonitor's* computational analysis.

User behaviour can be viewed as a time series in which there is regime-switching. In such a system, more recent observations are a more reliable predictor of the future evolution than older ones, and so it is natural to restrict bootstrap samples to a time window. However, there is a trade-off: as the window becomes shorter, sample size is reduced and prediction uncertainty (variance) is increased; if the window is too long, the predictive distribution is not adapted to regime-switching, and bias is increased. Holmes and Meinshausen's approach to modelling user regime-switching was based on ideas from Holmes' work on Bayesian inference for regime-switching in threshold models for time-series variability [1].

At the time, Holmes was also working on segmental analysis of genetic sequence data. In particular, thinking of genetic sequences as having a 'time-series like structure', he was developing loss-functions that could be used for recovering regime-switching ('segmental classification' in genetics). One can think of traditional approaches, such as reporting the most probable state sequence, or the most probable set of marginal predictions, as particular choices of loss function that may be inappropriate for segmental analysis of sequence data. In [2], he proposed a new class of Markov loss functions, which penalise misclassification of both state occupancy and transitions. The sequence of minimum expected loss is enumerated using methods from dynamic programming.

[Text removed for publication]

3. References to the research

[1] Journal Article: Dellaportas, P., Denison, D., and Holmes, C. (2007) "Flexible threshold models for modelling interest rate volatility", *Econometric Reviews*. Special Issue on Bayesian Dynamic Econometrics, 26(2), 419-437. DOI: 10.1080/07474930701220600

[2] Journal Article: Yau, C. and Holmes, C. (2013), "A decision theoretic approach for segmental classification", *Annals of Applied Statistics,* 7(3), 1814-1835. DOI: 10.1214/13-AOAS657

Funding:
Modern statistical approaches to increment/decrement models: an investigation in Bayesian regression for multiple state Markov models, EPSRC GR/S80615/01, 2004-2006, GBP110,000. PI Prof C Holmes.

4. Details of the impact

Ofcom's Communications Market Report 2020 states that the retail mobile telecoms market in 2019 was worth GBP13,400,000,000 [A]. *Billmonitor's Business Mobile Report* [B], released in 2018, estimated a total overspend on UK mobile phone contracts of more than 50%, totalling billions of pounds per annum. A follow-up report on SMEs later in the year, *An Investigation into the B2B Mobile Provider 'Wild West'* [C], suggested that the cost difference between the cheapest and most expensive provider was 16.3% for an average SME, and that 38,000 SMEs could save over GBP10,000 per year.These reports received extensive coverage in the specialist business press (including in MoneyWeek, Computing, Business Matters,The Register, Total Telecom, Bdaily News, ITProPortal and CityAm) [D]. In 2019, *Billmonitor* estimated that, in a single year, the mobile phone networks overcharged UK businesses and consumers approximately GBP7,600,000,000 [E].

The impact claimed in this case study is economic. During the period from 2014 to 2019, *Billmonitor* analysed the mobile phone contracts of nearly 150,000 private customers and nearly 700 business accounts (with nearly 25,000 connections) identifying combined total savings of GBP37,000,000 [F]. The NHS and other health and public sector organisations account for around 40% of all business accounts analysed [F], so the main beneficiaries are individuals, businesses, public sector organisations, and the SME Optimor, for which *Billmonitor* is the sole product.

Pathways to Impact

The impact is achieved through the SME Optimor, which launched the *Billmonitor* price comparison website in 2009. The Managing Director of Optimor has confirmed [F] *"The research done by Professor Chris Holmes and Professor Nicolai Meinshausen of the University of Oxford was an essential component which has enabled us to build an accurate algorithm for predicting an individual's future mobile phone usage and we have used this to develop Billmonitor"*. The statistical methodologies in *Billmonitor* analyse the mobile phone bills of both

individual customers and customers with business accounts to predict their future usage. Price comparisons based on the predicted patterns of usage identify the best pricing plans available. This allows users to understand their pattern of usage and so make informed decisions and save money.

Once prototyping was completed by Meinshausen, using the statistical programming language R, the front-end user interface of *Billmonitor* was designed by engineers at Optimor, with Holmes and Meinshausen advising on the graphical displays of information. Holmes and Meinshausen were directors of Optimor (Holmes from April 2008 until January 2012 and Meinshausen from April 2008 until September 2011) and Holmes continues to act as a scientific adviser, for example overseeing the statistical model used in the report into overcharging of SMEs [C]. The notes in the company accounts (year ending 31 March 2020) [G] report that Optimor employed 9 staff members (Headcount: 9; FTEs: 9).

The financial model used by Optimor allows *Billmonitor* to provide completely unbiased comparisons: Optimor receives a small affiliate commission if users buy packages via links on the site, but the user will pay exactly the same price as if they had purchased direct from the provider.The links are non-biased; advice is given exclusively on the basis of identifying the plan which provides the best deal for the user's projected usage.

Having provided their price comparison service to private customers since 2009, in 2015 Optimor began to apply the *Billmonitor* technology and expertise to help those with UK business accounts to analyse their mobile phone contracts. The Managing Director of Optimor writes [F] *"Chris's and Nicolai's work has been instrumental in helping us to launch our business-to-business service, which commenced in 2015."* Since April 2016, **MoneySuperMarket.com** has offered *Billmonitor* services to corporate clients.

Impact on private customers

As confirmed by the Managing Director of Optimor [F] in March 2020, between January 2014 and December 2019, 149,847 private users have provided details of their mobile phone usage through the *Billmonitor* website [E]. Savings have been identified for around 70% of these users, with an average of GBP295.16 savings per account for a 24-month contract. The total savings identified during the period are approximately GBP31,000,000.

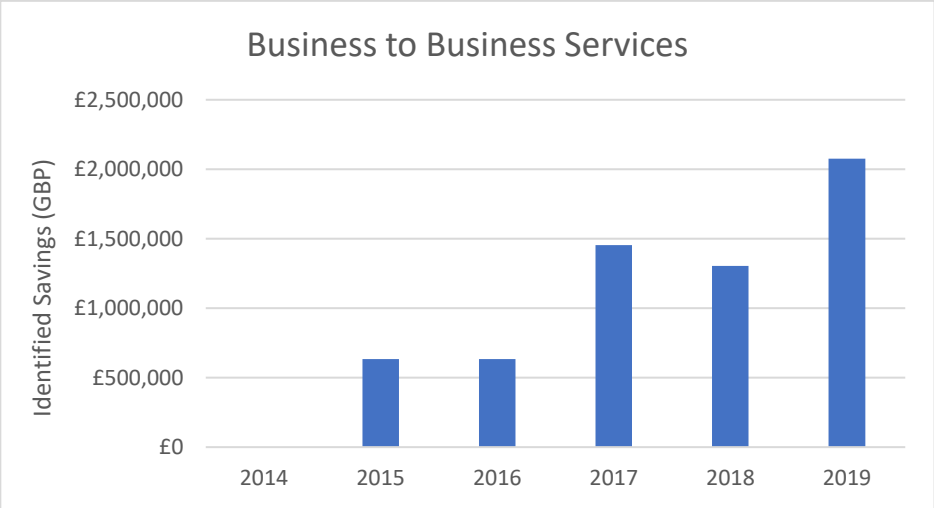
Satisfied customers have taken to Twitter [H]: *Thanks to @billmonitor I saved over £700* [GBP700] *per year this morning!* After a 2014 recommendation from Martin S Lewis of the Money Saving Expert (MSE) website, a user tweeted [H]: *Wow @MoneySavingExp wish you'd highlighted @billmonitor before! Look at the saving,* followed by a screenshot showing projected savings of GBP1359.61. A recommendation from MSE in 2017 led to so much interest that the website was overloaded [H]: *@MoneySavingExp@MartinSLewis has sent #billmonitor into a frenzy! #MSE.* Even those who do not change providers as a result of using the site can use the information from *Billmonitor* to negotiate with their existing providers [H]: *@MoneySavingExp I had to push a little, they came down in stages but we got there! £21 [GBP21] to £10.14 [GBP10.14] :-) Knew the deal I needed via #billmonitor.*

Impact on businesses

Once *Billmonitor* expanded to cover business accounts in 2015, the scale of overspend was even more startling: "*where consumers overpay by 66% for their required level of service, businesses overpay by 96%. Such huge savings…*[have been]… *found by so few.*" [B].

Since 2015, *Billmonitor* has analysed nearly 700 business accounts with nearly 25,000 connections, identifying savings of over GBP6,000,000. The **MoneySuperMarket.com** website [I] advises: "*The average saving over the contract duration for a small business*...[is]… *£3,360* [GBP3,360] *(based on an average savings per line of £336* [GBP336], *from savings calculations from over 10,000 lines under business contracts from companies that analysed*

their bills via Billmonitor for Business April 2016)". The year-on-year business savings, provided by the Managing Director of Optimor [F], are shown here:



Testimonials

Around 40% of the business accounts analysed have been for the health and public sectors [F].

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Billmonitor is also used by intermediaries to optimise their service to clients. On the *Billmonitor* website [L], the Founder and Director of independent mobile phone agent Oxford Street Connections Ltd. states "*Billmonitor saves me a lot of time. Its detailed analysis of Data, Voice, Roaming and International Calls by users allows me to gain a comprehensive understanding of a client['s] profile and their key issues. I can analyse and prioritise then plan recommendations to find one that meets my client['s] needs, offer[s] good savings and allows a meaningful handset fund.*"

Other testimonials on the *Billmonitor* website [L] include:

- *"AMS Aircraft saved 58% on out-of-allowance costs"*
- "*London-based Investment Management Firm saved £92,000* [GBP92,000]*"*
- "*Amius saved 37.5% through improved tariff and bundle selection"*
- "*City & Guilds realised instant cash flow savings of 30% with projected combined savings of 60%"*
- *"PLMR realised total savings of 65% over a new 24-month contract"*
- *"Fishawack Health realised combined cash savings of 23%"*

Ofcom accreditation

In 2009, *Billmonitor* was the first mobile phone contract price comparison tool to be accredited by Ofcom, and it has been regularly re-accredited at 18-month intervals ever since, most recently in November 2019 [M]. This required it to meet the terms of a rigorous independent audit, which tests whether the information provided is comprehensive, clear and easy to understand. The Director of Ofcom's Consumer and External Relations Group said [M]: *"Comparison websites like Billmonitor provide crucial information that helps consumers to choose the best products and deals for their needs. By ensuring this information is accurate, transparent and up to date, our accreditation scheme means consumers can navigate the market with confidence." Billmonito*r is one of only three Ofcom-accredited providers of advice for mobile phone users, saving consumers, public sector bodies, and businesses millions of pounds on their mobile phone costs.

5. Sources to corroborate the impact

[A] Ofcom's Communications Market Report, 2020.
[B] *Billmonitor* Business Mobile Report, 2018.
[C] *Billmonito*r An Invesigation into the B2B Mobile Provider 'Wild West' 2018.
[D] Business press coverage of *Billmonitor*'s 2018 reports [accessed 26 February 2021]: 1. 'How to cut your business phone costs', MoneyWeek, 14 December 2018; 2. 'OfCON? Regulator ignores UK SME 'Wild West' mobile provider market', Business Matters, 1 December 2018; 3. 'Stats model: UK small biz overpays for stealth mobile plans', The Register, 29 November 2018; 4. 'SMBs paying over the limit for phone charges', ITProPortal, 28 November 2018
[E] *Billmonitor* website [accessed 26 Oct 2020]: http://www.billmonitor.com/
[F] Letter from Managing Director of Optimor, parent company of *Billmonitor,* 15 Mar 2020.
[G] Optimor company accounts for year ending 31 March 2020 https://find-and-update.company-information.service.gov.uk/company/05391490/filing-history/MzI2MzUxNjI2OGFkaXF6a2N4/document?format=pdf&download=0
[H] Tweets from individual consumers confirming money saved through using *Billmonitor* and recommending the service.
[I] MoneySuperMarket.com website confirming use and endorsement of *Billmonitor* [accessed 29 Dec 2020] https://www.moneysupermarket.com/mobile-phones/business-mobiles/
[J] [Text removed for publication]
[K] [Text removed for publication]
[L] *Billmonitor* website case studies [accessed 12 Jan 2021] https://www.billmonitor.com/blog/?category=case_study
[M] Ofcom webpage confirming re-accreditation of *Billmonitor* on 15 Nov 2019 [accessed 26 Oct 2020]: https://www.ofcom.org.uk/about-ofcom/latest/features-and-news/billmonitor-reaccredited