Pass-through analysis for fixed-line telecommunications services

For the New Zealand Commerce Commission

24 May 2017

Public version

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The econometric analysis in this report was peer reviewed by Dr Adolf Stroombergen of Infometrics. This review included assessing whether the econometric models were fit-for-purpose, and replicating a random selection of results from the models used in this report.

Contents

1. Summary

1.1. Background

This report summarises analysis for the Commerce Commission of the extent to which regulated changes in wholesale recurring charges for services provided by Chorus on its copper network have been passed through by retailers to residential consumers of fixed-line voice and broadband services. The analysis focuses on the period from December 2011 to June 2016, i.e. after the market reforms that included structural separation of Telecom.

The scope of the analysis requested by the Commission is limited to estimation of rates of pass-through, and does not include analysis of the intensity of competition in fixed-line retail markets. It is not possible to reach conclusions about competition based on estimated rates of pass-through alone.

The analysis focuses on two key regulated prices for wholesale services that telecommunications retailers use to offer retail fixed-line voice and broadband services over Chorus's copper access network:

- The unbundled copper local loop (UCLL) price determines the basic access charge that applies to all copper lines regardless of the retail service that is provided, and it is paid by all retailers.

- The unbundled bitstream access (UBA) base price is the **additional** charge for a broadband bitstream service provided by Chorus over copper lines.

The price for a "full" bitstream service provided by Chorus is therefore the sum of the UCLL price and the UBA base price. Lines that have been unbundled (i.e. where the retailer provides the bitstream component of the service using their own infrastructure), or where voice-only service is provided by the retailer, attract only the UCLL price.

As at June 2016, there are around 1.06 million copper access lines where the bitstream service is provided by Chorus, attracting both the UCLL price and the UBA base price. 110,000 lines have been unbundled, and these lines attract the UCLL charge only, and a further 368,000 lines have voice-only service and only attract the UCLL charge.

The costs of UCLL and UBA are a significant part of the costs of providing fixed-line retail services. In the year ended June 2016, total recurring UCLL and UBA charges are estimated to be about $670 million, compared to total revenues from fixed-line residential customers of about $1.5 billion.

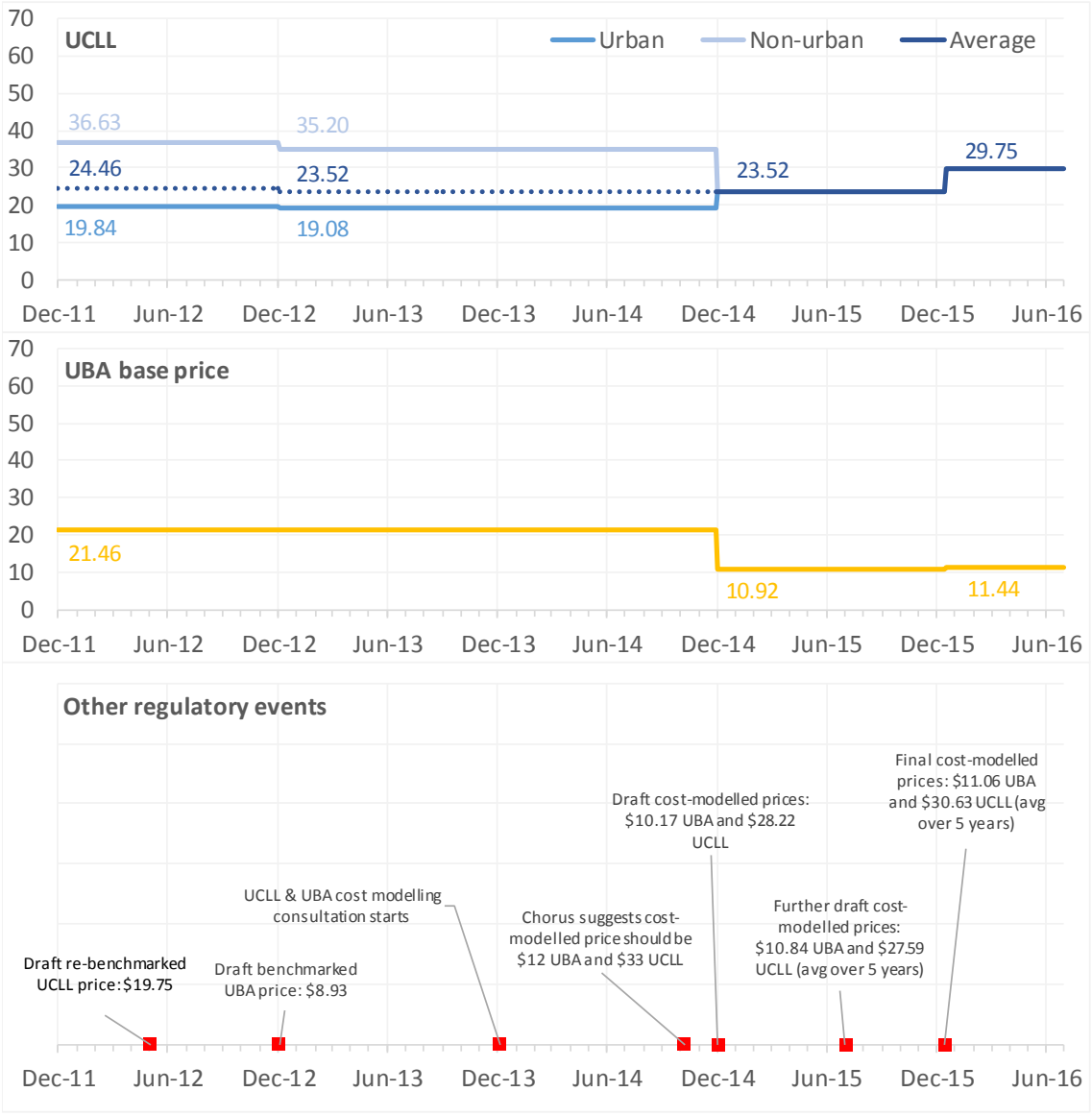
The history of these regulated prices is shown in Figure 1. Since December 2011, the wholesale UCLL and UBA base prices changed three times:

- In December 2012, a re-benchmarking exercise led to a small reduction in the UCLL price.

- In December 2014, the application of initial pricing principle (IPP) prices led to a relatively large reduction in the UBA base price by $10.54 per line per month. At the same time, UCLL prices were geographically averaged, effectively increasing the price for urban customers and reducing it for non-urban customers, with the overall average unchanged.

- In December 2015, application of final pricing principle (FPP) prices led to a relatively large increase in the UCLL price and a small increase in the UBA base price (with further increases scheduled for future years). This increased the "full" UBA price (applying to lines where Chorus provides the bitstream service) by $6.75 per line per month, offsetting much of the $10.54 reduction that occurred a year earlier. In comparison with the pre-IPP period, the post-FPP price for "full" UBA is lower by $3.79 per customer per month.

Figure 1 Timeline of UCLL and UBA price changes ($ per line per month).



Source: Schiff Consulting, using information provided by the Commerce Commission.

The bottom panel of Figure 1 shows other significant regulatory events that occurred during the same period. Importantly, the cost modelling work to determine the FPP prices was started in December 2013, i.e. before the application of the IPP prices, and draft cost modelled prices were published shortly after the IPP prices applied. These draft prices were then updated in the middle of 2015, before the FPP was finalised in December 2015.

In addition, changes introduced with the IPP resulted in increases in connection costs for copper customers. Information provided by the Commission suggests that these charges initially increased by an effective price of about $2.50 per customer per month, assuming the average connection charge per new customer is recovered by retailers over 24 months.

1.2. Methodology

Empirical analysis was undertaken to estimate the extent to which the regulated price changes shown in Figure 1 have been passed through to residential fixed-line consumers. To the extent possible, this analysis was designed to account for the following features of retail fixed-line telecommunications markets:

- Retail fixed-line services may be bundled together, most commonly as a bundle of voice and broadband. Pass-through of changes in wholesale broadband prices may therefore occur at the level of the bundle.

- "Headline" retail prices may not reflect prices paid by consumers, for example due to discounting for bundles and for new customers while some existing customers remain on older "grandfathered" plans, and due to charges for excess data and other services included in the total bill.

- As well as changes in retail prices, changes in wholesale prices could lead to changes in the quality of retail services. For this analysis, quality was measured by the size of data caps on broadband plans. Other dimensions of competition, such as bundled video content services with telecommunications services, could not be included in the empirical analysis and it is possible that unmeasured changes in the quality of retail services could have occurred in response to changes in wholesale costs.

- Over the period of the analysis, other factors may also have affected retail market outcomes, e.g. changes in costs of other inputs to fixed-line retail services, changes in demand, and changes in the nature and intensity of competition. To the extent possible, demand and cost drivers have been controlled for in the empirical analysis, but changes in the nature and intensity of competition could not be controlled for.

1.3. Analysis of a billing sample

The main results presented in section 4 of this report are based on econometric analysis of a sample of billing data provided by the three largest fixed-line retailers: Spark, Vodafone, and Vocus. This dataset provided information about the fixed-line services purchased and amounts paid from almost 80,000 bills sent to residential customers between March 2012 and June 2016. This dataset captures promotions, discounts, grandfathering, and other pricing adjustments that may have affected the prices that customers paid for fixed-line

services. It also provides information about the types of service purchased, and broadband data caps and data usage.

"Reduced form" regression models were estimated using this billing dataset to estimate how amounts paid by residential fixed-line customers have changed in response to regulated changes in the UCLL and UBA prices.
A key advantage of analysis based on billing data is that it can look at pass-through to prices actually paid by consumers. The econometric methodology was designed to be agnostic about the model of competition among retailers (hence the use of the "reduced form" approach), and allows for a variety of possible pass-through mechanisms (described below).

1.3.1. Model specifications

A set of models were estimated to allow for the fact that pass-through may occur in different ways and the exact mechanism is unknown:

- Changes in fixed monthly fees, or changes in the total amount paid for a bundle of fixed-line services including voice and value-added services such as voicemail;
- Changes in prices or the "quality-adjusted" price of service, where quality was measured by the size of broadband data caps;
- Changes in prices faced by copper network customers, or by both copper and fibre customers if copper and fibre are close substitutes; and
- Changes in prices targeted at a subset of new customers only (defined in the analysis as customers who have been with their current retailer for six months or less), through discounts and promotions.

In addition, different models were configured to account for the fact that changes in wholesale prices might take time to flow through to retail markets, or that retailers might adjust prices and qualities in advance of price changes if they can predict those changes during the regulatory process. In all, 144 different regression models were fitted to the billing sample data to estimate pass-through rates for the UCLL price and UBA base price (see section 4.4.4 for a summary). An additional set of 48 models was fitted to estimate the combined rate of pass-through of the two prices (i.e. pass-through of the "full" UBA price).

1.4. Main findings

The results of the billing sample analysis are subject to some important caveats and limitations, including the following (see section 4.5):

- Other factors aside from UCLL and UBA base prices that affect fixed-line retailers' costs are difficult to observe directly, and simple proxies were used for some types of costs. If relevant factors have been omitted, these could cause the estimated pass-through effects to be inaccurate and/or biased.
- There is not a lot of variation in the wholesale UCLL and UBA base prices in the period used for analysis. As illustrated in Figure 1, there are only three discrete

changes of these regulated prices in this period, and individually the UCLL and UBA base prices have only each changed twice. This lack of variation may make it difficult to estimate pass-through effects.

- Conversely, there is wide variation in the amounts paid by customers in the billing sample, which makes it difficult to model these amounts and isolate pass-through effects.

- The analysis focuses on changes in retail prices for fixed-line services and, to a lesser extent, changes in service "quality" measured by broadband data caps. It is not possible to quantify other types of changes in quality or other dimensions of competition, such as the recent trend towards bundling video content (e.g. Netflix and Lightbox services) and other utilities (e.g. residential electricity and gas) with telecommunications services. It is possible that changes to regulated wholesale prices have affected competition in these other dimensions, and/or that pass-through has occurred via unmeasured quality changes rather than price changes.

- Estimating many models and performing many simultaneous tests of statistical significance, such as done in this report, is likely to produce some "significant" findings that are in fact due to random variation. For this reason, and because the exact pass-through mechanism is unknown, the interpretation of the results is based on the total evidence provided by the set of models, rather than any one model.

- While some of the models fit the data better than others, there is no strong reason to prefer any one model or sub-set of models over the others. The explanatory power of most of the models is relatively low due to the wide variation in amounts paid by fixed-line customers, but on its own this does not mean that the models are incorrectly specified or that the results are not useful for analysing pass-through. However, the results are subject to uncertainty, and the confidence intervals for the pass-through estimates are relatively wide (see below).

Bearing in mind the caveats, the econometric analysis suggests that the best estimates of individual rates of pass-through of the two wholesale prices are that around 100% of the changes in the UCLL price shown in the top part of Figure 1 have been passed through to retail prices, and around 80% of the changes in the UBA base price shown in the middle part of Figure 1 have been passed through. The best estimate of pass-through of the "full" UBA price (i.e. the combined UCLL and UBA base price) is that 90% of changes in this price have been passed through. However, it is possible that actual pass-through was significantly higher or lower than these point estimates.

The analysis suggests that almost all the pass-through of the UCLL price occurred to monthly fees for fixed-line services, with possibly some small changes to other components of customers' bills such as voice calling and value-added services. Pass-through of changes to the UBA base price appears to have occurred to components of customers' bills excluding voice calling. This is presumably because the UBA base price only applies to copper customers who receive a bitstream broadband service provided by Chorus, so retailers have no incentive to pass changes of that price on to other retail services.

Comparing the pre-IPP (before December 2014) with post-FPP (after December 2015) periods, the wholesale cost of a copper bitstream service provided by Chorus (i.e. the sum of the UCLL price and the UBA base price) decreased by $3.79 per customer per month. This applies to approximately two-thirds of copper lines. The remaining one-third of lines have either been unbundled or have voice-only service and attract only the UCLL price, which increased by $6.23 per customer per month over the same period. The estimated rate of pass-through for the "full" UBA price suggests that 90% of the $3.79 reduction (i.e. $3.41) was passed through to retail prices, on average.

In addition:

- The above conclusions broadly remain true when quality (measured by data caps) is considered in the analysis. If quality is independent of wholesale prices, then adjusting for quality reduces the rate of pass-through of wholesale prices to retail prices. However, if quality depends partly on wholesale prices then the pass-through estimates of the quality-adjusted models cannot be directly compared to the models where quality is not controlled for. Given the difficulties of interpreting rates of pass-through after quality adjustment, the conclusions drawn above primarily rely on the results without quality adjustment.

- The period of analysis ends six months after the FPP prices were finalised. It is possible that additional changes to retail prices in response to changes in wholesale pricing occurred later, once retailers adjusted their retail pricing to the final wholesale prices. However, it is not clear whether this would lead to higher or lower estimated rates of pass-through, depending on the size of the FPP cost changes that were anticipated by retailers and how these were reflected in pricing for customers who are currently on term contracts.

- There is a relatively high range of uncertainty associated with these pass-through estimates, due to the difficulty of modelling real-world retail pricing in fixed-line markets. The 95% confidence ranges for the pass-through estimates presented above are approximately:

    - Between 30% and 170% pass-through of the UCLL price.

    - Between 5% and 155% pass-through of the UBA base price.

    - Between 10% and 170% pass-through of the combined UCLL and UBA base price (the 'full' UBA price).

    It is plausible that the true rates of pass-through for the wholesale prices are anywhere within these ranges. The width of these ranges means that it is difficult to be certain about exact rates of pass-through.

2. Background and scope

2.1. Objectives and scope of this report

This report analyses the effects of regulated changes in the wholesale prices for the unbundled copper local loop (UCLL) and unbundled bitstream access (UBA) services on outcomes in retail markets for residential fixed-line telecommunications services. The analysis focuses on the period from December 2011 to June 2016, i.e. after the market reforms that included structural separation of Telecom.

The scope of the analysis is limited to estimation of rates of pass-through only, and does not extend to analysis of the intensity of competition in retail markets. Rates of pass-through are only one of many factors that could inform an analysis of competition, and as shown in the appendix (section 7) a wide range of rates of pass-through can be consistent with a given model of competition. This means it is not possible to reach conclusions about competition based on pass-through analysis alone.

Estimation of other market parameters aside from rates of pass-through (e.g. demand elasticity) is also out of scope.

2.2. Overview of the regulated services

The UCLL and UBA services are key inputs that retail service providers (RSPs) use to offer retail fixed-line voice and broadband services over the copper access network, and the costs of UCLL and UBA are a significant part of the costs of providing such retail services.

The UCLL service can be used to provide fixed-line voice or DSL broadband service (or both) to a customer from an unbundled exchange. Unbundling and using UCLL to serve a customer requires the RSP to supply their own infrastructure for the voice and/or broadband service, i.e. to install a DSLAM in the unbundled exchange, and/or to provide a voice platform.

The UBA service is a bitstream service, i.e. the necessary active equipment to provide broadband service is provided by Chorus. UBA can be used to provide a retail DSL broadband service to a customer either on its own (“naked” broadband) or in conjunction with a fixed-line voice service (referred to in this report as a broadband + voice bundle). The wholesale price of the “full” UBA service equals the wholesale price of the UCLL service plus an extra amount that reflects the additional costs required to provide the bitstream service. This extra amount is referred to as the UBA base price in this report.

If UBA is used to provide broadband to a customer then to also provide a voice service to that customer, the RSP must either purchase a commercial wholesale “Homeline” voice service from Spark, or buy a voice channel (“baseband” or “baseband IP”) service from Chorus and provide its own voice platform, or use broadband to provide a voice over IP (VoIP) service.

Around half of all copper access lines have been “cabinetised”, i.e. are served from an active roadside cabinet, to provide higher DSL broadband speeds. While technically possible, it has generally not proven to be economic for RSPs to unbundle cabinetised lines and install their

own active equipment in cabinets. Thus, for cabinetised lines, broadband is usually provided using a UBA service, while voice can be provided via a combination of sub-loop from the cabinet (SLU) and a sub-loop extension service (SLES) to extend the voice channel back to the exchange. The combined SLU + SLES service is provided for the UCLL wholesale price plus a small extra charge.[1] Alternatively, combined voice and broadband service can be provided to customers over cabinetised lines by a combination of UBA plus the wholesale Homeline voice service from Spark, as for un-cabinetised lines.

Spark was prohibited from unbundling any copper lines until 1 December 2014, so always provided fixed-line services using the UBA and baseband wholesale services until that time. Other RSPs use a mix of UBA and UCLL to provide broadband services, and a mix of baseband or baseband IP, Spark wholesale voice services, and SLU + SLES to provide voice services. These mixes vary across RPSs depending on how many lines they have chosen to unbundle, so changes in wholesale prices for UCLL and UBA affect the RSPs in different ways.

2.3. Approach to the analysis of pass-through

The regulated prices of the UCLL and UBA services have changed several times between December 2011 and June 2016. The objective of this report is to analyse the effects those price changes had on retail broadband markets. This is generally described as the "pass-through" of changes in wholesale prices to retail prices and/or other dimensions of retail competition.

Several practical issues were considered to the extent possible during the analysis, and should be borne in mind when interpreting the results:

- Retail fixed-line services may be bundled together, most commonly as a bundle of voice and broadband. Pass-through of changes in wholesale broadband prices may therefore occur at the level of the bundle.

- "Headline" retail prices may not reflect prices paid by consumers, for example due to discounting for bundles and for new customers while some existing customers remain on older "grandfathered" plans, and due to charges for excess data and other services included in the total bill.

- As well as changes in retail prices, changes in wholesale prices could lead to changes in the quality of retail services.

- Over the period of the analysis, other factors may also have affected retail market outcomes, e.g. changes in costs of other inputs, changes in demand, and changes in the nature and intensity of competition.

[1] The wholesale price of SLU is regulated to be a proportion of the UCLL price, while Chorus provides SLES as a commercial service. This means that any regulated change in the UCLL price will also change the SLU + SLES price.

- As noted above, regulated changes in wholesale UCLL and UBA prices affect the costs of RSPs in different ways, due to their different utilisation of wholesale services.

2.4. Consideration of substitute retail services

For many consumers, retail fibre broadband services are likely to be relatively close substitutes for copper broadband services, and retail prices for fibre services are generally similar to those for copper services. While UCLL and UBA are not used to provide retail fibre services, this demand-side substitution means that regulated changes in UCLL and UBA wholesale prices could also affect retail prices for fibre broadband services. Residential retail fibre services provided over the UFB network are therefore included in the analysis.

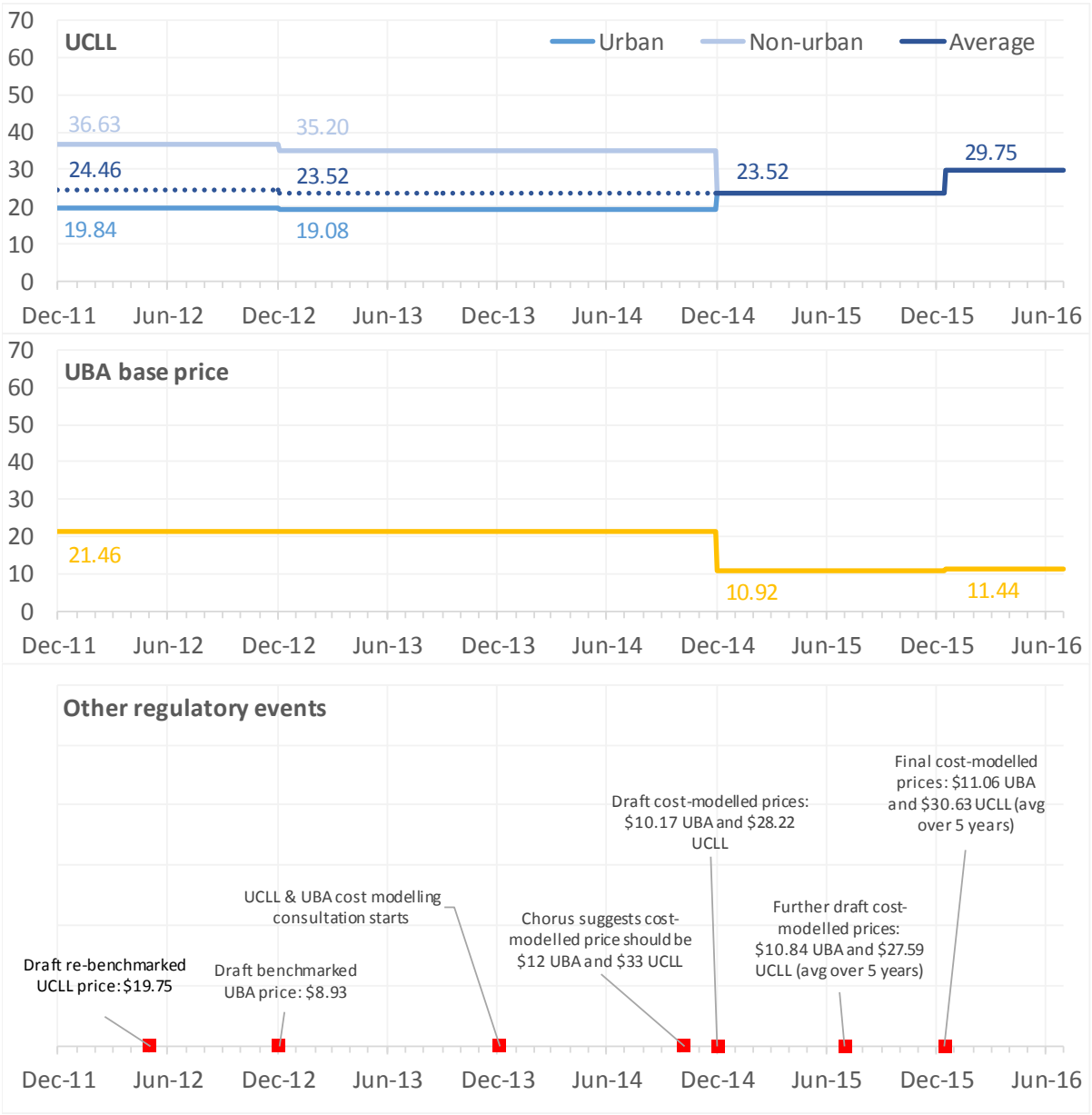
Retail mobile and fixed wireless services are partial substitutes for fixed-line services, and thus in theory regulated changes in fixed-line wholesale access prices could also have some impact on outcomes in those markets. However, any such effects are likely to be difficult to measure, due to the range of other factors that are expected to have a much larger impact on mobile and fixed wireless markets. Furthermore, fixed wireless services were very limited in availability during the study period. Mobile and fixed wireless services are therefore out of scope of this analysis.

3. Context

3.1. Timeline of relevant regulatory events

Figure 2 shows the changes between December 2011 and June 2016 in the regulated UCLL and UBA base prices, as well as a timeline of other significant regulatory events. All of the panels in Figure 2 were constructed using a calendar of regulatory decisions and events provided by the Commission (see Appendix 1).

Figure 2 Changes to wholesale prices and other significant regulatory events between December 2011 and June 2016.



Source: Schiff Consulting, using information provided by the Commerce Commission.

3.1.1. Changes in regulated UCLL and UBA prices

UCLL

Prior to December 2014, separate regulated UCLL prices set by benchmarking applied for "urban" and "non-urban" customers served by unbundled lines. A re-benchmarking exercise led to a small reduction in both regulated prices in December 2012.

From December 2014, a single average UCLL price was applied, which resulted in an effective increase in the cost to serve urban customers and a decrease in the cost to serve non-urban customers, although the overall average was unchanged.

In late 2013 a cost modelling exercise was commenced, and this led to an increase in the regulated UCLL price two years later, from mid-December 2015. The regulated UCLL price will also increase each year in December for the next five years, reaching $31.68 in December 2019.

UBA base price

A cost-based benchmarked UBA base price was applied from December 2014, at the same time as the UCLL prices were averaged. This led to a significant reduction in the UBA base price (from $21.46 to $10.92) and hence the price of "full" UBA also fell.

The results of the cost modelling exercise slightly increased the UBA base price (from $10.92 to $11.44). Future prices for the UBA base price will fall slightly over the next five years.

3.2. Significance of the regulated services

Table 1 (overleaf) shows information compiled from Chorus's annual reports about the number of fixed lines that it served at different points in time. The total number of fixed-line connections has fallen slightly over time, while the total number of copper lines supplied using the regulated UCLL and UBA services has fallen more rapidly as customers have switched to fibre services. However, as at the end of June 2016, Chorus still has approximately 8.5 copper customers for every fibre customer.

The bottom section of Table 1 shows a breakdown of the types of regulated copper lines served by Chorus. This information is not directly reported by Chorus and has been calculated from other data in the table. This shows that:

- The number of unbundled copper lines peaked in late 2014 and has subsequently declined, with about 21,000 fewer unbundled lines at the end of June 2016 compared to the end of December 2014.

- The number of UBA lines (either naked or bundled with voice service) also peaked in late 2014 and has fallen by about 74,000 as at the end of June 2016.

- The number of voice-only lines has steadily declined over time. Most of these customers presumably converted to a broadband service (either unbundled or UBA).

- In the four years between June 2012 and June 2016, the total number of regulated copper lines served by Chorus has fallen by about 214,000.

Total industry fixed-line revenues for the year ended June 2015 (the most recent year available) were reported as $2.58 billion[2]. The data in Table 1 indicate that, as at 30 June 2016, there are 1,537,000 copper lines that attracted the UCLL wholesale price, and of those, 1,059,000 also attracted the UBA base price. These translate to combined annual payments from retailers to Chorus of $694 million, implying that wholesale UCLL and UBA charges correspond to around one-quarter of total annual fixed-line revenues.

Table 2 shows Chorus's annual revenues in the categories that it reports. The recurring charges for UCLL and UBA that are the focus of this report are included in the "basic copper" and "enhanced copper" categories. However, these categories may also include other types of revenue e.g. non-recurring charges for copper lines, and possibly other revenues for commercial services. In addition, as noted above, the number of regulated copper lines has fallen over time due to the transition to fibre. For these reasons, the changes in Chorus's reported copper revenues over time cannot be entirely attributed to regulated changes in the wholesale prices for UCLL and UBA.

With those caveats in mind, Chorus's total basic and enhanced copper revenues declined by $77 million in the year ended June 2015 versus the preceding financial year. The large reduction in the UBA base price occurred mid-way through the 2015 financial year. Chorus's enhanced and basic copper revenues also declined by $28 million in the 2016 financial year, however its revenue per regulated copper line increased slightly and the higher regulated prices under the FPP applied mid-way through that financial year. This suggests that at least some of the reduction in copper revenues in that year was due to the reduction in the number of copper lines.

[2] *Annual Telecommunications Monitoring Report 2015*, Commerce Commission.

Table 1 Chorus's fixed-line services

As at	30-Jun-12	31-Dec-12	30-Jun-13	31-Dec-13	30-Jun-14	31-Dec-14	30-Jun-15	31-Dec-15	30-Jun-16
Total fixed line connections	**1,776,000**	**1,793,000**	**1,784,000**	**1,776,000**	**1,777,000**	**1,782,000**	**1,794,000**	**1,761,000**	**1,727,000**
Baseband copper (incl. baseband IP)	1,585,000	1,559,000	1,521,000	1,497,000	1,471,000	1,435,000	1,408,000	1,326,000	1,230,000
UCLL	97,000	109,000	122,000	125,000	127,000	127,000	123,000	116,000	108,000
SLU/SLES	19,000	16,000	6,000	5,000	4,000	4,000	3,000	3,000	2,000
Naked copper (UBA / VDSL)	50,000	72,000	91,000	103,000	117,000	136,000	159,000	180,000	197,000
Data services over copper	15,000	22,000	25,000	19,000	16,000	15,000	13,000	11,000	10,000
Fibre	10,000	5,000	19,000	27,000	42,000	65,000	88,000	125,000	180,000
Total broadband connections	**1,040,000**	**1,076,000**	**1,112,000**	**1,132,000**	**1,163,000**	**1,186,000**	**1,207,000**	**1,223,000**	**1,226,000**
Copper UBA (includes naked UBA)	1,040,000	1,074,000	1,100,000	1,091,000	1,068,000	1,040,000	1,016,000	972,000	900,000
VDSL (includes naked VDSL)		2,000	4,000	25,000	64,000	93,000	116,000	139,000	159,000
Fibre (mass market)			8,000	16,000	31,000	53,000	75,000	112,000	167,000
Regulated copper lines, calculated from above:									
Unbundled lines (UCLL + SLU/SLES)	116,000	125,000	128,000	130,000	131,000	131,000	126,000	119,000	110,000
UBA lines	1,040,000	1,076,000	1,104,000	1,116,000	1,132,000	1,133,000	1,132,000	1,111,000	1,059,000
Voice only lines	595,000	555,000	508,000	484,000	456,000	438,000	435,000	395,000	368,000
Total regulated copper lines	**1,751,000**	**1,756,000**	**1,740,000**	**1,730,000**	**1,719,000**	**1,702,000**	**1,693,000**	**1,625,000**	**1,537,000**

Source: Complied and calculated from Chorus's annual reports.

Table 2 Chorus's annual revenues ($m).

Year ended June	2013	2014	2015	2016
Basic copper	631	543	491	489
Enhanced copper	215	293	268	242
Fibre	60	75	98	133
Value added network services	37	38	36	35
Infrastructure	17	19	21	20
Field services	85	75	84	83
Other	12	15	6	6
Total	**1,057**	**1,058**	**1,006**	**1,008**
Calculated from above:				
Basic + enhanced copper revenue ($m)	846	836	759	731
Revenue per regulated copper line ($/month)*	40.15	40.27	37.16	37.49

* Based on the number of lines as at 31 December in each year, from Table 1 above.
Source: Complied and calculated from Chorus's annual reports.

3.3. Changes to Homeline prices

Spark also changed the price for its commercial Homeline wholesale service a number of times during the same period. Changes to the wholesale Homeline price affect the cost to retailers of providing a combined fixed-line broadband and voice service without unbundling and without their own voice platform.

These changes included a gradual removal of geographic price discrimination in Homeline prices, overall increases in Homeline prices over time. Notably, Spark increased the Homeline wholesale prices shortly after the regulated reduction in the UBA base price in December 2014, which offset some of the gains of this reduction to retailers using UBA + Homeline to provide voice and broadband bundles.

3.4. Other regulatory events

The most significant of the other regulatory events shown in the bottom panel of Figure 2 relate to the cost modelling consultation under the final pricing principle (FPP) for the UCLL and UBA services, which commenced in December 2013. This exercise was still underway at the time the regulated reduction in the UBA base price from $21.46 to $10.92 was applied in December 2014. Two months earlier, Chorus made a presentation suggesting that the cost-modelled prices should be $33 for UCLL and $12 for the UBA base price, implying a price of $45 for full UBA, which was significantly higher than the price of $34.44 for full UBA that applied after the December 2014 reduction in the UBA base price.

Very soon after the regulated reduction in the UBA base price was applied in December 2014, the Commission released its first draft cost modelled prices, implying a small reduction in the UBA base price (from $10.92 to $10.17) but a larger increase in the UCLL price (from $23.52 to $28.22), which would have increased the full UBA price from $34.44 to $38.39. The prices were not finalised until mid-December 2015, and the final prices involved (for the first year) an increase in the UBA base price from $10.92 to $11.44 and an increase in the UCLL price from $23.52 to $29.75, taking the full UBA price from $34.44 to $41.19.

Thus, at the time of the relatively large regulated reduction in the UBA base price in December 2014, retailers would have faced uncertainty about what the FPP prices would be, and there were already early indications (i.e. Chorus's estimate and the Commission's FPP first draft) that the UCLL price and possibly the UBA base price could increase.

The net impacts of the two regulated price changes in December 2014 and December 2015 were:

- an increase in the average UCLL price of $6.23 per customer per month, i.e. a 26.5% increase in the price of access to an unbundled line relative to the average price that applied before December 2014; and

- a net reduction in the "full" UBA price of $3.79 per customer per month, i.e. an 8.4% reduction in the cost of providing broadband service using UBA relative to the average price that applied before December 2014.

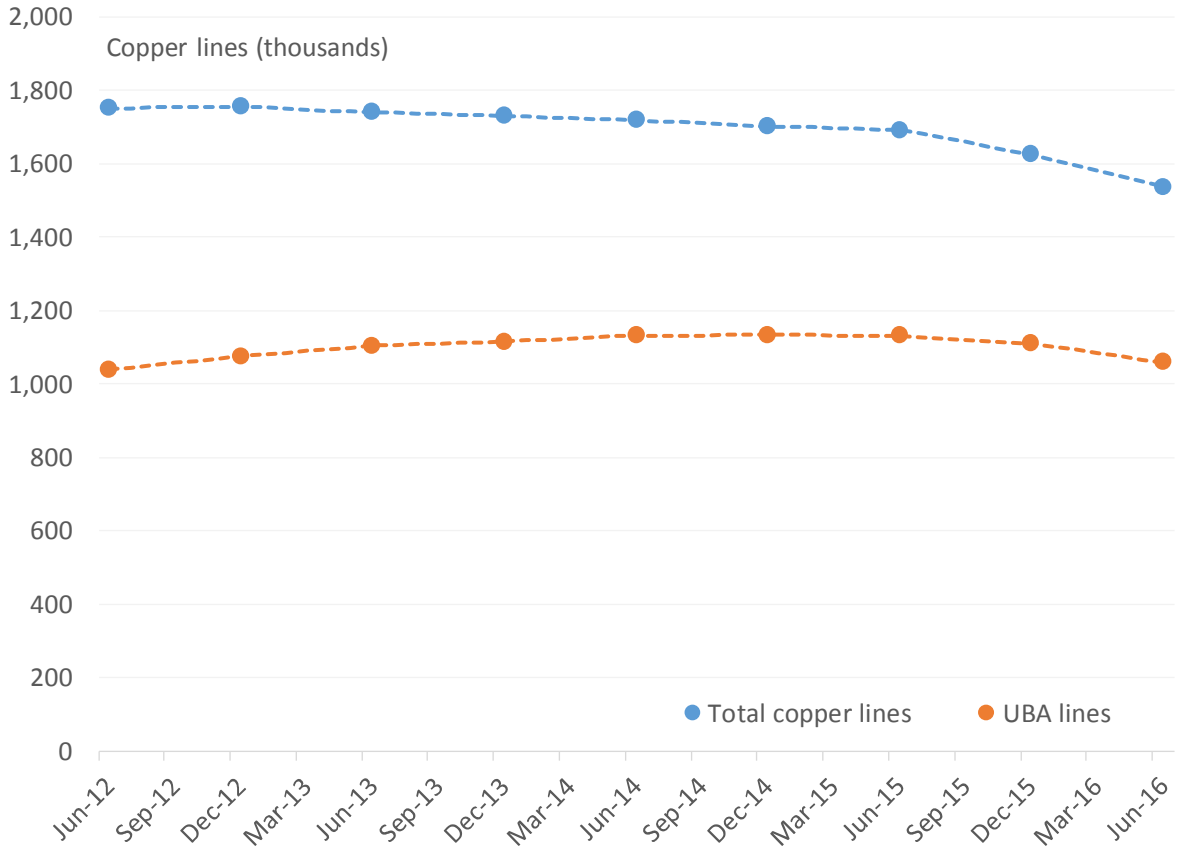
Over the same period, the combined price of "full" UBA and the Homeline service decreased by $3.62 (6.1%) per customer per month for customers in the main cities and by $7.33 (11.6%) per customer per month for customers elsewhere. These changes reflect the combined effect of regulated price changes and Spark's changes to the wholesale prices for the Homeline service.

3.5. Estimated changes in total recurring charges for UCLL and UBA services

3.5.1. Estimated number of copper lines

Table 1 above shows the number of copper lines that attracted the UCLL and UBA charges at six-monthly intervals, as reported by Chorus. To enable estimation of the total recurring charges for these services, the number of lines between these points in time were estimated by linear interpolation (Figure 3).

Figure 3 Copper lines attracting UCLL and UBA recurring charges. Dots are based on Chorus's reported figures, and dashed lines are estimates.

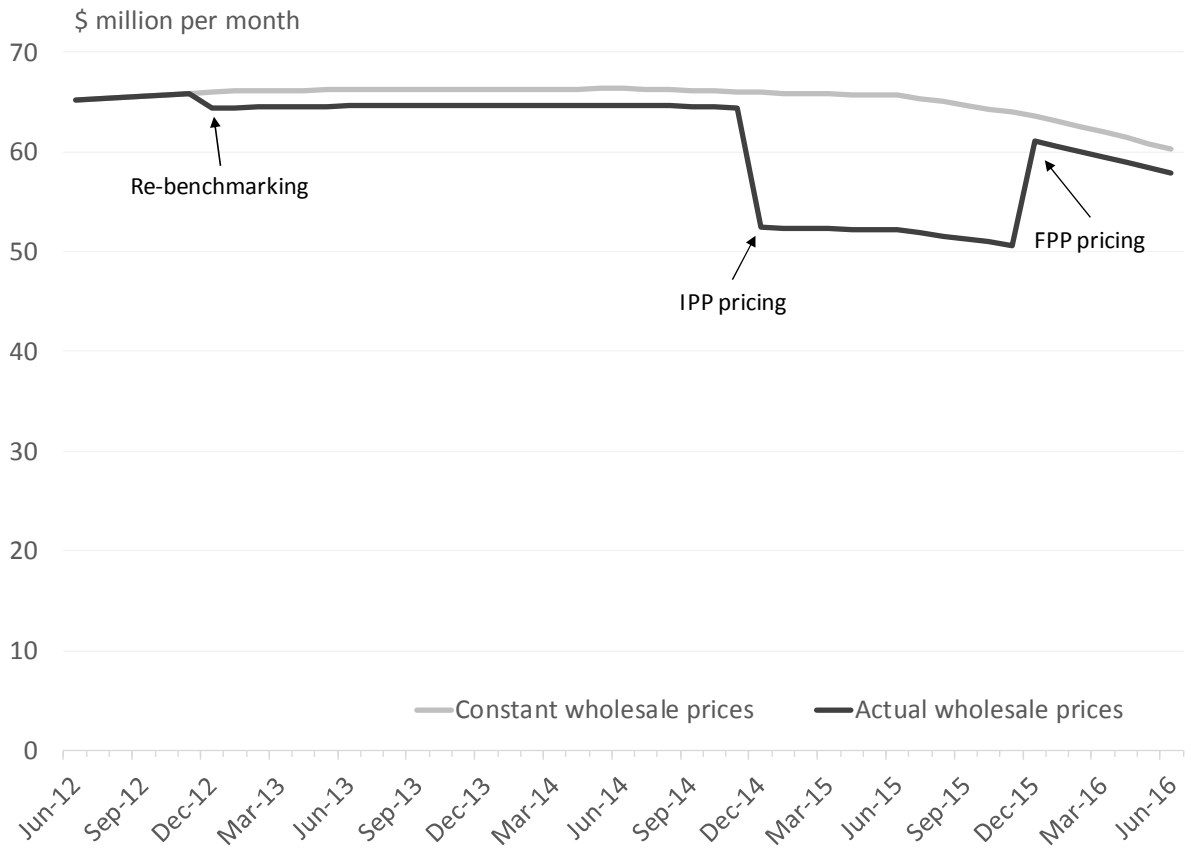


Source: Calculated from Chorus annual reports.

3.5.2. Estimated total recurring charges for UCLL and UBA

The UCLL and UBA recurring charges that applied in each month can then be multiplied by the number of lines in each month, to estimate the total cost to retailers associated with these charges. Figure 4 shows these estimated monthly charges, in comparison with what the charges would have been if they had remained at the prices that applied in early 2012.

Figure 4 Estimated total monthly cost to retailers of UCLL and UBA recurring charges.



Source: Schiff Consulting estimates.

Table 3 summarises these estimates of recurring charges on an annual basis. The largest impacts are in the year ended June 2015, when the application of the IPP prices is estimated to have reduced recurring charges for UCLL and UBA services by $103 million relative to what these charges would have been if wholesale prices remained at their 2012 levels. The difference is smaller in the year ended June 2016, as the IPP prices applied for roughly half of this year, with the higher FPP prices being imposed in December 2015. As at June 2016, the estimated difference between the two scenarios shown in Figure 4 is about $2.5 million per month, i.e. about $30 million per year.[3]

Table 3 Estimated annual impacts of regulation on recurring UCLL and UBA charges ($m).

Year ended June	2013	2014	2015	2016
Estimated recurring charges with constant wholesale prices	791	795	791	757
Estimated actual recurring charges	780	776	689	672
Difference	-12	-20	-103	-84

Source: Schiff Consulting estimates.

[3] This difference is expected to reduce in future years due to the future price paths for UCLL and UBA recurring charges set in the FPP.

On a cumulative basis since the year end June 2013, it is estimated that regulation has reduced total costs to retailers for UCLL and UBA recurring charges by $218 million, compared to if these charges had remained at their 2012 levels.

3.6. Comparison with aggregate fixed-line retail market outcomes

Aggregated information about retail market outcomes is available in the Commission's telecommunications market monitoring reports and accompanying data spreadsheets.[4] Table 4 shows data extracted from the spreadsheet files published by the Commission, focussing on residential subscribers. Arguably, the drivers of retail pricing for businesses are more complex, and it may be more difficult to determine the impacts of changes in wholesale prices on business retail pricing.

At the time of writing, the Commission's monitoring data is available to the year ended June 2015. This includes the IPP pricing in December 2014 but as at June 2015 the FPP process was in progress and there was some uncertainty about final pricing, as discussed above.

With the caveat that revenues prior to changes in wholesale prices are not necessarily a good counterfactual for revenues after those changes, these observations can be made:

- On an annual basis, most of the changes in recurring UCLL and UBA costs occurred between 2014 and 2015. Comparing these two years, total recurring charges reduced by about $100 million.

- At the same time, retail revenue reduced by about $50 million in aggregate.

- If these changes in revenues could be entirely attributed to changes in recurring UCLL and UBA charges, this implies pass-through of around 50%.

- However, other significant changes have occurred in the retail market between 2014 and 2015. For example, the average monthly number of chargeable call minutes per residential customer reduced from 121 in 2014 to 113 in 2015, while average broadband data usage increased from 33 GB per customer per month to 49 GB.

More generally, the fall in total fixed-line revenues between 2014 and 2015 could be consistent with retailers passing through some of the reduction in recurring UCLL and UBA charges that occurred during this period. This pass-through may have occurred as reductions in prices of fixed-line voice and data bundles, and/or as increases in broadband data caps leading to effectively lower prices per gigabyte and increased data usage. However, with aggregated data across only a few years it is not possible to quantify the rate of pass-through with any precision, particularly given that voice calling demand appears to have fallen while demand for broadband services appears to have increased at the same time.

[4] http://www.comcom.govt.nz/regulated-industries/telecommunications/monitoring-reports-and-studies/monitoring-reports/

It is also relevant that the reduction in retailers' costs due to regulated changes in the recurring UCLL and UBA prices is relatively small in comparison with total revenues, and a large part of the cost reduction was only temporary as the FPP in December 2015 reversed most of the cost reductions of the IPP in December 2014, for customers where the bitstream service is provided by Chorus. Given these facts, it is not surprising that pass-through to retail market outcomes is difficult to detect at the aggregate level.

The following sections attempt to overcome these problems by looking at changes in retail market outcomes in more detail.

Table 4 Fixed-line telecommunications market outcomes.

Year ended June	2013	2014	2015
Total residential retail revenues ($m)	1,473	1,560	1,511
Number of residential fixed-line subscribers			
Non-fibre broadband subscribers	1,130,408	1,139,425	1,093,253
Fibre broadband subscribers	6,260	33,318	84,629
Total broadband subscribers	1,136,668	1,172,743	1,177,882
Total fixed access lines	1,338,446	1,442,204	1,415,161
Monthly revenue per residential subscriber ($)	91.71	90.12	88.96
Residential chargeable call minutes			
Total minutes (millions)	2,277	2,086	1,926
Minutes per residential access line per month	142	121	113
Total broadband usage (including non-residential customers)			
Total broadband data use by customers (TB)	391,731	499,916	783,515
Total fixed line broadband subscribers	1,288,790	1,282,592	1,359,400
Broadband data usage per subscriber per month (GB)	26	33	49

Source: Commerce Commission telecommunications market monitoring data spreadsheets, and Schiff Consulting calculations.

4. Estimating pass-through from a sample of retail bills

The extent to which recent changes in recurring charges for UCLL and UBA were passed through to retail prices was investigated empirically using a large sample of data obtained from actual bills sent by retailers to residential customers for fixed-line voice and broadband services. Regression models were estimated using this sample that attempt to explain the amounts paid by customers as a function of recurring UCLL and UBA charges and other cost drivers.

This approach is an application of a "reduced form" approach to empirical estimation of pass-through. The strengths and weaknesses of the reduced form approach, and other approaches to estimating pass-through, are discussed in the appendix to this report (section 7.6).

As discussed in the appendix (section 7.3), the rate of pass-through observed in a market depends on several factors, including the characteristics of demand, costs, and competition. There is no direct relationship between pass-through and the intensity of competition, and it is possible for very low or very high rates of pass-through to be consistent with any given level of competition. This means that the results in this section should not be used on their own to reach conclusions about the state of competition in fixed-line telecommunications markets, but these results could be a useful input to competition analysis.

4.1. Description of the sample

The three largest fixed-line retailers, Spark, Vodafone, and Vocus, were asked to give the Commission a set of data extracted from random samples of bills sent to residential customers for fixed-line voice and broadband services.[5]

- Each retailer was asked to provide a sample of at least 500 bills in each month, randomly sampled from bills sent to active fixed-line residential customers at that time. Retailers were asked to select bills without replacement from the relevant set of bills in each month. In practice, retailers used random sampling functions provided by their billing databases and there is no reason to believe those algorithms are biased.

- The retailers were asked to exclude all personally identifying information from the data provided to the Commission, such as customers' names, addresses, phone numbers, account numbers, etc. Each bill in the sample was given a unique randomised ID number so that the relevant retailer could be asked to look up the source data if required to check any anomalies. Non-identifying information about customers and the types of services they received was retained in the sample and use to create explanatory variables for the pass-through models (see below for details).

[5] Extracting the data from each retailer's billing system was a challenging task, and the assistance of the retailers in providing this data is gratefully acknowledged.

- The sampling was based on bills rather than customers, to allow for the fact that some residential customers may use the same retailer for multiple fixed lines for which they receive separate bills (e.g. their main home and a holiday home).

- The combined sample covers the period from March 2012 to June 2016, i.e. 52 consecutive months.

- The sampling was carried out independently each month, so that new customers of the retailers would be captured in the sample over time.

- The retailers were not asked to stratify the sample based on customer characteristics. This means that the number of customers with certain characteristics in the sample may be quite low in any given month, e.g. fibre customers in the early days of the UFB roll-out. Given the way the sample was constructed, the analysis below focuses on averages across all customers, rather than segments of customers. If customer segments are analysed, care must be taken that the sample sizes of the segments are large enough.

- For some retailers in some months, the actual sample size provided was greater than 500. A small number of invalid or erroneous records had to be removed from the sample. There are 77,922 valid observations in the combined sample from the three retailers, i.e. an average of 1,499 observations per month.

- The actual number of valid observations provided by each retailer in each month was used in the calculation of weights that were applied to the data to calculate market averages and estimate the regression models. Weights were also based on the estimated market shares of the retailers (this is discussed further below).

- The sample includes residential customers served by both copper and fibre networks. Customers on Vodafone's hybrid fibre-coaxial (HFC) cable network were excluded from the sample that Vodafone provided, so that all customers in the billing sample are either on copper or UFB fibre.

- To the extent possible, bills sent to non-residential customers were excluded from the sample, by restricting the sample to bills sent to customers who purchased retail products targeted at residential customers. However, it is not always possible for a retailer to distinguish between residential and non-residential customers, e.g. in the case of small home-based businesses. The sample therefore contains some unknown number of non-residential customers.

- Customers who joined or left a retailer during a month, or changed their plan during a month, were excluded from the pool of customers to be sampled, to avoid issues arising from pro-rate billing for such changes.

- Vocus has several retail brands, and to reduce the burden of extracting billing data it was asked to sample only from bills sent to customers of its Slingshot brand. It is understood that Spark and Vodafone sampled from their entire customer base

(except HFC customers for Vodafone). The exclusion of Vocus's other brands is not expected to have a significant impact on the pass-through results at the market level, due to the relatively small market shares of these brands.

4.2. Variables in the sample

The data provided by the three retailers to the Commission was cleaned, combined, and standardised to produce a dataset with the following variables:

Identifiers

- **bill_id**: A unique ID for the bill allowing the Commission to ask a retailer to trace the bill back to the source if required.
- **retailer**: The name of the retailer serving the customer.
- **bill_month**: The month in which the bill was issued. Retailers typically issue bills to some customers on each day during the month, depending on each customer's billing cycle. To construct this sample, only the month of the billing date was used.
- **bill_year**: The year in which the bill was issued.

Service characteristics

- **voice-only**: An indicator of whether only retail voice services were provided (i.e. no broadband service).
- **naked**: An indicator of whether the retail service was for broadband only (i.e. no voice service).
- **vdsl**: An indicator of whether broadband service was provided by VDSL over copper.
- **fibre**: An indicator of whether the fixed-line service was provided by the UFB network.
- **unbundled**: An indicator of whether the service was provided over an unbundled copper line.
- **short_tenure**: An indicator of whether the customer has joined the retailer within the past six months. For technical reasons, this indicator could only be calculated from September 2012 onwards.

Data cap and data usage

- **unlimited**: An indicator of broadband plans with unlimited monthly data caps.
- **data_cap_gb**: The notional monthly data cap in gigabytes, for those broadband customers not on unlimited data plans. The data cap value is missing for some bills, particularly those earlier in the sample for broadband plans that no longer exist. An NA value for this variable indicates that either the broadband plan was unlimited, or

only a voice service was provided, or the data cap is unknown.

- **data_usage_gb**: The actual data usage in gigabytes during the month. This information could not be provided for some bills in the sample.

Charges (i.e. retail revenues) excluding GST

- **rev_monthly_fees**: Net revenue from fixed monthly fees.

- **rev_voice_calling**: Net revenue from voice calls of all types.

- **rev_value_added_services**: Net revenue from fixed-line services such as caller display, call waiting, voicemail, etc.

- **rev_excess_data**: Net revenue from charges for additional broadband data above the notional data cap.

- **rev_bundle_discounts**: Discounts applied for purchasing fixed-line and mobile telecommunications services from the same retailer.

- **rev_other**: All other charges for fixed-line services not included in the above. This includes a wide variety of miscellaneous charges such as fees for paper invoices, late payment fees, charges for some types of customer service, etc.

- **rev_total**: The sum of all the charges above, i.e. the total amount of the bill for fixed-line services.

The characteristics of the combined sample are described in more detail in the appendix (section 8).

Notes about the combined sample

- Not all retailers were able to provide data for the exact variables above, but all provided enough information to allow these variables to be constructed for each bill in the sample. Any assumptions required to construct these variables, and any other interpretation issues, were discussed with the retailers.

- Each of the retail revenue variables described as “net” above is net of any discounts or refunds that customers received specific to that category. For example, retailers sometimes offer discounted voice calling promotions and the value of such discounts was subtracted in the calculation of voice calling revenue to reflect the amounts that customers paid. Similarly, new customers are sometimes offered discounted monthly fees, or free monthly fees for the first few months. Such discounts were subtracted from the monthly fees variable.

- It is not clear how “bundle” discounts for buying fixed-line and mobile services from the same retailer should be allocated to fixed-line and mobile services. For this reason, such discounts were separated so that different allocations could be tested.

This is discussed further below.

- There is a small number of bills in the sample where the total amount charged was very low or negative (i.e. the customer received a refund or credit).[6] Such bills were retained in the sample on the basis that they may reflect corrections for previous over-charging or other billing errors. These will offset other customers who are charged too much in any given month.

- Vodafone allows customers to bundle Sky TV services with fixed-line services. The charges for Sky TV services were included in the "other" revenues category in the data that Vodafone provided. The treatment of the "other" revenue category is discussed further below.

4.3. Weighting

Each observation in the sample was assigned a weight reflecting:

- The estimated market share of the relevant retailer in the month in which the bill was issued; and

- The total number of valid bills from the relevant retailer in the sample in that month.

The total weights across all bills in each month therefore sum to one, and the weights represent the relative importance of each observation within a month. These weights were used to calculate the monthly averages presented in the appendix (section 8), and were used as weights in the estimation of the regression models described below.

Specifically, the weight assigned to each bill of retailer i in month m was calculated as:

$$w_{i,m} = s_{i,m}/n_{i,m}$$

where $s_{i,m}$ is the estimated share of retailer i in the residential fixed-line market in month m, and $n_{i,m}$ is the total number of valid bills provided by retailer i in month m.

Market shares were estimated for the three retailers using data on the number of residential fixed-line customers that each retailer reported to the Commission. Annual observations of market share were converted to monthly estimates using interpolation and smoothed to reduce variations that may have been caused by changes in the way that retailers reported customer numbers. For calculating weights, market shares were calculated as each retailer's share of the total number of customers across the three retailers in the billing sample (i.e. other small retailers were ignored).

The estimated monthly fixed-line retail market shares that were used to derive weights for the pass-through analysis are shown in Figure 5.

[6] For about 2.5% of the sampled bills, the total amount is less than $30 excluding GST, and for about 0.1% the total amount is negative.

Figure 5 Estimated fixed-line retail market shares.

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Source: Schiff Consulting analysis of Commerce Commission data.

4.4. Regression model specification

Linear "reduced form" regression models were estimated to investigate the relationship between wholesale prices and retail prices. The "reduced form" approach was chosen because it avoids the need to specify a potentially very complex model of competition prior to estimating pass-through rates. As shown in the appendix, in theoretical models there can be a complicated relationship between demand and cost parameters and rates of pass-through, depending on the competition model. The "reduced form" approach avoids that complexity. An estimated "reduced form" model can be thought of as a linear approximation to some more complex (but unspecified) model of competition.

To estimate the models, each bill was treated as one observation. An alternative approach considered was to reduce the data to a panel dataset with one observation for each retailer in each month. However, this would reduce the dataset from just under 80,000 observations to 156, and the process of monthly averaging would potentially discard useful variation in retail charges that could allow pass-through to be identified. Furthermore, the retailer-specific fixed effects that could be estimated with such a panel data model can effectively be captured in models estimated using the full sample by including dummy variables for the retailers (this is discussed further below).

Different model specifications were tested to allow for different mechanics of pass-through. Twenty-four different model specifications were estimated, with different dependant variables and/or using different sub-samples of the data (explained below).

Each of these 24 models was tested with six different combinations of wholesale UCLL and UBA charges, and lags and leads of these charges, included as explanatory variables. This allows for the fact that the UCLL and UBA charges are correlated and if both are included in a regression model it may be difficult to isolate pass-through of either wholesale charge from the other. In total, 144 reduced form models were estimated to analyse pass-through of the UCLL and UBA base prices separately.

An additional 48 models were estimated to analyse pass-through of the combined UCLL and UBA base prices (i.e. the "full" UBA price). This involved estimating two variations of each of the 24 model specifications described below.

4.4.1. Dependant variables

The 24 basic model specifications were generated from all combinations of the following specifications for the dependent variable:

- **Price measure**: The amount that the customer paid was defined as one of:
    - The total bill including the full amount of any bundle discount and excluding charges in the "other" category
    - The total bill including the full amount of any bundle discount and excluding voice calling charges and charges in the "other" category
    - The monthly fee component of the bill including the full amount of any bundle discount
- **Price units:** The price measure was expressed as one of:
    - Dollars, i.e. the amount paid excluding GST
    - A "quality-adjusted" price, calculated as dollars divided by the natural logarithm of the data cap in GB, i.e. the amount paid excluding GST divided by the logarithm of the customer's notional data cap in gigabytes. Customers on unlimited broadband plans were assumed to have a notional data cap of 300 GB per month and voice-only customers were excluded in these models. The log transform of the data cap was used to account for customers' diminishing marginal utility of the size of the data cap.[7]

[7] Some justification for this assumption is provided by current retail pricing – customers typically have to pay an additional $10 per month to approximately double their data cap from 80 GB to 150 GB, and an additional $10 on top of that to go to an unlimited plan. "Quality-adjusted" models where price was simply divided by the data cap were also tested and these had lower R-squared values, further supporting the use of the log transform.

4.4.2. Sample used for estimation

The 24 basic specifications were also defined by the dataset used to estimate the model:

- **Network:** The models were estimated using bills for one of:
    - All bills, i.e. customers served by copper and fibre networks combined
    - Only customers served by copper networks
- **Customer tenure:** The models were estimated using bills for one of:
    - All bills
    - Only bills for customers who joined their current retailer within the past six months.

4.4.3. Discussion of model specifications

These different specifications were chosen to allow for the fact that pass-through could occur in different ways:

- The three price measures were chosen to allow for pass-through to occur across the total bill, which is plausible given that most customers purchase a voice + broadband bundle, or in the monthly fee component only, which is plausible given that UCLL and UBA charges are fixed charges per customer per month. Excluding voice calling charges was tested as a way of controlling for falling demand for voice calling over time. In other models, a proxy for voice calling demand was included as an explanatory variable (see below).

- "Other" charges were excluded from the models where the dependent variable was the total bill. The variation in these charges across customers and across retailers is difficult to explain and introduces excessive noise into the estimation of the models. Given the types of charges included in this category and the unpredictable nature of these revenues, it seems less likely that retailers will pass-through changes in recurring UCLL and UBA charges to retail prices in this category.

- As noted above, bundle discounts are offered to some customers for having mobile and fixed-line services with the same retailer. In all models, including where the dependent variable is fixed-line monthly fees, such bundle discounts were included, to give the amount paid net of any such discounts. This effectively assumes that all the discount is allocated to fixed-line services, and none is allocated mobile services. In reality, the allocation of bundle discounts between fixed and mobile services is arbitrary.

- The two price units were chosen to allow for pass-through to occur to prices only, or to prices and quality of service measured by the data cap for broadband customers. Data caps rather than actual data consumption were used because arguably the data cap reflects the potential "quality" of service that the customer purchased, i.e. even

if they did not use all their data allocation in a month, they had bought the option to do so.

- The two technology subsets were chosen to allow for the fact that, for many customers, fibre and copper broadband may be close substitutes, and if these are effectively two products in the same market then pass-through may occur to both copper and fibre prices. Alternatively, since UCLL and UBA charges are specific to copper customers, and since retailers can easily differentiate pricing based on technology, pass-through might only occur to copper pricing.

- The two customer tenure subsets were chosen to allow for the fact that pass-through may occur to all customers (on average), or potentially focus on new customers who are often offered special discounts and promotions. However, the number of customers in the sample with tenure of less than six months is relatively small (see section 8) and the analysis where the sample is restricted to such customers may be less reliable.

4.4.4. Summary of basic model specifications

Table 5 summarises the 24 basic model specifications that define the reduce-form pass-through regression models.

Table 5 Summary of basic model specifications

Model	Price units	Price measure	Network	Customer tenure
1	Dollars	Total bill excl. "other"	Fibre & copper	All
2	Dollars	Total bill excl. "other"	Fibre & copper	Short tenure
3	Dollars	Total bill excl. "other"	Copper only	All
4	Dollars	Total bill excl. "other"	Copper only	Short tenure
5	Dollars	Total bill excl. voice calling & "other"	Fibre & copper	All
6	Dollars	Total bill excl. voice calling & "other"	Fibre & copper	Short tenure
7	Dollars	Total bill excl. voice calling & "other"	Copper only	All
8	Dollars	Total bill excl. voice calling & "other"	Copper only	Short tenure
9	Dollars	Monthly fees incl. bundle discounts	Fibre & copper	All
10	Dollars	Monthly fees incl. bundle discounts	Fibre & copper	Short tenure
11	Dollars	Monthly fees incl. bundle discounts	Copper only	All
12	Dollars	Monthly fees incl. bundle discounts	Copper only	Short tenure
13	Dollars / ln(GB)	Total bill excl. "other"	Fibre & copper	All
14	Dollars / ln(GB)	Total bill excl. "other"	Fibre & copper	Short tenure
15	Dollars / ln(GB)	Total bill excl. "other"	Copper only	All
16	Dollars / ln(GB)	Total bill excl. "other"	Copper only	Short tenure
17	Dollars / ln(GB)	Total bill excl. voice calling & "other"	Fibre & copper	All
18	Dollars / ln(GB)	Total bill excl. voice calling & "other"	Fibre & copper	Short tenure
19	Dollars / ln(GB)	Total bill excl. voice calling & "other"	Copper only	All
20	Dollars / ln(GB)	Total bill excl. voice calling & "other"	Copper only	Short tenure
21	Dollars / ln(GB)	Monthly fees incl. bundle discounts	Fibre & copper	All
22	Dollars / ln(GB)	Monthly fees incl. bundle discounts	Fibre & copper	Short tenure
23	Dollars / ln(GB)	Monthly fees incl. bundle discounts	Copper only	All
24	Dollars / ln(GB)	Monthly fees incl. bundle discounts	Copper only	Short tenure

4.4.5. Recurring UCLL and UBA charges

The recurring UCLL and UBA charges that applied in each month were included as explanatory variables in the regression models. The UBA price that was used in the models is the "base" price, i.e. the component of the price that is added to the UCLL price to form the total price of the "full" UBA service. This is to avoid having to estimate separate models for unbundled and non-unbundled customers.

Six different variations of these charges were tested for each of the 24 model specifications defined above (Table 5), giving 144 models in total:

a. Both UCLL and UBA recurring charges, and six-month lags of these

b. Only the UCLL recurring charge and a six-month lag of it

c. Only the UBA recurring charge and a six-month lag of it

d. Both UCLL and UBA charges, and six-month leads of these

e. Only the UCLL recurring charge and a six-month lead of it

f. Only the UBA recurring charge and a six-month lead of it

As noted above, the UCLL and UBA charges were tested separately and in combination to allow for the fact that their correlation may make it difficult to estimate pass-through of each charge when both are included together in a model.

Two variations of the 24 model specifications were tested to estimate the rate of pass-through of the "full" UBA price:

a. The "full" UBA recurring charge and a six-month lag of that charge

b. The "full" UBA recurring charge and a six-month lead of that charge

The variations of six-month lags and leads were tested to allow for different theories of how retailers might respond to regulated changes in wholesale prices. The lag models assume that retailers wait until regulated prices are finalised, and then change retail prices over the next six months to reflect how their costs have changed. The lead models assume that retailers can anticipate regulated price changes six months in advance, using the information available to them during the regulatory process (e.g. any draft decisions published by the Commission, and submissions made by interested parties).

4.4.6. Other control variables

Other explanatory variables were included in the models, to try to control for other factors aside from recurring UCLL and UBA charges that may affect the amounts charged to customers:

- The producer price index (PPI) input cost index for the "telecommunications, internet and library services" sector published by Statistics New Zealand. This is a broad measure of input costs of the communications sector. This data is published on a quarterly basis and was converted to monthly frequency using the Denton-Cholette algorithm. The PPI input cost index has been used as a proxy for components of retailers' costs, e.g. national and international bandwidth costs.

- The monthly average 90-day interest rate published by the Reserve Bank. This may reflect a component of capital costs for retailers. It also reflects general economic conditions (other macroeconomic indicators such as GDP growth are not available at monthly frequency).

- The current and six-month lagged values of the PPI input cost index and 90-day interest rate were also included as explanatory variables, to allow for the fact that retailers may take time to adjust their pricing in response to changes in costs and/or economic conditions.

- The rate of household broadband uptake, measured by the total number of broadband connections in Statistics New Zealand's ISP survey divided by Statistics

New Zealand's estimate of the number of households. Both of data series are published annually, up to the year ending June 2016. These were converted to monthly estimates using the Denton-Cholette algorithm.

- A six-month lag of the weighted average voice calling revenue per customer, calculated across all customers in the dataset each month. This is to control for the fact that demand for fixed-line voice services appears to have been falling over time, which may have affected retailers' pricing strategies and pass-through. This variable was not included in models where the dependent variable was the total bill excluding voice calling charges.

- A six-month lag of average monthly broadband data use per broadband customer, using data from Statistics New Zealand's ISP survey. This is available annually to the year ending June 2016 and was converted to monthly frequency.

- The average "Homeline" wholesale price across the Auckland, Wellington, and Christchurch areas (see section 3.3).

- An estimate of the average connection charge per copper customer and its six-month lag. The average connection cost was calculated using information provided by the Commission, and was calculated per new connection and converted to a monthly cost by assuming recovery over 24 months. Prior to December 2014, connection charges did not apply for most new connections, and the average is estimated to be $0.35 per customer per month. From December 2014 (i.e. at the same time as the reduction in the UBA base price under the IPP) connection charges were more widely applied and the average increased to $2.62 and subsequently gradually declined to around $2.00 by mid-2016.

The rate of broadband uptake, average voice calling revenue, and average broadband data use were included using six-month lagged values only. This is to attempt to avoid the bias that could arise from the fact that current usage and uptake depend partly on retail prices, i.e. current usage and uptake are not exogenous variables. By contrast, the values of these variables six months earlier are pre-determined.

Variations of the models where all lag and lead variables were shifted by three months instead of six months were also tested. The three-month models produced a relatively large number of results where the estimated pass-through coefficients were negative and statistically significant (i.e. counter-intuitive results). The three-month models were therefore not used in the final analysis. The fact that changing the lag and lead duration to three months caused many of the results to be unreliable does raise some questions about the robustness of the results, however this is not considered to invalidate the results of the models with six-month leads and lags. It is plausible that the six-month lag models are more representative of retailers' pricing given that many residential customers are on fixed-term contracts of 12 months or more.

A set of dummy variables were also included in each model:

- Dummy variables indicating the retailer for each bill.
- An indicator of whether the bill was for an "unlimited" broadband plan
- An indicator of whether the customer was served by fibre
- An indicator of whether the bill was for a voice-only service
- An indicator of whether the bill was for a naked broadband service
- An indicator of whether the customer was served by VDSL

The retailer dummy variables were included to control for the fact that there may be systematic differences across retailers in terms of their pricing strategy and the types of customers that they target. These dummy variables play a similar role to "fixed effects" in a panel regression model, i.e. they can control for unobserved factors that affect pricing across retailers or across types of service.

For models including all customers, these retailer dummy variables were interacted with the other dummy variables listed above. This controls for the fact that different retailers may have different pricing strategies and different costs, and may choose to set different price levels overall and/or to target different customer segments.

For the models estimated using only short tenure customers, the retailer dummy variables and interaction of these with other dummy variables were omitted, due to the smaller number of such customers in the sample and the inability to estimate all the interaction effects.

4.5. Caveats and limitations of this analysis

The following should be kept in mind when interpreting the results of the models below:

- With reduced-form regression models, there are always concerns that explanatory variables are not truly exogenous (i.e. depend on price), and/or that other variables that partly determine prices have been omitted from the model. The estimated coefficients on explanatory variables that are not exogenous may be biased.
- The exogeneity issue has been addressed to the extent possible as described above, i.e. explanatory variables that are potentially endogenous have been included with a six-month lag. This allows the trend in these variables to be included but breaks the relationship with current prices. Importantly, the main variables of interest – the UCLL price and UBA base price – are set by regulation and so are independent of retail prices in any given month, i.e. these wholesale price are exogenous.
- All regression models can also suffer from problems caused when relevant explanatory variables have been omitted. Omitted variables may also cause

estimated coefficients to be biased, if the omitted variables are correlated with explanatory variables that have been included and have an independent effect on the dependent variable. Alternatively, if omitted variables directly affect the dependent variable but are not correlated with other explanatory variables then the estimated coefficients of the model may be less accurate (i.e. have larger standard errors than if variables were not omitted) but will not be biased.

- It is possible that relevant variables have been omitted from the regression models estimated here, e.g. cost drivers that are not picked up by the PPI input cost index and the other variables described above. Given that regulated wholesale prices are supposed to reflect costs, it is possible that the UCLL and UBA cost variables could be correlated with such omitted factors. If such factors also affect retail prices independently then the estimated coefficients on UCLL and UBA prices could be biased, i.e. we could reach incorrect conclusions about pass-through. It is also not possible to test whether relevant variables have been omitted from a regression model unless there is data on those variables.

- In terms of potentially omitted costs:

    - While the PPI input index has been used as a proxy, this is not a perfect measure of retailers' costs and it is not clear if this adequately reflects factors such as wholesale national and international backhaul costs.

    - The PPI also excludes labour costs. A labour cost index was tested as a potential explanatory variable in early analysis, however this was highly correlated with the PPI input index and so was not included in the final models.

    - The PPI is considered to be the best available proxy for retailers' costs at the market level. The retailers did not provide an alternative that could be used to control for cost changes in the econometric models.

    - Specific connection charges for new VDSL customers have not been included in the analysis and these are understood to have increased over time. However, the proportion of VDSL customers in the billing dataset is relatively small (see Figure 10 in the appendix) so this is not expected to have a large effect on the results.

- In some of the estimated pass-through models, the estimated coefficients on some control variables are of the opposite sign to what would be expected in theory, and this may be a symptom of bias caused by these variables not being exogenous and/or omitted variables. These problems mostly affect coefficients on the other control variables aside from the UCLL and UBA prices, which is of less concern since it is not necessary to interpret those coefficients to analyse pass-through. However, there are some models in the set of 144 where statistically significant negative rates of pass-through have been estimated.

- The analysis focuses on changes in retail prices for fixed-line services and, to a lesser extent, changes in service "quality" measured by broadband data caps. It is not possible to quantify other dimensions of competition, such as the recent trend towards bundling video content (e.g. Netflix and Lightbox services) and other utilities (e.g. residential electricity and gas) with telecommunications services. It is possible that changes to regulated wholesale prices have affected competition in these other dimensions, and consequently that pass-through has occurred via improvements in quality rather than price reductions, however such changes cannot be easily measured.

- There is not a lot of variation in the wholesale UCLL and UBA charges in the period used to estimate the models. As illustrated in Figure 2, there are only three discrete changes of these regulated prices in this period, and each of the wholesale prices only changes twice. This lack of variation may make it more difficult to estimate pass-through effects than if, say, the wholesale prices had changed every month.

- The lack of variation in wholesale charges also makes it difficult to estimate the coefficients on lags and leads of these charges, because in many months the value of the wholesale charges six months prior or six months later is the same as in the current month.

- Whether the wholesale UCLL and UBA prices are included in the telecommunications sector input PPI, and if so, their relative weight in that index, is not known. However, it is important to control for other factors affecting retailers' costs, so the PPI input index was retained as an explanatory variable in the models.

- There is a relatively high degree of variability in the amounts charged by retailers to customers in the sample. The variability is higher in the data for Spark and Vodafone compared to Vocus. This variability may make it difficult to accurately estimate pass-through effects, particularly for individual retailers.

- Estimating many models and performing many simultaneous tests of statistical significance, such as done here, is likely to produce some "significant" findings that are in fact due to random variation. For this reason, and because the way that pass-through shows up in fixed-line retail markets is uncertain, the interpretation of the results below is based on the total evidence provided by all the models, rather than any one model.

- While some of the models fit the data better than others, there is no strong reason to prefer any one model or sub-set of models over the others. The explanatory power of most of the models is relatively low, but on its own this does not mean that the models are incorrectly specified.

- Changes in wireless broadband technology (which is a partial substitute for fixed-line broadband services) have not been accounted for in the analysis. Such technological changes may have caused unmeasured shifts in demand for broadband services, and

changes in the costs and pricing incentives of retailers that sell both fixed and wireless broadband services.

4.6. Empirical pass-through estimates

The results of estimating the reduced-form models described above are presented in the appendix (section 9). Market-level results were obtained by estimating each model using the combined dataset from all three retailers, by applying weighted least squares with the weights described above. Models 1, 3, and 9 were also estimated using each retailer's data separately, by applying unweighted least squares.[8] Estimation was done using R version 3.3.2. Plots of residuals versus fitted values were visually inspected to determine if there was any remaining structure in the residuals. This did not suggest additional variables needed to be added to the models.

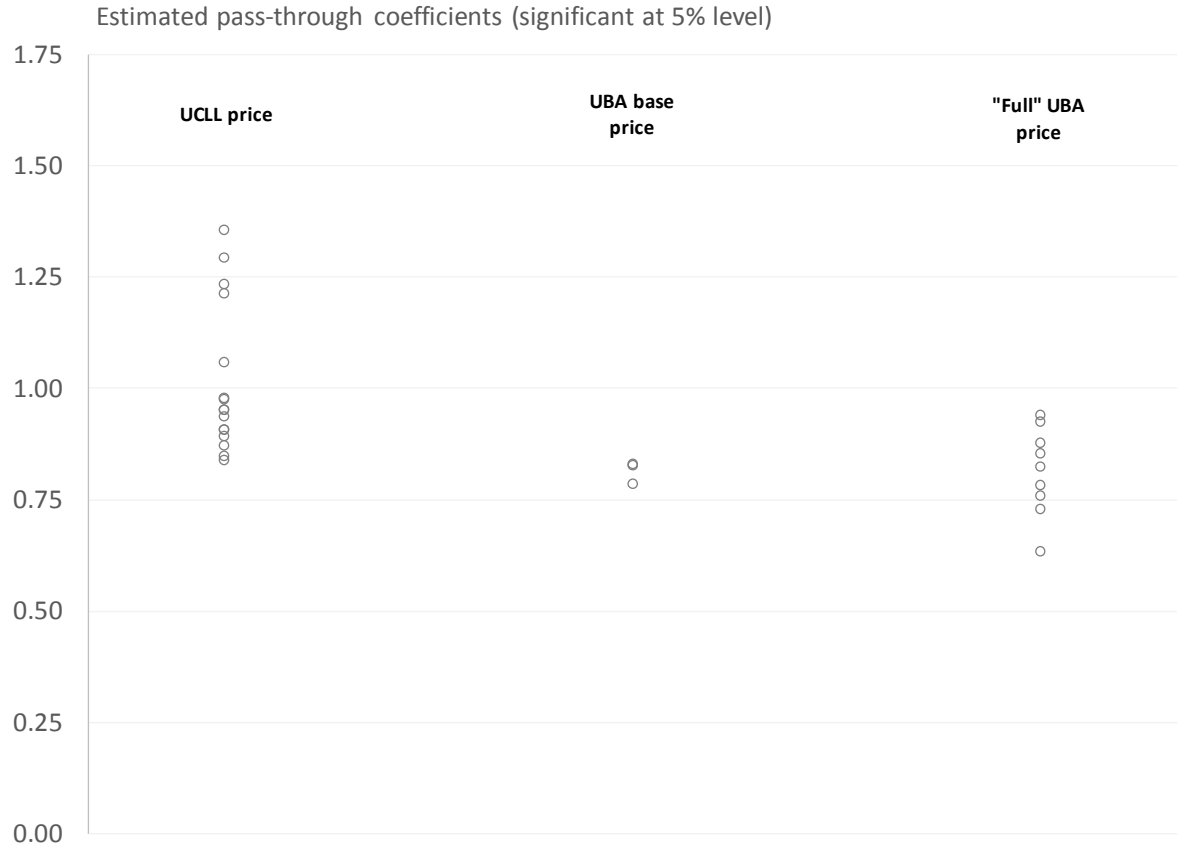
4.6.1. Market-level results

The estimated pass-through coefficients from the various models where price is the dependent variable[9] that are statistically significant at the 5% level are shown in Figure 6, and additional regression results are reported in section 9.1 of the appendix.

[8] For obvious reasons, the retailer dummy variables and interactions with other dummy variables could not be included in the retailer-specific models; otherwise the specification of these models was the same as the market-level models. The "Homeline" variable was excluded from the models for Spark, since Spark sells this wholesale service.

[9] Estimated rates of pass-through in models where the dependent variable is quality-adjusted price are generally lower. However, as discussed below, pass-through rates for price and quality-adjusted price models cannot be easily compared.

Figure 6 Summary of pass-through results for models where price is the dependent variable



At the market level, the regression results suggest the following:

Pass-through of changes in the UCLL price

- There is good evidence of pass-through of changes in the UCLL price to retail prices in relatively unrestricted models where the dependent variable is the total bill excluding "other" revenues (i.e. models 1, 3, 5, and 7). Depending on the model specification, the estimated rate of pass-through is around 100%, i.e. it appears that all of the UCLL price is reflected in customers' total bills. Some of the models estimate rates of pass-through in excess of 100% but this is more likely due to random variation in the data, therefore it seems reasonable to infer a rate of pass-through for the UCLL price of 100%.

- In some models (models 1 and 3), there is evidence of additional pass-through in advance of regulated UCLL price changes. However, the overall evidence for advance changes in prices is not strong.

- In the models where the dependent variable is monthly fees including bundle discounts (i.e. models 9 – 12), the estimated rate of pass-through is around 90%. The fact that this is slightly lower than the estimated rate of pass-through in the total bill models suggests that most pass-through of the UCLL price occurred to monthly fees, however there may have been some small adjustments in prices for parts of the bill, e.g. amounts paid for value-added services or voice calls.

- Pass-through of regulated changes in the UCLL price to retail prices appears to occur relatively quickly, i.e. the estimated coefficients on the six-month lag of the UCLL charge are insignificant and/or small. There is also no clear evidence that retail prices change in advance of regulated price changes, i.e. the estimated coefficients on the six-month lead of the UCLL price are also insignificant and/or small. However, as noted above, accurately estimating timing effects may be difficult due to the lack of variation in wholesale charges over time.

- There is also evidence that changes in the UCLL price are passed through to "quality adjusted" prices (models 13 – 24). If it is assumed that quality (measured by the log of the data cap) is independent of wholesale prices then these results suggest that once changes in quality are controlled for, the rate of pass-through is lower than when quality is not controlled for, and is around 30 – 50%. However, it is plausible that wholesale prices affect quality as well as prices, and in that case the pass-through coefficients of these models cannot be directly compared with the models where the dependent variable is price. The conclusions drawn in section 5 below therefore primarily rely on the pass-through rates estimated in models where the dependent variable is not quality-adjusted, since these rates are more straightforward to interpret.

- Over the period of analysis, the UCLL price has increased overall (see Figure 2). This means that, overall and everything else equal, regulated changes to the UCLL price are estimated to have led to increases in fixed-line retail prices.

Pass-through of changes in the UBA base price

- In models where voice charges are excluded from the dependent variable (models 5 – 8), there is evidence that around 80% of changes in the UBA base price were passed through to retail prices. Since the UBA base price only applies to copper customers where a broadband bitstream service is provided by Chorus, it is perhaps not surprising that pass-through of this price does not appear to occur to other elements of the bundle.

- As with the UCLL price, pass-through of the UBA base price appears to have occurred relatively quickly and there is no evidence of pass-through occurring either six months before or after wholesale price changes. However, again timing effects are difficult to estimate precisely.

- In the models where the dependent variable is "quality adjusted" prices (models 13 – 24), in some cases the estimated coefficient on the UBA base price is statistically significant and negative, but reasonably close to zero. As with the UCLL price, the interpretation of this depends on beliefs about how wholesale prices affect quality.

- Over the period of analysis, the UBA base price has decreased overall (see Figure 2). If pass-through of changes in the UBA base price has occurred, overall and everything else equal it has estimated to have led to decreases in fixed-line retail prices.

Pass-through of the "full" UBA price

Results from the additional 48 models estimated to test pass-through of the "full" UBA price suggest that:

- In models where the dependent variable is the total bill excluding "other" charges (models 1 and 3) there is evidence that around 90% of changes in the "full" UBA price were passed through to retail prices.

- The estimated rate of pass-through of the "full" UBA price drops to around 80% if voice calling charges are excluded (models 5 and 7) and to around 70% if only monthly fees are included (model 9). This suggests that most, but not all, pass-through of the "full" UBA price occurred via changes in monthly fees, with smaller changes in other components of customers' bills.

Explanatory power of the models

- The explanatory power of the models, measured by R-squared, is relatively low. The fitted models explain between 16% and 38% of the variation of the relevant dependent variable. Explanatory power is generally higher for models where the dependent variable is monthly fees including bundle discounts; this is not surprising as monthly fees are affected by fewer factors than other components of a customer's bill.

- The low R-squared values of the fitted models reflect the fact that customers' bills are affected by many factors, but this does not necessarily mean that the models are incorrectly specified or that pass-through coefficients are biased. The goodness of fit of the models can only be improved if other relevant explanatory variables can be found and included in the models.

- The F-statistics of all models are significant at the 1% level, indicating that the estimated coefficients are jointly significant. The F-statistics for the models estimated using only short-tenure customers are noticeably lower than when all customers are included, indicating that the short-tenure results may be less robust. This partly reflects the fact that the number of short-tenure customers in the dataset is relatively small.

Confidence intervals

- There is a relatively high range of uncertainty associated with these pass-through estimates, due to the difficulty of modelling real-world retail pricing in fixed-line markets. The 95% confidence ranges for the pass-through estimates presented above are approximately:

    - Between 30% and 170% pass-through of the UCLL price.

    - Between 5% and 155% pass-through of the UBA base price.

- Between 10% and 170% pass-through of the combined UCLL and UBA base price (the "full" UBA price).

- It is plausible that the true rates of pass-through for the wholesale prices are anywhere within these ranges. The width of these ranges means that it is difficult to be certain about exact rates of pass-through.

4.6.2. Retailer-specific results

The results of estimating models 1, 3, and 9 for each retailer individually are reported in section 9.3 of the appendix. The purpose of this is to cross-check the results from the market-level models where the evidence of pass-through of changes in the UCLL price is strongest, and to see if there are differences in the ways that the three retailers responded to changes in regulated wholesale prices. As with the market-level models, these results should be interpreted by looking across all the models, rather than relying on estimates from any single model.

The retailer-specific results suggest the following:

- There is evidence that Vocus responded strongly to regulated changes in both the UCLL price and the UBA base price. The estimated coefficient on the two wholesale prices in the models estimated with Vocus's data is highly statistically significant in several cases and generally exceeds one.[10]

- There is no clear evidence that Spark or Vodafone responded to regulated changes in the UCLL price. However, in some of the models the estimated UCLL coefficient for Spark is on the borderline of statistical significance with an estimated coefficient close to one. Similarly, in some models for Vodafone the estimated coefficient on the UBA base price is on the borderline of statistical significance with an estimated coefficient around one.

- In some of the models for Vocus, the estimated coefficient on the six-month lead of the UBA base price is significant and negative, while in some other Vocus models, the estimated coefficient on the six-month lag of the UBA base price is significant and negative. The reason for this is not clear, but one possibility is that Vocus incorrectly predicted changes in the UBA base price and changed its retail prices on that basis either some time before or very close to the time of the UBA base price change, then corrected this after the UBA base price was finalised.

- The explanatory power of the retailer-specific models is similar to that for the market-level models. The estimated models can explain the variation in Vocus's bill sample better than for the other two retailers. This may imply that Vocus has adopted a simpler pricing strategy compared to the other retailers, however the data for Vocus relates to its Slingshot brand only, so it is difficult to be sure. As noted above, there appears to be more variability in the charges faced by Spark and Vodafone customers compared to Vocus (Slingshot) customers.

[10] Rates of pass-through in excess of 100% are theoretically possible – see section 7.3.

It should be noted that Spark's pricing is somewhat constrained by the Telecommunications Services Obligation (TSO). This limits its ability to pass on cost increases to voice-only customers. In 2016, such customers make up just under 10% of the overall billing sample on a retailer-weighted basis.

5. Conclusions about pass-through

The following conclusions are based on the analysis presented in the previous sections, relying primarily on the results from the regression models discussed in section 4:

- Between March 2012 and June 2016, the best estimate of UCLL pass-through is that, in aggregate, fixed-line retailers passed through around 100% of changes in the recurring UCLL price to retail prices.

- Pass-through of UCLL price changes also appears to have occurred when prices paid for fixed-line services are adjusted by broadband data caps. If quality is independent of wholesale prices, then adjusting for quality reduces the rate of pass-through of wholesale prices to retail prices. However, if quality depends partly on wholesale prices it is not possible to interpret this rate of pass-through in a simple way, and the pass-through estimates from the quality-adjusted models cannot be directly compared to the models where quality is not controlled for.

- During the period of analysis, the regulated average recurring UCLL price reduced by a small amount in December 2012, and increased by a larger amount in December 2015. Therefore, pass-through of UCLL price changes on their own have mostly led to retail price increases, everything else equal, in the period to June 2016.

- Pass-through of the UCLL price appears to have mainly affected monthly fees for fixed-line services (net of promotions and discounts, including bundle discounts). Amounts paid for other components of the bundle typically purchased by consumers, such as voice calling and value-added services, appear to have been affected but to a much lesser extent than monthly fees.

- There is evidence of pass-through of changes in the UBA base price (i.e. the amount that is added to the UCLL price to get the cost of a wholesale bitstream service) to charges for fixed-line services excluding voice calling. The best estimate is that around 80% of changes in the UBA base price were passed through. Over the period of analysis, the UBA base price has mostly decreased, therefore pass-through of this wholesale price has mostly led to retail price decreases, everything else equal.

The overall impacts of the main regulated changes to the UCLL and UBA base prices can be analysed by comparing the pre-IPP (before December 2014) and post-FPP (after December 2015) periods. Between these periods, the wholesale cost of a copper bitstream service provided by Chorus (i.e. the sum of the UCLL price and the UBA base price) decreased by $3.79 per customer per month. This applies to approximately two-thirds of copper lines. The remaining one-third of lines have either been unbundled or have voice-only service and attract only the UCLL price, which increased by $6.23 per customer per month over the same period.

Pass-through of this combined change in wholesale cost was estimated from an extra set of models where the sum of the UCLL and UBA base price was used as an explanatory variable

in place of the individual prices. Results from these models suggest pass-through of around 90% of the change in the 'full' UBA price (i.e. a $3.41 reduction in retail price on average).

When interpreting the above results, it should be kept in mind that:

- The estimated 95% confidence intervals for the pass-through rates are relatively wide, due to the inherent variability in the billing data that cannot be explained by simple cost and demand drivers. It is possible that the true rates of pass-through during the analysis period were significantly higher or lower than the point estimates presented above.

- Pass-through may have occurred through unmeasured improvements in quality, rather than (or as well as) reductions in prices. During the period of analysis, fixed-line retailers have started to bundle content platforms with broadband services, and bundling of fixed-line services with other utilities such as electricity and gas has become more common.

6. Appendix 1: Regulatory decisions and related events

The following table was provided by the Commission and summarises regulatory decisions and other events that are relevant to the analysis in this report. The information in this calendar was used to construct the history of wholesale prices shown in Figure 2.

The UBA price here is the price column is expressed as the UBA bitstream component to which a line access charge, resold voice service or equivalent must be added. The most notable retail price changes are also listed.

N = wholesale price payable by retailers to Chorus to get a naked broadband service - and by Telecom/Spark to get UBA + baseband to provide broadband + voice using Spark's voice equipment.

V = wholesale price payable by retailers to Telecom/Spark + Chorus to get a broadband and analogue voice service.

Event/announcement/decision	**Date**	**Price(s)**	**Actual price**	**Actual "full" UBA price**
UCLL price (also line access charge for UBA) set by benchmarking	7 Nov 2007	$24.46 avg $19.84 urban $36.63 non-ub	$19.84 UCL urban $36.63 UCL non-ub	
Telecom raises Homeline prices	1 June 2011	$41.60 Wg, CC $45.75 Auk $50.23 RoC	34.37 W/S 37.79 W/S 41.50 W/S	Prices from 1 Dec below
Legislation to make UBA cost-based from 1 December 2014 passed	30 June 2011	N/A		
Draft decision on UCLFS (baseband for voice service)	16 Sept 2011	$23.93		
Final decision on averaged UCLL price set by benchmarking to apply from 1 Dec 2014	24 Nov 2011	$24.46		
Final decision on UCLFS price set by benchmarking to apply from 1 Dec 2011	24 Nov 2011	$24.46		
Structural separation of Telecom occurred	30 Nov 2011			
Post structural separation prices apply	1 Dec 2011	$21.46 UBA	As above	$45.92 N 55.83 V 59.25 V 62.96 V
Draft decision on re-benchmarking UCLL price	4 May 2012	$19.75		
Commission announces further discussion paper on copper pricing	21 June 2012	N/A		
Discussion document on approach to setting UBA cost-based price released	26 July 2012	N/A		
Proposed framework for considering copper prices released	17 Aug 2012	N/A		
Telecom revamps Homeline and increases prices but only for new customers	1 Oct 2012	$46 A, W, Cc $51 RoC		
Telecom and Vodafone introduce entry level fixed line telephone and broadband bundles with 30GB of data, enough for an average user and $10 a month less than previous comparable bundles	October 2012	$75 retail bundle price		

Draft benchmarked cost-based UBA price for 1 Dec 2014 announced	3 Dec 2012	$8.93		
UCLL benchmarked price revised with averaged price to take effect from 1 Dec 2014 and non-averaged prices to take effect immediately (and averaged for UBA)	3 Dec 2012	$23.52 avg $19.08 urban $35.20 non-ub	$19.08 UCL urban $35.20 UCL non-ub	$44.98 N 55.83 V 59.25 V 62.95 V
Telecom increases Homeline prices for existing Wellington and Christchurch customers to match Auckland	1 Sept 2013	$45.75	37.79 W/S	$59.25 V
Final decision on benchmarked cost-based UBA price for 1 Dec 2014	5 Nov 2013	$10.92		
Consultation document on cost modelling price for UCLL released and announced that request received to cost model UBA price	6 Dec 2013	N/A		
Chorus makes a presentation suggesting what cost modelled prices for UBA and UCLL should be	7 Oct 2014	$12 UBA $33 UCLL		$45 N implied
Geographically averaged UCLL price and re-benchmarked UBA price applied	1 Dec 2014		$23.52 UCL	$34.44 N
Draft cost modelled prices for UBA and UCLL to released	2 Dec 2014	$10.17 UBA $28.22 UCLL		
Spark and Vodafone increased the price of the entry level phone line broadband bundle with 40GB of data	1 Feb 2015	$79 retail bundle price		
Spark increases line rentals for all residential customers	1 Feb 2015	$50 A,W, Cc $53.50 RoC	41.31W/S 44.19 W/S	52.23 V 55.11 V
Further draft decisions on modelled UBA and UCLL prices - averages for 5 year price paths	2 July 2015	$10.84 UBA av $27.59 UCLL av		
Final decision on cost modelled UBA and UCLL prices to apply from notification date – averages and 5 year price path	15 Dec 2015	$11.06 UBA $30.63 UCLL if 5 year avg		
Year 1 FPP prices applied	16 Dec 2015	$11.44 UBA	$29.75 UCL	$41.19 N
Spark increases price of entry level broadband bundle with 40GB of data	1 Feb 2016	$84.99 retail		
Spark increase Auck, Wgtn and Chch residential line rental to match the rest of the country	1 Feb 2016	$53.50	44.19 W/S	55.63 V
Vodafone increases price of broadband bundles to follow Spark apart from 40GB which is was offered only as a special BYO modem offer	1 March 2016	$74.99 retail BYO modem		
Year 2 FPP prices applied	1 Dec 2016	$11.22 UBA	$30.22UCL	$41.44 N
Year 3 FPP prices applied	1 Dec 2017	$11.01 UBA	$30.70UCL	$41.71 N
Year 4 FPP prices applied	1 Dec 2018	$10.83 UBA	$31.19UCL	$42.02 N
Year 5 FPP prices applied	1 Dec 2019	$10.67 UBA	$31.68UCL	$42.35 N

7. Appendix 2: Pass-through economics

This section briefly reviews the economic theory relating to pass-through of changes in firms' marginal costs. A lot of the material in this section is based on a detailed review of pass-through economics prepared by RBB Economics for the UK's Office of Fair Trading.[11]

7.1. Measuring pass-through

Pass-through can be measured as the change in a firm's output price(s) in response to a change in the price of one of its inputs. This is usually expressed in percentage terms, e.g. if a $1 per-unit cost increase caused an 80c per-unit price increase, pass-through is said to be 80%. Less commonly, pass-through can be expressed as an elasticity, e.g. if a 1% increase in unit costs causes a 0.6% increase in unit price, then the pass-through elasticity is 0.6.

In real-world markets, firms often compete on quality and other differentiators, as well as prices. This makes analysis of pass-through more challenging. Pass-through where firms compete on both price and quality is discussed further below.

7.2. Summary of relevant theoretical pass-through results

The key results from the theoretical literature that are relevant to analysis of regulated changes in wholesale telecommunications prices are:

- The rate of pass-through of changes in marginal cost of an input to changes in prices depends on the "curvature" of demand, whether firms have increasing, decreasing, or constant returns to scale, and the intensity of competition among firms.

- Many theoretical models predict that pass-through is higher if the intensity of competition among firms is greater. However, for some types of demand curvature, pass-through could decrease as competition becomes more intense.

- A wide range of pass-through rates are possible even in the extreme cases of monopoly or perfect competition. For example, high rates of pass-through are theoretically profit-maximising behaviour for a monopoly under certain demand and cost conditions. It is even theoretically possible for monopoly pass-through to exceed 100%. Similarly, pass-through in a perfectly competitive market could be relatively low.

- If firms compete on quality as well as price, then changes in costs will generally lead to some change in firms' choice of quality, as well as price. This complicates the relationship between cost changes and price changes, since consumers' willingness to pay for a product depends partly on its quality, and firms will take this into account when setting prices. It is theoretically possible that a cost reduction could lead to an increase in quality and an *increase* in price, i.e. "negative" pass-through if

[11] *Cost pass-through: Theory, measurement, and potential policy implications*. RBB Economics report for the Office of Fair Trading, February 2014.

we look at the effect on price alone.

- In oligopoly markets, pass-through of industry-wide cost changes that affect all firms equally is generally expected to be greater than that of firm-specific cost changes that affect only one firm or a subset of firms in the market.

These results imply that:

- It is not possible to assess pass-through in a market using theory alone, and empirical analysis of changes in costs and market outcomes is necessary.

- Empirical estimates of pass-through in a market do not, on their own, provide strong evidence about the intensity of competition in that market, because any given competitive intensity could be consistent with a wide range of pass-through rates. However, analysis of pass-through may be useful for analysis of competition if it is combined with other evidence about competitive intensity.

- Some consideration must be given to changes in quality as well as changes in price, if quality is an important strategic variable of firms.

The following sub-sections explain these results in more detail. For clarity, the discussion below considers the case of an increase in marginal costs, however the same results apply in reverse for a decrease in marginal costs.

The last sub-section briefly considers issues that arise in the empirical estimation of pass-through from market data.

7.3. Pass-through of industry-wide cost changes where firms compete only on price

If firms only compete on price, the theoretical rate of pass-through of industry-wide cost changes depends on the intensity and nature of competition among firms (i.e. whether products are homogeneous or differentiated in some way), the curvature of demand, and whether firms have constant, increasing, or decreasing marginal costs.

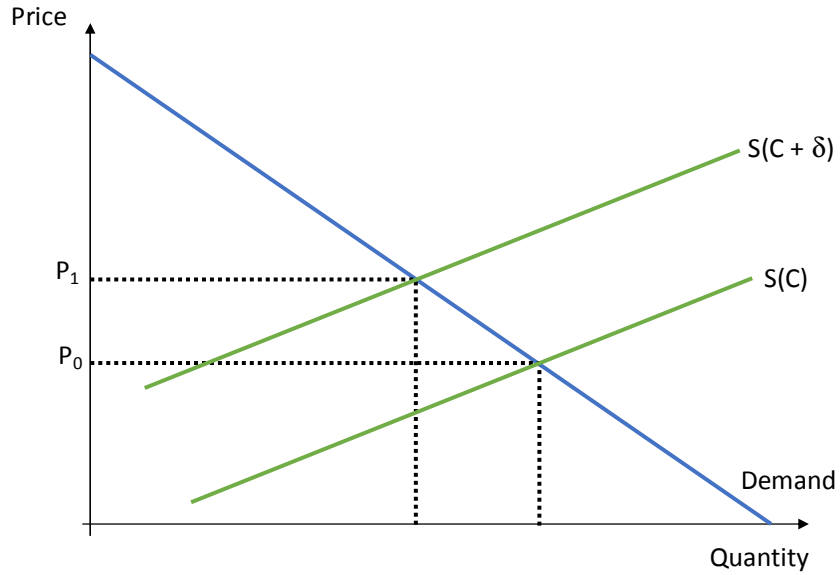
7.3.1. Homogeneous products

Theoretical analysis of pass-through of industry-wide cost changes is most straightforward when firms sell a single, identical product. The results differ depending on the assumed model of competition.

Perfect competition

In a long-run equilibrium in a perfectly competitive market, free entry and exit means that firms make zero economic profits. If firms' marginal costs increase by a constant amount δ, each firm will require the price it receives to also increase by δ to continue supplying the same quantity. The industry supply curve therefore shifts upwards vertically by δ, and the impact on the equilibrium market price depends on the price elasticity of the market demand and supply curves (Figure 7).

Figure 7 Illustration of perfectly competitive pass-through



In a perfectly competitive setting, it is possible to show that:

$$\text{pass-through} = \frac{1}{1 + \frac{e_D}{e_S}}$$

where e_D is the absolute values of the price elasticity of the market demand curve and e_S is the price elasticity of the market supply curve.

Thus, in a perfectly competitive market, if supply is perfectly elastic (i.e. $e_S = \infty$), pass-through will be 100%. This occurs in the long run if firms' costs exhibit constant returns to scale, i.e. the long-run market supply curve is horizontal. Otherwise, pass-through will be less than 100%, and will depend on the elasticities of both demand and supply.

Monopoly

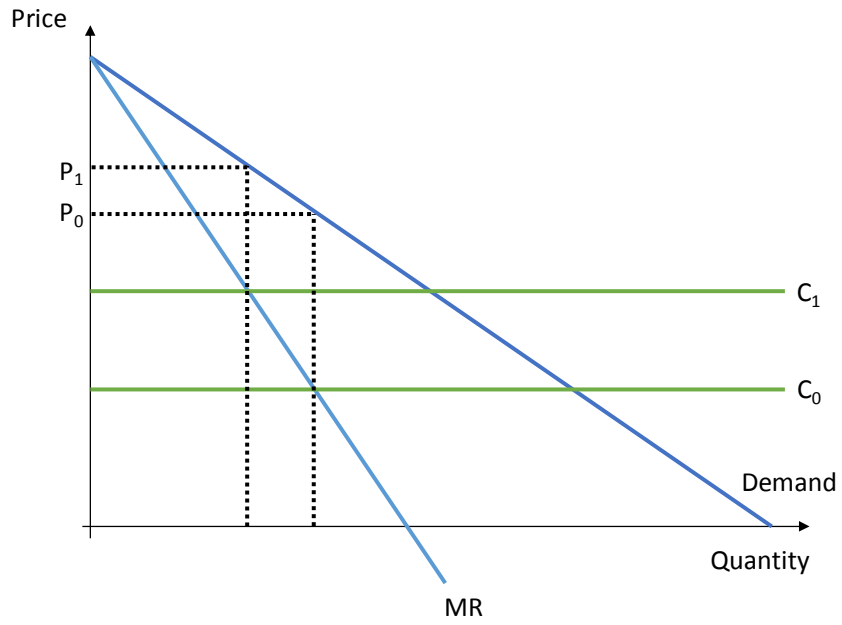
Monopolists maximise profit where marginal revenue equals marginal cost, and thus an increase in marginal cost will cause a monopolist to reduce its output (i.e. increase its price) to increase marginal revenue.

In the simple case where a monopolist's marginal cost is constant with respect to its output level, pass-through is given by:

$$\text{pass-through} = \frac{\text{slope of demand}}{\text{slope of marginal revenue}}$$

When marginal cost increases, the monopolist must reduce its output to increase marginal revenue. The required reduction in output depends on the slope of the firm's marginal revenue curve. This reduction in output corresponds to an increase in price, which depends on the slope of the demand curve (Figure 8).

Figure 8 Illustration of monopoly pass-through with constant marginal cost.



With constant marginal cost, monopoly pass-through can also be expressed as:

$$\text{pass-through} = \frac{1}{2 + e_{SID}}$$

where e_{SID} is the elasticity of the *slope* of the inverse demand curve, i.e. a measure of the "curvature" of demand. In the simple case of linear demand, $e_{SID} = 0$, and hence monopoly pass-through equals 50%. However, with non-linear demand, it is theoretically possible for monopoly pass-through to take on any value between 0 and 100%, or even to exceed 100% if demand is sufficiently convex.

If marginal cost is not constant with respect to the monopolist's output, the general expression for monopoly pass-through becomes:

$$\text{pass-through} = \frac{\text{slope of demand}}{\text{slope of marginal revenue} - \text{ slope of marginal cost}}$$

Thus, for example, if a monopolist faces increasing marginal costs as its outputs increases, the rate of pass-through will be less than if marginal costs are constant, everything else equal. This is because the reduction in output that occurs as part of the pass-through response will cause marginal cost to decrease as well as marginal revenue to increases. This means that a smaller total change in output is required compared to the case where marginal cost is constant.

Overall, the theoretical pass-through results for monopoly show that pass-through depends on the shape of demand and cost curves, and pass-through can take on a wide range of values even when the firm faces no competition.

Oligopoly

Theoretical analysis of pass-through in oligopoly markets is more complicated because the strategic interactions between firms must also be considered. In the well-known Cournot model where n identical firms compete in quantities and have constant marginal costs, pass-through is given by:

$$\text{pass-through} = \frac{1}{\frac{n+1}{n} + \frac{e_{SID}}{n}}$$

where e_{SID} is the elasticity of the slope of inverse demand.

In the Cournot model, pass-through therefore depends on the number of competing firms, which can be thought of as reflecting the intensity of competition in the market. With constant marginal costs and if demand is not too convex (i.e. $e_{SID} < -1$), the rate of pass-through increases with the number of firms. However, if demand is very convex, pass-through may reduce with the number of firms, thus the relationship between the number of firms (competitive intensity) and pass-through is not clear-cut even in this simple model.

Under the further simplifying assumption of linear demand, the rate of pass-through in the Cournot model reduces to $n/(n+1)$, which only depends on the number of firms. This includes the monopoly rate of pass-through (50%) when $n = 1$ and approaches 100% as n becomes large. However, as seen above, pass-through is no longer restricted to be between 50% and 100% if demand is not linear.

Theoretical expressions of pass-through in the Cournot model are more complicated if firms are not identical (e.g. have different cost functions) and/or do not have constant marginal costs with respect to output. This serves to further emphasise the point that a wide range of pass-through rates are theoretically possible for any given market structure (i.e. any given number of firms in the Cournot model).

7.3.2. Differentiated products

The above discussion assumed that all firms sell an identical product. This simplifies the analysis of strategic interactions between firms, and leads to relatively straightforward expressions for pass-through. However, in many real-world markets, firms sell differentiated products that are not perfect substitutes in the eyes of consumers.

In a simple differentiated product model where symmetric firms have constant marginal costs and compete in prices (i.e. “Bertrand” competition), the rate of pass-through is given by:

$$\text{pass-through} = \frac{1}{2 - D + \frac{e_{SD}}{e_p}}$$

where D is the aggregate diversion ratio (the proportion of sales that a firm loses to its rivals as it raises its price), e_{SD} is the elasticity of the slope of demand, and e_p is a firm's own-price elasticity of demand. In this situation, pass-through therefore depends on the degree of differentiation of the firms' products (represented by D), and properties of demand.

In the simple case of linear demand, the above expression reduces to $1/(2 - D)$, which encompasses the monopoly case of 50% pass-through with linear demand (i.e. $D = 0$), and increases to 100% as the firms' products get closer to being perfect substitutes (i.e. $D = 1$).

However, as illustrated above, if demand is not linear then the relationship between pass-through and the intensity of competition is more complex, and the rate of pass-through may take on a wider range of values. The expression for pass-through is further complicated if firms' marginal costs are not constant. In that case, the rate of pass-through also depends on the slope of the marginal cost curve, as for monopoly above.

7.3.3. Bundled products

If firms sell bundles of products, such as a bundle of broadband and voice services, changes in costs of any part of the bundle will be passed through to the bundle price. In addition, changes in demand for any part of the bundle may affect the rate of pass-through.

For example, if demand for voice services is falling, this will reduce demand for bundles of voice and broadband, everything else equal, and may change the elasticity of demand. As described above, the impacts of such changes depend on the properties of demand for bundles and how this changes. In a simple perfectly competitive setting, if falling voice demand makes demand for broadband and voice bundles more price sensitive, i.e. the elasticity of demand increases, then the rate of pass-through is expected to be lower (see section 7.3.1 above).

7.4. Pass-through of firm-specific cost changes

Theoretical analysis of pass-through in oligopoly markets is more complicated if the cost change in question applies to only some firms or affects different firms in different ways. In general:

- Pass-through of firm-specific cost changes depends on the intensity and nature of competition (i.e. whether products are homogeneous or differentiated), the curvature of demand, and the shape of firms' cost functions, as in the case of industry-specific cost changes.

- In the Cournot model with constant marginal costs, pass-through of firm-specific cost changes will be less than pass-through of industry-wide cost changes, where the difference depends on the total number of firms in the market and the number of firms that received the cost change.

- In the Bertrand model with differentiated products, pass-through of firm-specific cost changes will also generally (but not always) be less than pass-through of industry-wide cost changes. Pass-through of firm-specific cost changes may *reduce* as the number of competing firms increases, as with greater competition each individual firm has less ability to increase its price in response to a cost change. In contrast, pass-through of industry-wide cost changes generally increases as the number of competing firms increases.

7.5. Pass-through where firms compete on both quality and price

As mentioned above, if firms compete on both quality and price, theoretical analysis of pass-through is even more complicated since firms have multiple strategic variables, and because the firms' price and quality choices are interrelated due to the influence of quality on demand and willingness to pay of consumers.

The RBB Economics report cited above provides a relatively tractable model to illustrate pass-through issues where there is price and quality competition. This model makes several specific assumptions (e.g. a functional form for demand), so its results are not general. However, it is useful for illustrating the complexities that arise in analysing pass-through in such a setting.

In the model used by RBB, two horizontally differentiated firms with symmetric production costs first choose the quality levels of their products, then compete on price taking quality as given. Higher quality levels are assumed to be costlier, but the marginal cost of production is assumed to be independent of the quality level. After solving for the strategic equilibrium of this two-stage model, RBB analyse the impacts of a change in marginal cost on equilibrium prices and quality levels.

The main result is that the relationship between marginal cost and the equilibrium price is not constant, and depends on the degree of differentiation of the firms and the cost of improving quality. In addition:

- An increase in marginal cost may cause the firms to *reduce* their equilibrium prices. This occurs if the firms' products are close substitutes, so that even a small increase in one firm's price would cause a large loss of market share, and if the cost of increasing quality is relatively low. In such a case, a firm will respond to an increase in marginal cost by significantly reducing its quality and reducing its price.

- Firms may respond more strongly to changes in other firms' costs, if competition is intense and the cost of quality is low. An increase in one firm's cost will cause it to reduce its quality, and its rival will respond by raising quality and raising its price. If competition is intense and it is cheap to increase quality, the rival may increase its price by more than the firm experiencing the cost increase.

- A wide range of pass-through rates are possible, once effects on quality and the consequences for consumers' willingness to pay are considered.

7.6. Empirical estimation of pass-through

Given the wide range of pass-through rates that are theoretically possible even in simple models, empirical analysis must be performed to estimate the rate of pass-through in any market. There are two main ways that this can be done:

1. Assume a theoretical (structural) model and set the parameters of this model either by econometric estimation of structural equations, or by calibration so that the predictions of the model match some observations of market outcomes.

2. Estimate the relationship between costs and prices using a "reduced form" regression model that does not make strong assumptions about the process of competition or the shape of the demand curve (for example).

If the objective is simply to understand the relationship between costs and prices, the second "reduced form" approach is arguably more straightforward and flexible, however care must be taken to account for all relevant costs and other factors that may have affected prices (this is discussed further below). The structural approach is more useful if there is a need to use the model for other purposes, for example to estimate the effects on pass-through and prices of a proposed merger in a market.

7.6.1. General guidance for empirical analysis

The RBB Economics review offers the following general guidance for empirical estimation of pass-through:

- It is important to obtain data on appropriate measures of cost. If all relevant cost changes are not included in the analysis, pass-through rates may be over-estimated. If irrelevant cost changes are included, pass-through rates may be under-estimated.

- The relationship between prices and different categories of cost should be estimated rather than assumed. For example, in some cases changes in fixed costs may be passed through.

- Time lags in the response of prices to changes in cost must be accounted for.

- Other factors that may also affect prices (e.g. changes in demand) must be controlled for to isolate the effect of cost changes on prices.

- Care must be taken to avoid using overly restrictive demand and cost specifications, given the key role that these play in determining pass-through rates. It is preferable to use flexible functional forms.

- There is no perfect method for estimating pass-through and empirical results should be evaluated with reference to the limits of each approach. Where possible, results should be checked for consistency by using different methods for estimating pass-through.

- Pass-through only represents one aspect of the assessment of competition in a market, and pass-through rates should not be analysed in isolation. Other relevant context and features of market competition must be considered when analysing and interpreting evidence about pass-through.

7.6.2. Estimating pass-through with a "reduced form" model

The "reduced form" approach involves estimating a regression with price as the dependent variable and relevant costs and other variables that are expected to influence prices as the explanatory variables. In contrast with the structural approach, the reduced form approach does not require making specific assumptions about the model of competition among firms or the characteristics of demand and costs. Instead, these features of the market are implicitly embedded in the coefficients of the reduced-form model that is estimated.

This means that the reduced form approach is not usually able to estimate underlying structural parameters of the market in question. However, for simple pass-through analysis this may not matter, if all we are interested in is the empirical relationship between costs and prices once competition has played out. If such a relationship is all that is required, the reduced-form approach is relatively simple to implement.

For example, we could estimate a linear model of the form:

$$p_i = a + b_1 c_i + b_2 X_i + e_i$$

where p_i is the relevant price
c_i is the relevant cost
X_i is a matrix of other factors believed to influence prices
e_i is an error term with zero mean and constant variance

The definition of "i" in this equation depends on the data that is available. If we have time-series data on prices and costs of a single product over time, i will represent different points in time. Alternatively, we might have prices and costs for a cross-section of firms or products at a given point in time, or panel data for the prices and costs for firms and products at various points in time.

In the equation above, the coefficient b_1 is an estimate of the overall rate of pass-through, which implicitly depends on the intensity and nature of competition in the market, and the characteristics of demand and costs, as explained previously. For b_1 to be unbiased, the cost variable c_i must be exogenous. This means that there are no variables omitted from the model (i.e. not included in X_i) that that affect both costs and prices.

Costs are trivially exogenous if firms face constant marginal costs. However, in many cases marginal costs are unlikely to be constant except perhaps for small changes in the level of output. Otherwise, if marginal costs are not constant then there may be variables omitted from the model that affect both costs and prices (e.g. unobserved factors that shift the demand curve). Such effects will be captured in the error term e_i and thus the cost variable and error term will be correlated. If present, such correlation violates one of the assumptions of OLS regression and means that the estimate of b_1 will be biased.

Fortunately, if we are only interested in the pass-through of *regulated* costs to prices, it is safe to assume that these costs are truly exogenous, and bias in the estimated pass-through coefficient is less of a concern.

Even if it is unbiased, for the estimated pass-through coefficient b_1 to be as accurate as possible, we must also take care that:

- All other factors that could affect prices are included in X_i; and
- The functional form of the estimated regression model is correct.

Including other factors that could affect prices in the model obviously depends on relevant data being available. It is more difficult to know the appropriate functional form, but it is common to use a linear functional form as this approximates any arbitrary functional form for small changes in the explanatory variables. There are also diagnostic tests that can be performed on an estimated regression model to test for evidence of omitted variables or incorrect functional form (e.g. the RESET test).

With panel data, it is possible to control for certain types of unobserved factors that may affect prices by including so-called "fixed effects" in the model. This is done by including dummy variables in the model for each group of the cross-sectional dimension of the data, or for each unit of time.

For example, if we have panel data for multiple firms over time, we could include a dummy variable for each firm. These dummy variables would capture any unobserved firm-specific effects on prices (e.g. the effect of product differentiation or brand loyalty) as long as these effects are constant over time. Alternatively, dummy variables can be included for each time period, to capture unobserved time-specific effects on prices that are constant across firms. Obviously, it is not possible to include fixed effects across both firms and time, as this would require estimating more coefficients than the number of observations in the dataset.

7.6.3. Controlling for other factors that affect retail prices

As explained above, it is important to include in an estimated reduced-form model all factors other than costs that may affect prices, to eliminate possible sources of bias and estimate the pass-through coefficient as accurately as possible. In retail broadband and voice markets, important factors that affect retail prices include retail pricing strategies and competition, and the influence of other costs aside from the regulated wholesale prices. However, it is not always possible to find variables that measure these factors so that they can be included in econometric analysis.

Retail pricing strategies and competition

Fixed-line retailers in New Zealand have at different times used various pricing strategies, including:

- Incentives for new customers: New customers are commonly offered incentives in the form of a few months of free service, or a discounted price for the first six or twelve months. Discounts may also be offered to existing customers threatening to

change to another retailer. Such discounts are not typically offered to existing customers who simply change plans.

- "Grandfathering" of existing pricing plans: While new plans may be offered to new customers and existing customers that choose to change plan, existing plans may be "grandfathered" so that existing customers can remain on them. This may or may not be beneficial for those customers, depending on how new plans compare to the existing ones in terms of pricing and other characteristics.

- Price discrimination: Retailers commonly offer a range of different broadband services differentiated by data caps designed to appeal to different types of customers. Different prices are also typically charged for broadband provided by fibre, VDSL, and ADSL, due to the differences in data transfer speeds and service quality.

- Geographic pricing: While less common now, in the recent past retailers sometimes charged different prices in different areas, or depending on whether the customer was served by an unbundled line or not.

- Bundled services and bundle discounts: Some retailers offer other services in addition to fixed-line voice and broadband, and some offer discounts for purchasing a bundle of services. Both Vodafone and Spark have offered discounts to customers who buy both fixed-line and mobile services. Some retailers bundle entertainment services, e.g. Spotify, Lightbox, and Sky TV. Trustpower offers bundles of electricity and broadband services.

Other costs

In addition to the costs of the wholesale UCLL and UBA services, retailers face direct costs to provide fixed-line and broadband services for:

- The equipment used to provide broadband and voice services from the exchange for unbundled lines.

- The cost of the platform to provide voice services. This could be provided by the retailer's own platform, or they could purchase the wholesale Homeline service from Spark.

- The cost of national and international backhaul for data traffic.

- The costs of the customer premises equipment (CPE, typically a combined broadband router and wifi base station) and/or connection, which are often provided "free" to customers (i.e. recovered from ongoing charges).

The difference between the retail price and these direct costs gives the retailer a margin that contributes to covering its other overhead costs, such as:

- Customer support, billing, and credit control.

- Marketing and other retailing costs, e.g. the costs associated with operating retail stores.

- “Core” network infrastructure that supports multiple services, e.g. network switches and backup systems.

- Head office and other administrative overhead.

8. Appendix 3: Characteristics of the billing sample

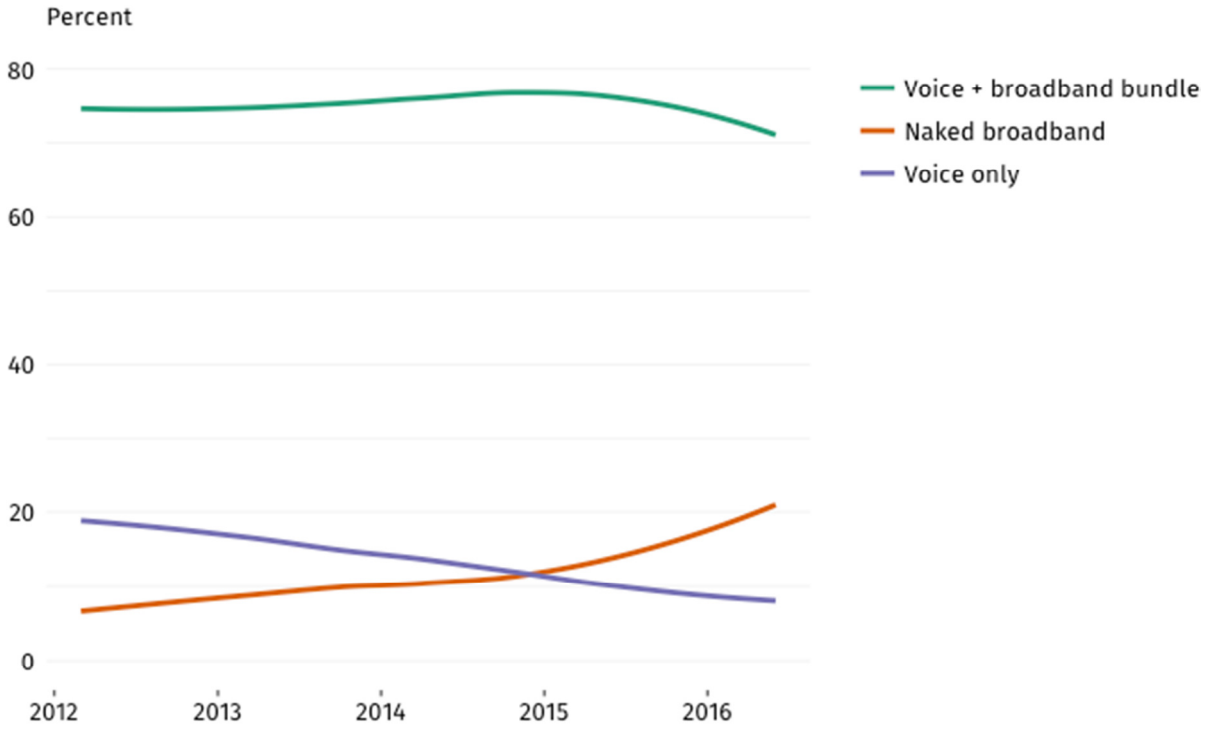
The following sections summarise the characteristics of the bills in the combined sample from Spark, Vodafone, and Vocus. This dataset consists of 77,922 invoices for residential fixed-line voice and broadband services over 52 months from March 2012 to June 2016. To calculate the aggregated results below, responses were weighted by the estimated relative market shares of the retailers among residential customers in each month and the valid number of responses provided by each retailer in each month (see section 4.3 details).

There is some variation from month to month in the characteristics of customers in the sample. Much of this is likely due to sampling variation, so all charts below have been smoothed over time to eliminate short-term variations and highlight the overall trends that are more likely to reflect changes in the composition and characteristics of the customer base.

8.1. Type of retail service

The estimated proportion of customers buying naked broadband plans has increased from around 7% in early 2012 to just over 20% in mid-2016, while the proportion of customers buying voice-only service has steadily declined (Figure 9). The proportion of customers buying voice and broadband bundles appears to have peaked in early 2015 but as at mid-2016 the bulk of customers are still buying such bundles.

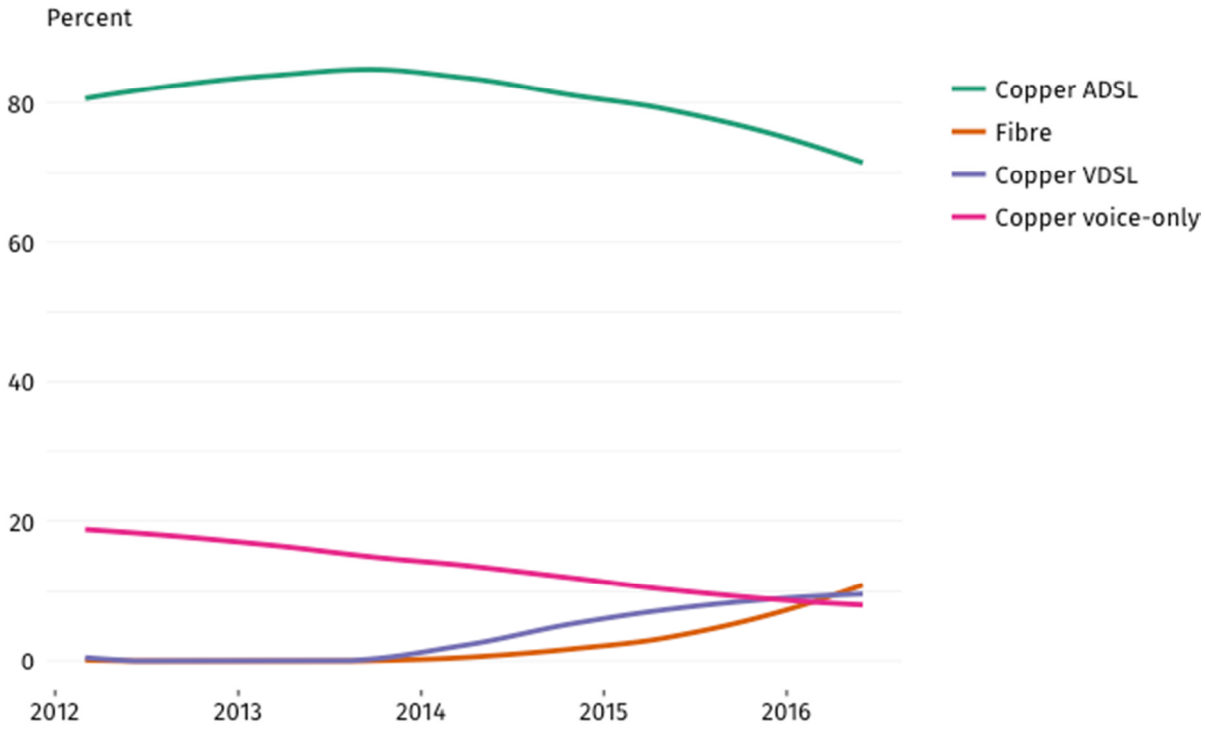
Figure 9 Weighted proportion of customers by retail service type.



8.2. Technology used to provide service

The proportion of customers using copper ADSL appears to have peaked in late 2013, however remains at just over 70% as at mid-2016 (Figure 10). The proportion of fibre customers has increased rapidly from the start of 2014, reaching just over 10% by mid-2016. The proportion of copper VDSL customers has also grown over the same period, but it appears that the growth rate of VDSL connections has slowed as fibre has accelerated.

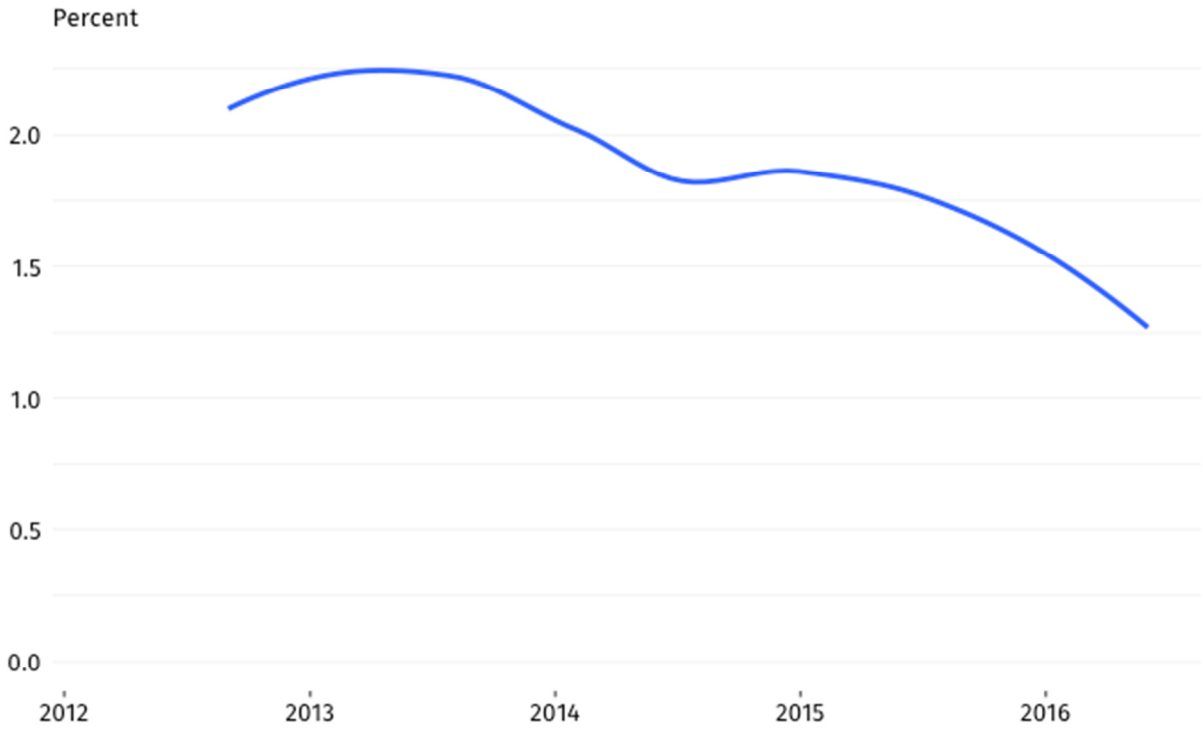
Figure 10 Weighted proportion of customers by network type.



8.3. Customer tenure

Most customers in the sample have been with their current retailer for more than six months (Figure 11). The proportion of customers who have been with their retailer for six months or less has generally declined over time and as at mid-2016 is estimated to be around 1.25% of residential customers.

Figure 11 Weighted proportion of customers who have been with their current retailer for six months or less.

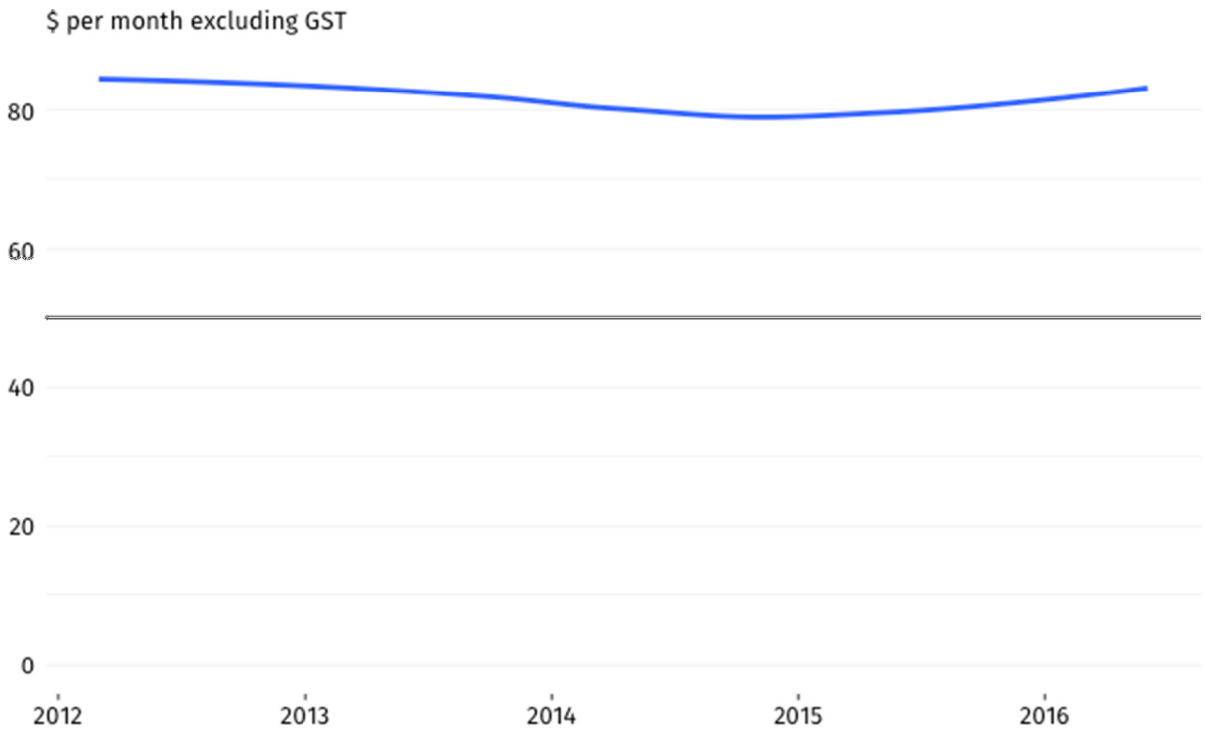


8.4. Average bill per customer

8.4.1. Total bill for all customers

Figure 12 shows the total average bill per residential customer over time, across all customers, net of any discounts and refunds. Changes in this average over time reflect changes in retail prices, changes in usage levels (e.g. voice calling) and changes in the type of service that customers receive (the proportion of voice-only customers). This means that it is not possible to reach conclusions about pass-through by looking at changes in the total bill alone. The overall average has not changed greatly over time and was around $83 in 2012 and around $82 in 2016 (excluding GST).

Figure 12 Weighted average total bill per month, including bundle discounts.

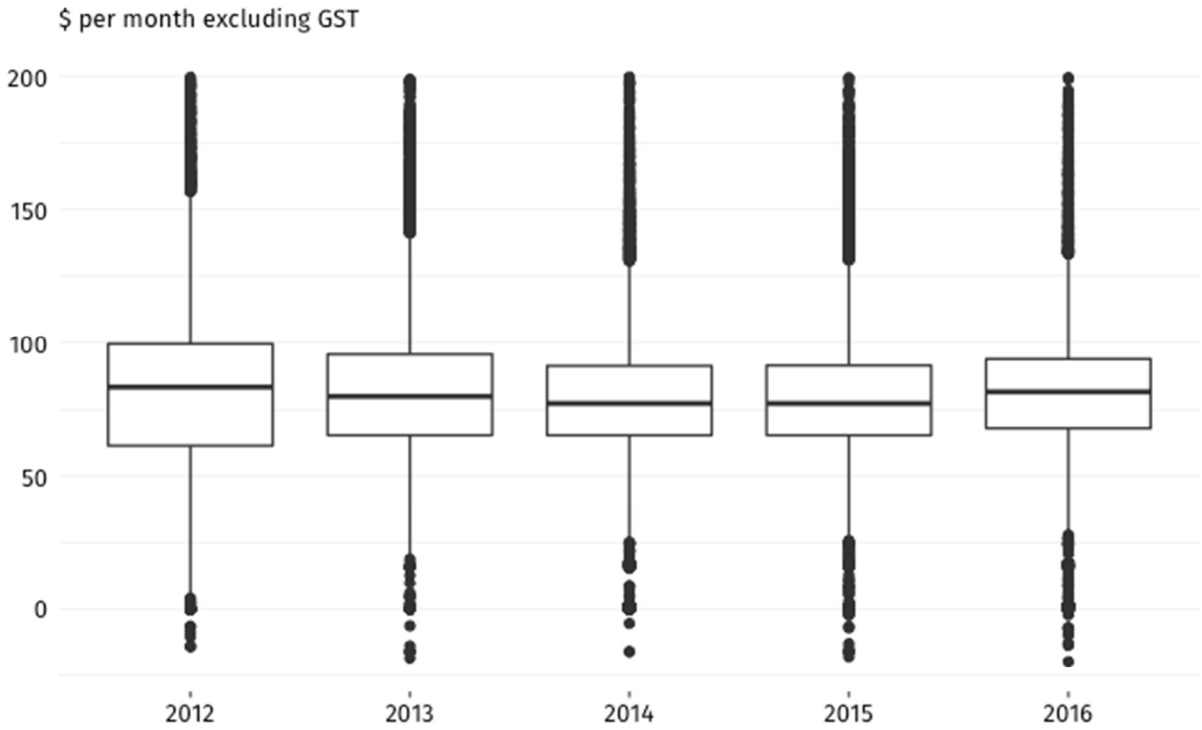


8.4.2. Distribution of the total bill for all customers

The box plots in Figure 13 show the distribution of total bills in each calendar year across all customers. The distribution is similar across years, with a slightly wider spread in 2012. Most bills appear to line in a range from about $60 to $90 per month excluding GST.

There is a long tail of higher bills -- the highest bill recorded in the sample is around $1,500 excluding GST, although most bills are below $150. There is also a small number of low or negative bills. This is due to some customers receiving refunds or credits in the month that they appeared in the sample.

Figure 13 Unweighted distribution of total bills in each calendar year.



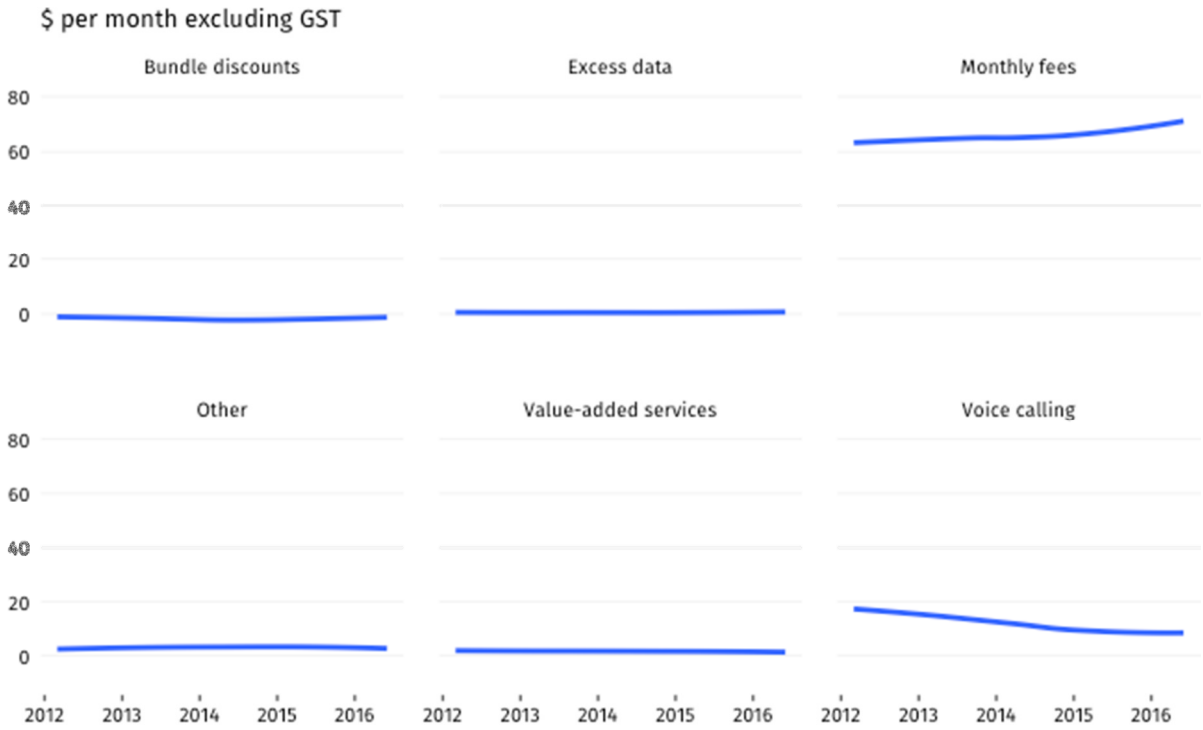
8.4.3. Bill components

Figure 14 show the average components of the average bill across all customers, net of any discounts applied within each category. As above, this reflects changes in prices as well as changes in usage and take-up of services within each category. In June 2016, the average components of the bill were (excluding GST):

- A monthly fee of $72.09
- $7.68 for voice calling
- $1.38 for value added services (e.g. call waiting and caller display)
- $0.71 on additional broadband data over the customer's notional data cap
- $2.46 on other fixed-line charges (e.g. late payment fees, paper invoice charges, or Sky TV services for Vodafone customers)
- A bundle discount for having multiple services with the same retailer (e.g. fixed-line and mobile) of $1.46 (not all customers received such a discount; among those who did the average discount was $11.50).

The average amount spent on voice calling has been steadily declining over time; this likely reflects falling demand for voice calling as well as increased take-up of naked broadband service. Average monthly fees have been gradually increasing, reflecting declining voice-only customers and possibly additional take-up of higher-end broadband plans, as well as pricing changes. The other components of the average bill are relatively small and have remained essentially constant over time.

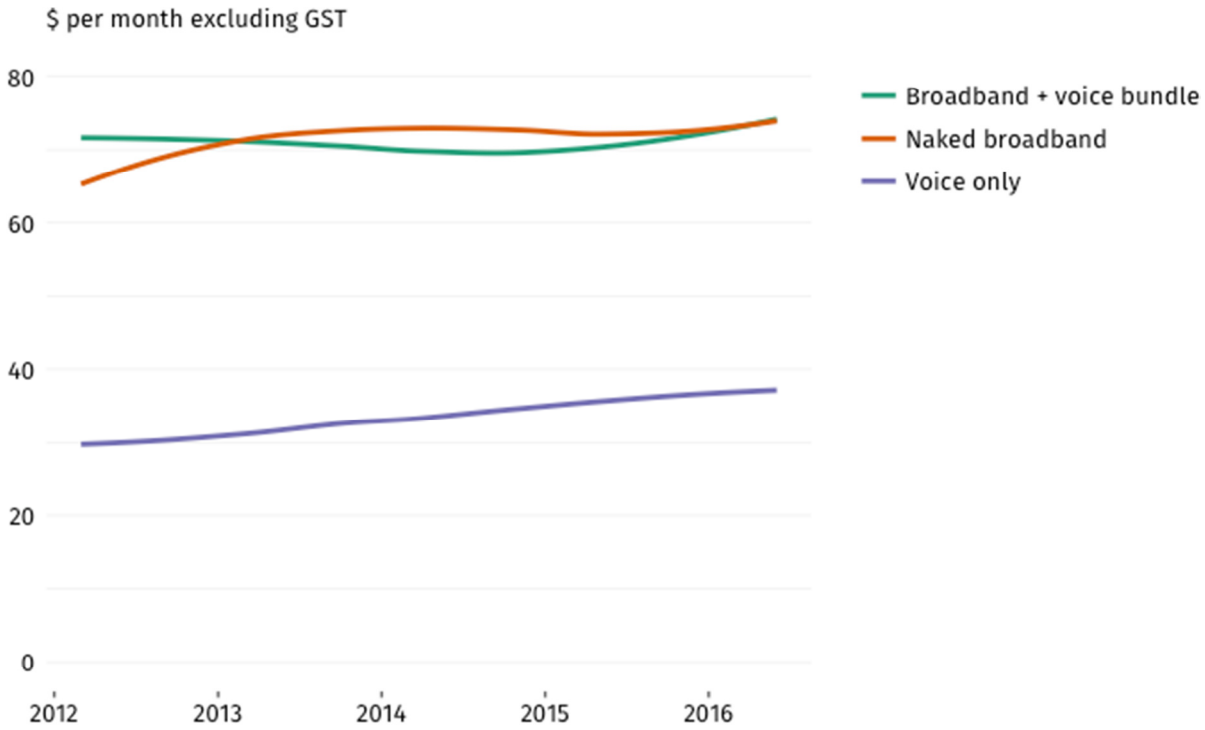
Figure 14 Weighted average components of the sampled bills



8.4.4. Monthly fees by retail service type

Figure 15 shows the average monthly fixed fee by service type. This is net of any discount specific to the monthly fee (e.g. first three months free for new customers) but bundle discounts have not been subtracted in this chart. Monthly fees for voice-only service have steadily increased over time, while monthly fees for bundled and naked broadband service have fluctuated between around $75 and $85 per month (excluding GST).

Figure 15 Weighted average net monthly fees by retail service type

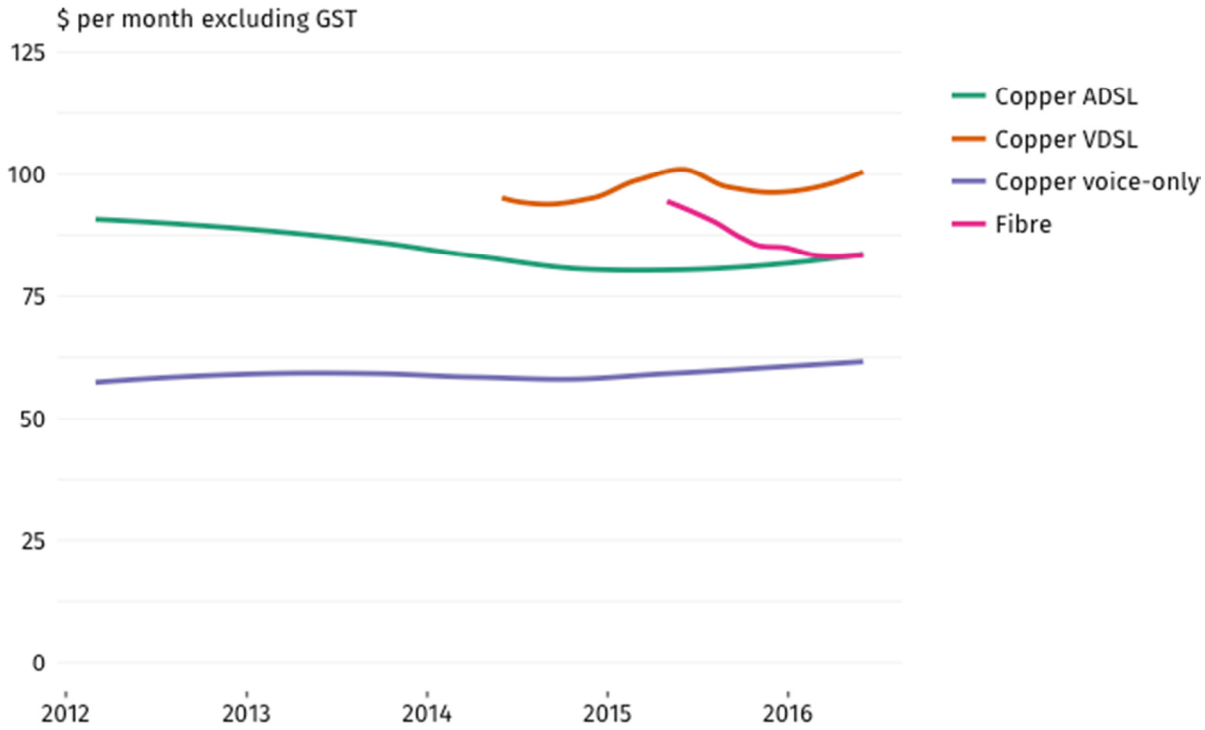


8.4.5. Average total bill by technology type

Figure 16 shows the average total bill for the four types of technology used to provide the retail service, including bundle discounts. The differences across technology types reflect differences in pricing as well as differences in average usage and the types of plans selected by of customers for each technology type. The results in this graph for VDSL and fibre have been filtered to exclude months where there are fewer than 50 such customers in the sample.

As at mid-2016, the total bill for copper ADSL and fibre customers is very similar, at around $88 excluding GST. Copper VDSL customers are paying around $12 per month more, while voice-only customers pay about $25 less.

Figure 16 Weighted average total bill by technology type



8.5. Voice usage

Figure 17 shows the weighted cumulative distribution of voice revenue where customers have been ranked from highest to lowest usage in each year. This distribution has shifted inwards, consistent with fixed-line voice being a declining service. In 2012 approximately the top 30% of customers accounted for 80% of voice revenues. By 2016 the top 20% of customers accounted for 80% of voice revenues.

Figure 18 shows the weighed distribution of voice calling revenues across customers in each calendar year and the weighted means (the dotted lines). This distribution has shifted to the left over time, which is also consistent with fixed-line voice being a declining service.

Figure 17 Weighted cumulative distribution of voice revenue in each calendar year.

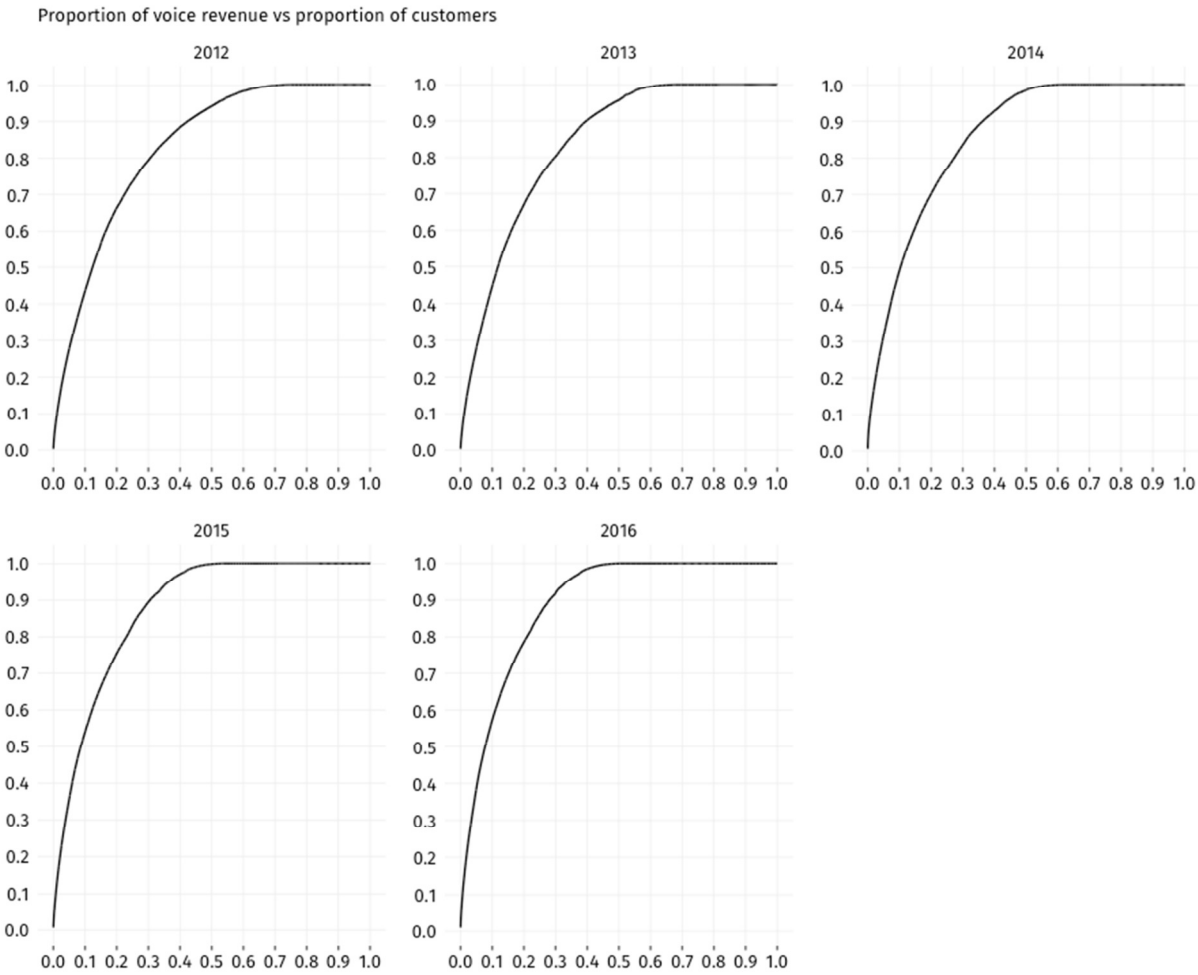
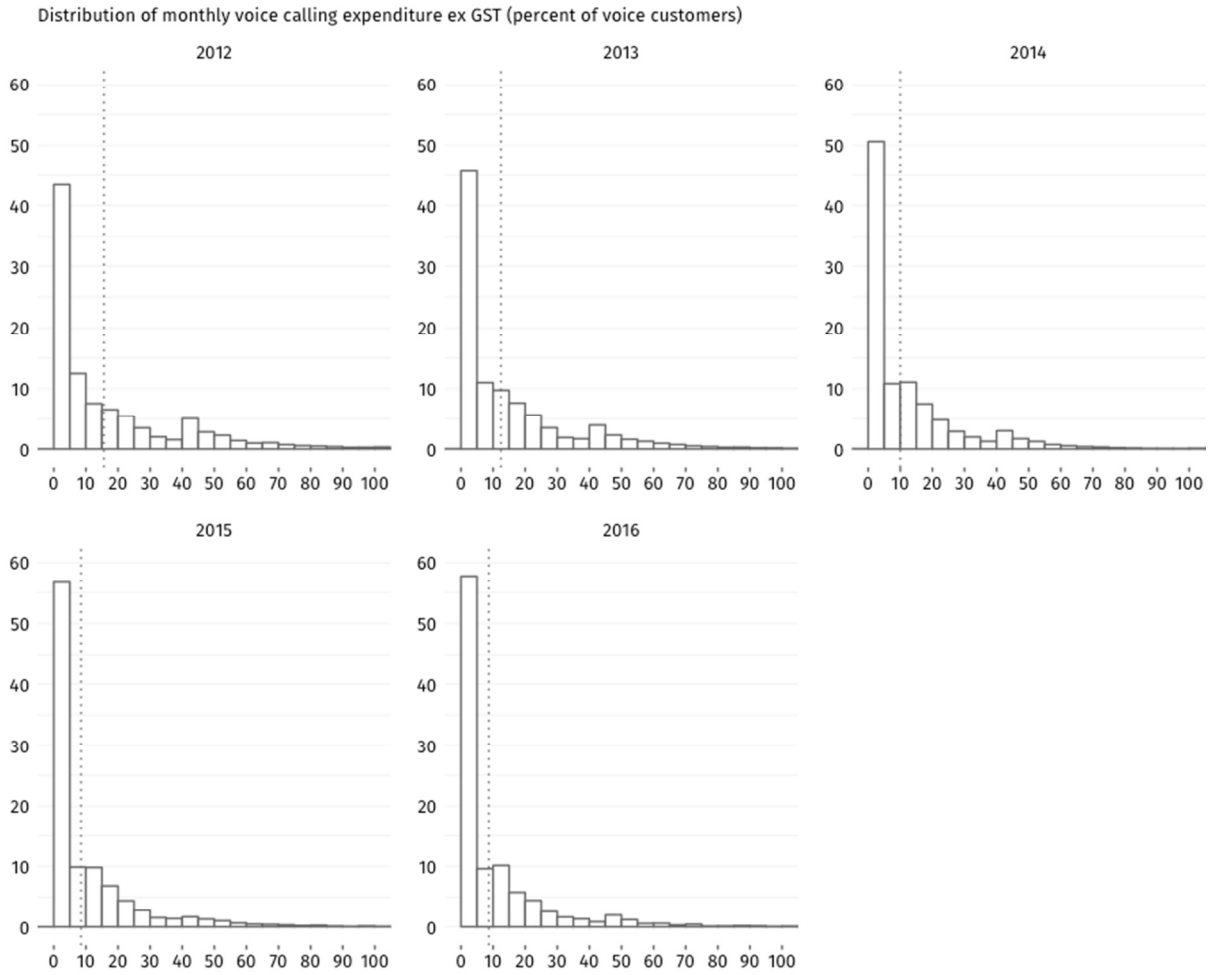


Figure 18 Weighted distribution of voice calling revenues in each calendar year. The dotted lines show the weighted means.



8.6. Data caps and data usage

8.6.1. Data caps

Figure 19 shows the proportion of broadband customers who were on unlimited data plans in each month (voice-only customers have been excluded from the denominator of this proportion). Unlimited data caps have becoming increasingly common since 2014, with almost half of broadband customers in the sample on unlimited plans as at mid-2016.

Figure 20 shows the monthly average data cap for broadband customers who were not on unlimited data plans. This peaked at around 80 GB per month in late 2014. The subsequent decline likely reflects customers with higher than average data usage switching to unlimited plans, reducing the average cap among the remaining set of customers on capped plans.

Figure 19 Weighted proportion of customers on unlimited broadband data plans.

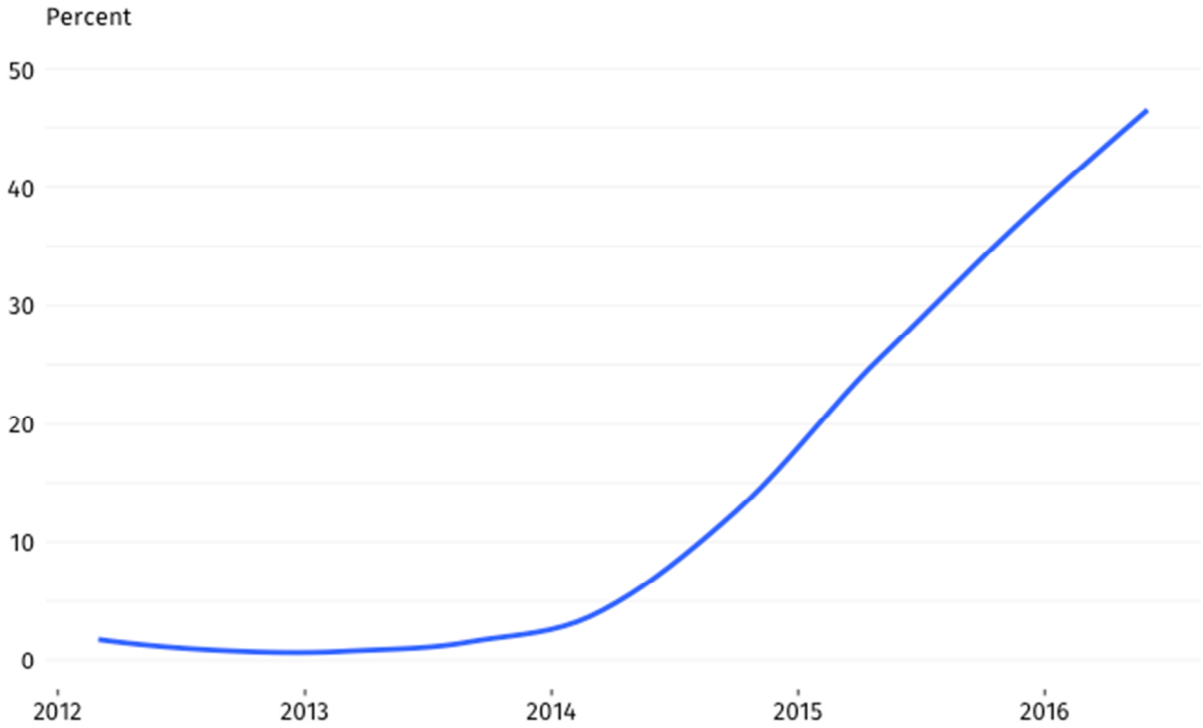
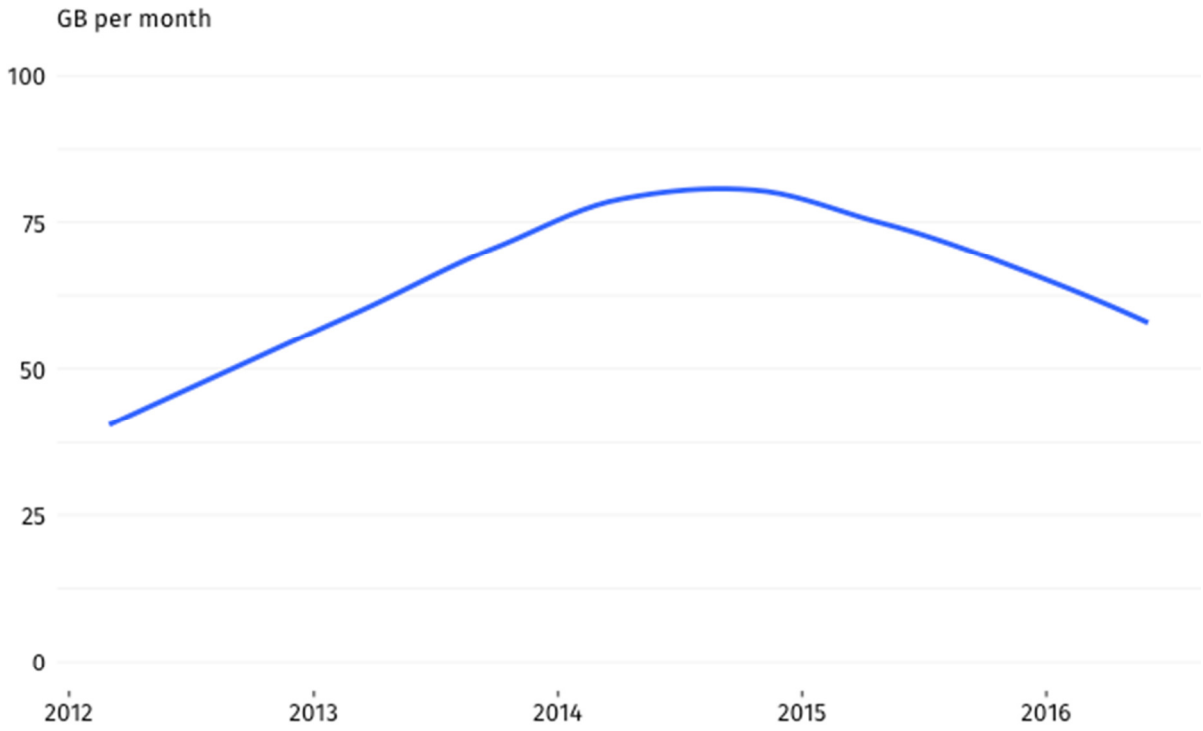


Figure 20 Weighted average monthly data cap for broadband customers not on unlimited plans.



8.6.2. Monthly data usage

Spark was not able to provide historic data on actual monthly data usage for each invoice. Figure 21 below is based on Vocus and Vodafone's data only, across bills for which actual data usage was able to be provided. As at mid-2016, average broadband data usage is around 100 GB per month.

Figure 21 Weighted average actual data usage per month.

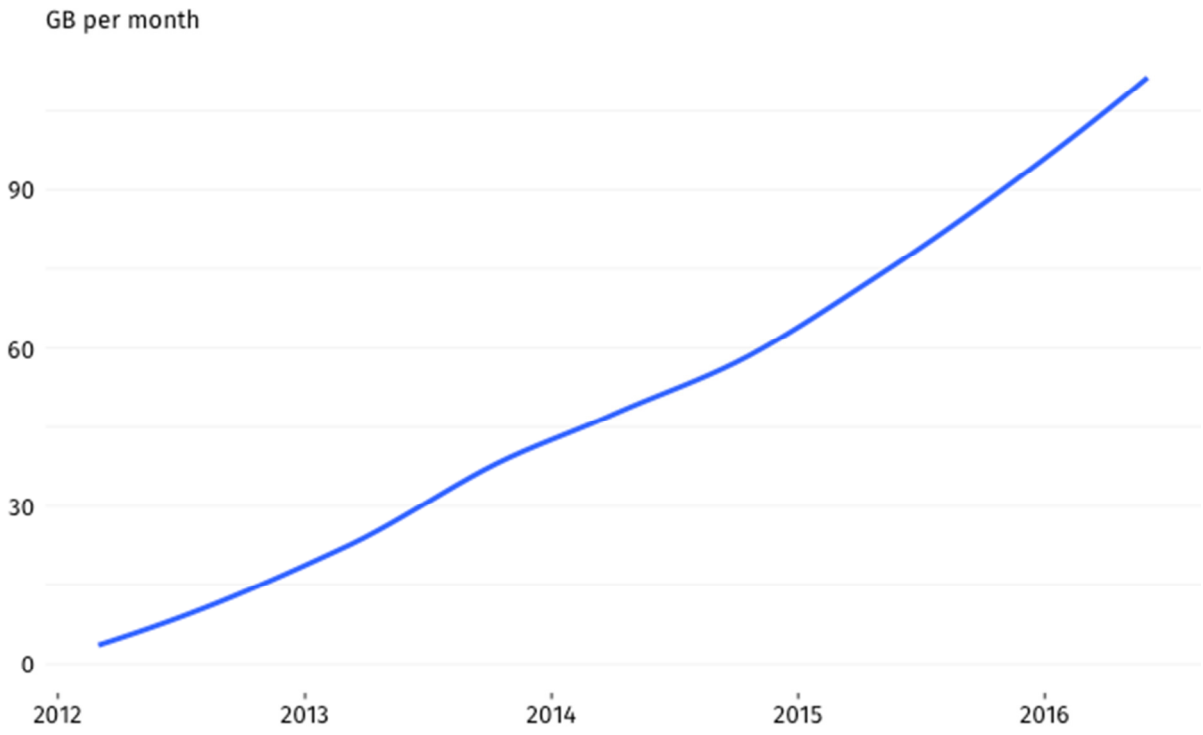


Figure 22 shows the weighted cumulative distribution of actual data usage across bills in each calendar year, where customers have been ranked from highest to lowest usage. The distribution has generally spread out over time – in 2013 approximately the top 30% of customers were responsible for 80% of data usage, while in 2016 the top 38% of customers generated 80% of data use.

Figure 23 shows the weighted distribution of actual data usage across customers, and the mean data usage (the dotted line) in each year. The distribution has spread outwards and the mean has increased in each year.

Figure 22 Weighted annual cumulative distribution of data usage.

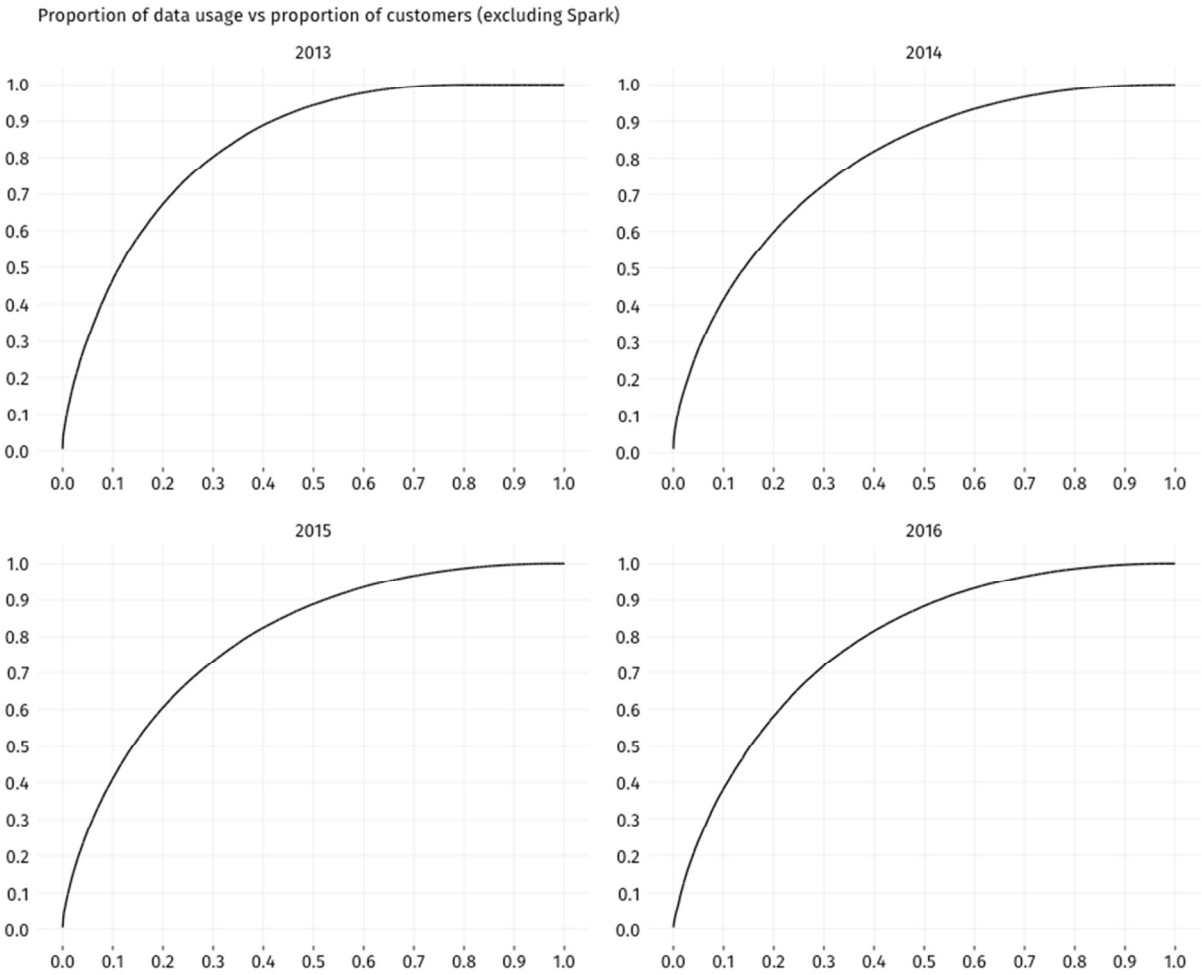
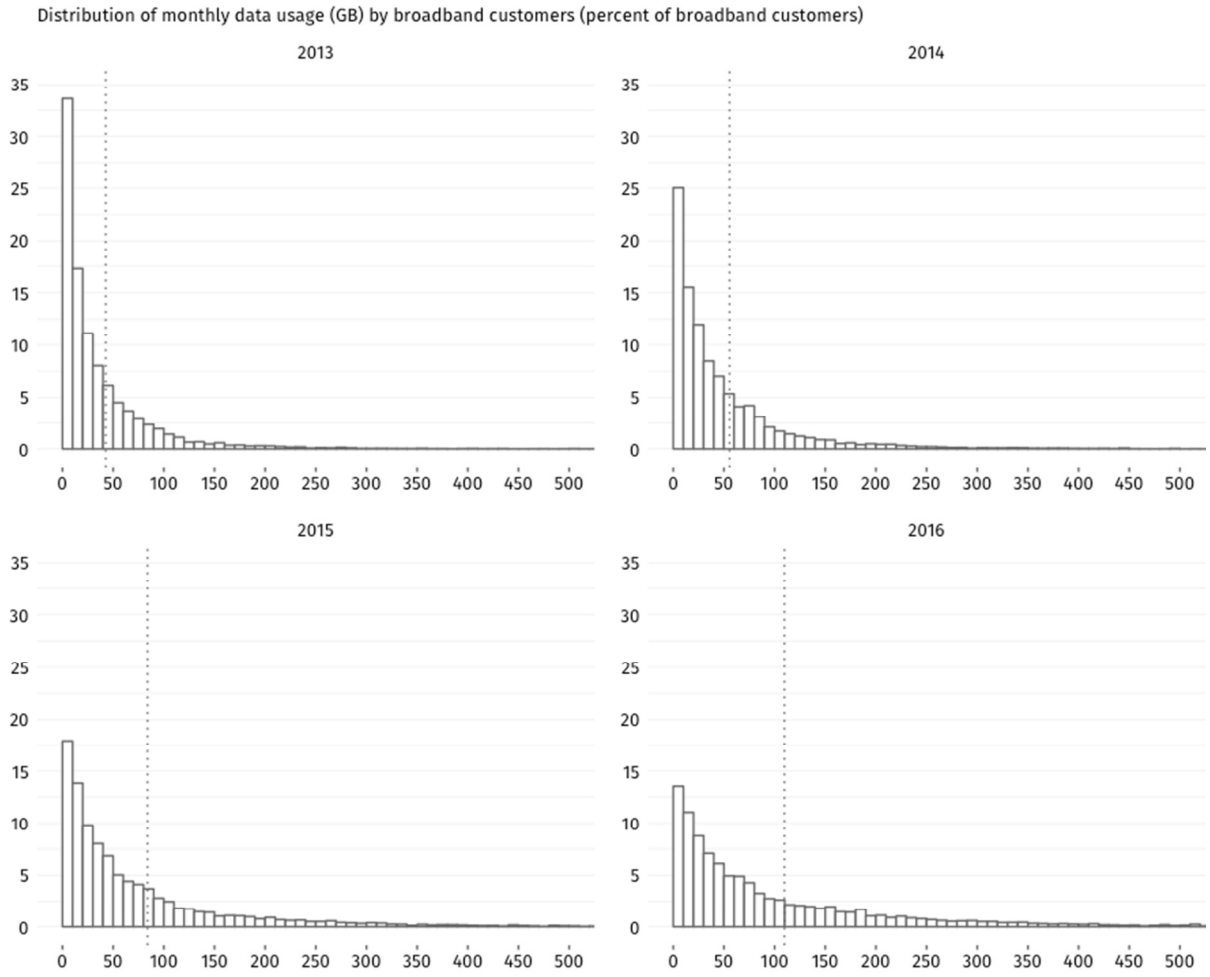


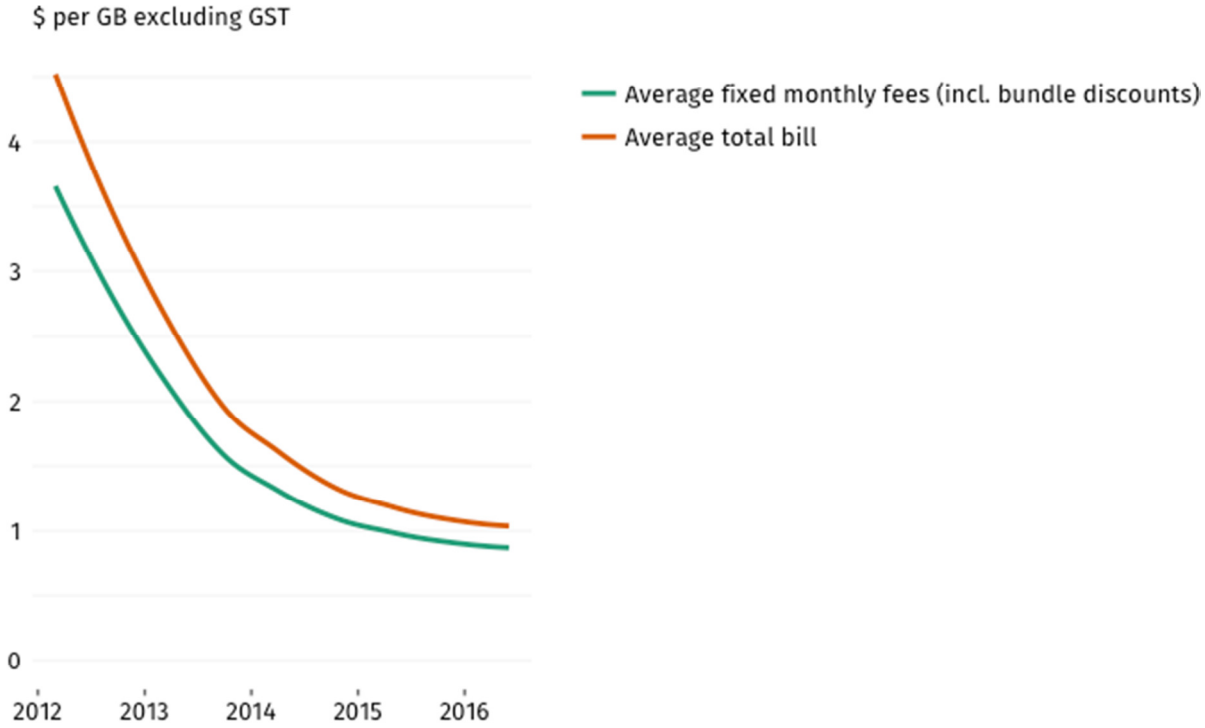
Figure 23 Weighted distribution of actual data usage across broadband customers (excluding Spark). The dotted line indicates the weighted mean in each year.



8.6.3. Effective price per gigabyte of data cap

Figure 24 estimates the average price per GB of data cap that customers purchased over time. A constant value of 300 GB has been assumed for customers on unlimited plans, to enable calculation of an average across all broadband customers. The price per GB has declined rapidly as the proportion of customers on monthly plans has increased, although the rate of decline appears to have slowed as the effective price has approached $1/GB.

Figure 24 Weighted average effective price per gigabyte of data cap per month.



9. Appendix 4: Regression results

The following tables summarise results of estimating the reduced form pass-through models described in section 4.4. For brevity, only the estimated coefficients and p-values of the wholesale UCLL and UBA prices, and their lags and leads, are reported. Each p-value corresponds to the estimated coefficient on the same row in the column immediately to the left; p-values less than 0.05 are highlighted.

9.1. Market-level results (UCLL and UBA base prices separately)

The following tables show coefficients of models estimated using the combined dataset from the three retailers.

9.1.1. Total bill excl. "other"; dollars (models 1 – 4)

Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
1a	1.35	0.01	0.61	0.18			0.51	0.31	0.37	0.42			0.17	433.65
1b	0.91	0.00	0.26	0.47									0.17	462.50
1c							-0.57	0.07	0.29	0.44			0.17	462.26
1d	1.29	0.01			1.03	0.07	0.45	0.40			-0.03	0.80	0.17	369.93
1e	0.98	0.01			1.14	0.04							0.17	394.57
1f							-0.19	0.60			0.05	0.66	0.16	394.22
2a	2.66	0.64	2.35	0.67			-0.80	0.89	0.56	0.93			0.18	8.79
2b	3.15	0.41	2.31	0.62									0.18	9.84
2c							-2.62	0.51	-0.38	0.94			0.18	9.83
2d	1.98	0.75			8.80	0.19	-0.32	0.96			1.12	0.39	0.20	8.41
2e	3.03	0.51			9.17	0.16							0.20	9.38
2f							-0.10	0.98			1.33	0.29	0.19	9.30
3a	1.23	0.01	0.49	0.29			0.42	0.41	0.40	0.39			0.17	469.45
3b	0.85	0.01	0.16	0.67									0.17	504.17
3c							-0.57	0.08	0.36	0.36			0.17	503.96
3d	1.21	0.02			1.33	0.02	0.34	0.52			-0.05	0.67	0.17	402.40
3e	0.95	0.01			1.40	0.01							0.17	432.19
3f							-0.18	0.62			0.03	0.81	0.16	431.73
4a	2.29	0.70	2.40	0.68			-1.23	0.84	1.36	0.83			0.18	8.64
4b	2.95	0.45	2.15	0.66									0.18	9.74
4c							-2.73	0.50	0.32	0.96			0.18	9.73
4d	0.75	0.90			8.63	0.20	-0.58	0.92			1.22	0.35	0.19	8.65
4e	2.06	0.66			8.98	0.17							0.19	9.69
4f							0.34	0.94			1.36	0.28	0.19	9.63

9.1.2. Total bill excl. voice calling & "other"; dollars (models 5 – 8)

Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
5a	1.06	0.00	0.51	0.14			0.83	0.04	0.05	0.90			0.28	897.49
5b	0.44	0.06	0.26	0.35									0.28	959.20
5c							-0.03	0.92	-0.05	0.88			0.28	959.03
5d	0.95	0.02			-0.21	0.56	0.79	0.05			0.01	0.90	0.28	798.17
5e	0.43	0.13			-0.09	0.80							0.28	851.22
5f							0.11	0.71			0.04	0.55	0.28	851.12
6a	2.99	0.53	2.21	0.62			2.71	0.58	-2.48	0.61			0.24	13.14
6b	1.37	0.66	2.62	0.49									0.24	14.77
6c							0.58	0.86	-3.27	0.44			0.24	14.78
6d	5.13	0.32			5.05	0.34	3.36	0.50			-0.30	0.76	0.22	10.59
6e	2.73	0.48			5.63	0.28							0.22	11.90
6f							1.04	0.79			-0.02	0.98	0.22	11.79
7a	0.97	0.01	0.47	0.19			0.83	0.04	0.06	0.87			0.28	994.75
7b	0.36	0.13	0.22	0.45									0.28	1071.06
7c							0.04	0.87	-0.03	0.92			0.28	1070.94
7d	0.91	0.02			0.03	0.94	0.74	0.06			-0.01	0.93	0.28	872.41
7e	0.40	0.16			0.14	0.71							0.28	936.88
7f							0.14	0.62			0.03	0.70	0.28	936.79
8a	2.74	0.57	2.23	0.64			2.60	0.60	-2.33	0.65			0.23	12.65
8b	1.21	0.71	2.53	0.54									0.23	14.34
8c							0.68	0.84	-3.21	0.49			0.23	14.35
8d	4.31	0.40			4.70	0.38	3.29	0.51			-0.26	0.79	0.21	10.75
8e	1.98	0.61			5.26	0.31							0.21	12.18
8f							1.42	0.71			-0.02	0.98	0.21	12.09

9.1.3. Monthly fees incl. bundle discounts; dollars (models 9 – 12)

Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
9a	0.94	0.01	0.46	0.18			0.64	0.10	0.04	0.92			0.29	867.31
9b	0.45	0.06	0.25	0.36									0.29	925.02
9c							-0.10	0.68	-0.04	0.89			0.29	924.86
9d	0.89	0.03			-0.38	0.38	0.65	0.11			-0.02	0.81	0.28	722.12
9e	0.45	0.13			-0.21	0.61							0.28	770.16
9f							-0.02	0.94			0.02	0.83	0.28	770.03
10a	2.18	0.63	0.68	0.88			0.55	0.90	-2.78	0.55			0.26	13.66
10b	2.18	0.47	1.77	0.63									0.26	15.28
10c							-1.13	0.72	-2.82	0.49			0.26	15.29
10d	5.01	0.31			7.14	0.20	0.86	0.86			-0.60	0.57	0.24	10.72
10e	4.02	0.29			7.11	0.18							0.24	12.00
10f							-1.07	0.77			-0.26	0.80	0.23	11.80
11a	0.87	0.02	0.42	0.24			0.64	0.10	0.05	0.89			0.29	949.49
11b	0.38	0.11	0.20	0.47									0.29	1019.70
11c							-0.04	0.86	-0.02	0.94			0.29	1019.57
11d	0.84	0.04			-0.16	0.71	0.61	0.14			-0.03	0.70	0.28	785.00
11e	0.41	0.16			-0.01	0.98							0.28	843.05
11f							0.02	0.95			0.00	0.96	0.28	842.95
12a	2.00	0.66	0.59	0.90			0.36	0.94	-2.05	0.68			0.25	13.08
12b	2.06	0.50	1.34	0.73									0.25	14.74
12c							-1.18	0.71	-2.14	0.63			0.25	14.74
12d	4.16	0.41			6.81	0.22	0.69	0.89			-0.58	0.59	0.23	10.81
12e	3.29	0.39			6.75	0.21							0.23	12.17
12f							-0.76	0.84			-0.28	0.79	0.23	12.01

9.1.4. Total bill excl. “other”; dollars / ln(data cap GB) (models 13 – 16)

Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
13a	0.38	0.00	-0.05	0.58			0.12	0.27	-0.07	0.47			0.28	704.50
13b	0.30	0.00	-0.05	0.49									0.28	753.04
13c							-0.22	0.00	0.05	0.53			0.28	752.16
13d	0.56	0.00			0.25	0.05	0.09	0.45			0.00	0.90	0.27	582.07
13e	0.50	0.00			0.28	0.02							0.27	622.21
13f							-0.21	0.01			0.04	0.11	0.27	621.10
14a	0.08	0.95	1.30	0.24			-0.93	0.46	2.35	0.07			0.19	5.23
14b	0.43	0.61	0.65	0.49									0.18	5.61
14c							-0.81	0.34	1.61	0.16			0.18	5.75
14d	-2.24	0.10			0.32	0.81	-0.99	0.42			0.50	0.07	0.19	4.73
14e	-1.26	0.24			0.33	0.80							0.18	5.06
14f							0.28	0.77			0.40	0.14	0.18	5.11
15a	0.37	0.00	-0.08	0.40			0.10	0.35	-0.04	0.66			0.28	765.63
15b	0.29	0.00	-0.09	0.25									0.28	824.50
15c							-0.23	0.00	0.09	0.29			0.28	823.48
15d	0.55	0.00			0.33	0.01	0.06	0.63			0.00	0.94	0.27	636.66
15e	0.51	0.00			0.35	0.00							0.27	685.65
15f							-0.22	0.01			0.04	0.12	0.27	684.30
16a	0.12	0.92	1.34	0.23			-0.86	0.50	2.38	0.07			0.19	5.52
16b	0.41	0.62	0.66	0.49									0.18	5.95
16c							-0.76	0.37	1.62	0.16			0.18	6.10
16d	-2.26	0.10			0.31	0.82	-0.96	0.43			0.53	0.06	0.19	5.01
16e	-1.28	0.24			0.35	0.79							0.18	5.38
16f							0.32	0.73			0.42	0.12	0.19	5.45

9.1.5. Total bill excl. voice calling & "other", dollars / ln(data cap GB) (models 17 – 20)

Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
17a	0.15	0.03	-0.09	0.14			0.04	0.54	-0.12	0.07			0.33	998.88
17b	0.14	0.00	-0.04	0.40									0.33	1070.07
17c							-0.11	0.02	-0.02	0.64			0.33	1069.54
17d	0.31	0.00			-0.10	0.16	0.11	0.15			0.00	0.74	0.34	926.90
17e	0.24	0.00			-0.08	0.25							0.34	990.74
17f							-0.11	0.03			0.02	0.24	0.34	989.92
18a	-0.15	0.82	0.72	0.21			0.59	0.36	0.66	0.32			0.23	7.12
18b	-0.68	0.12	0.33	0.51									0.22	7.89
18c							0.81	0.07	0.24	0.69			0.22	7.84
18d	-0.81	0.30			-0.73	0.29	0.64	0.35			0.19	0.16	0.20	5.70
18e	-1.04	0.08			-0.51	0.45							0.19	6.21
18f							0.96	0.07			0.14	0.27	0.19	6.26
19a	0.13	0.06	-0.12	0.05			0.04	0.62	-0.09	0.15			0.34	1133.60
19b	0.12	0.01	-0.08	0.10									0.34	1224.19
19c							-0.10	0.03	0.01	0.84			0.34	1223.47
19d	0.30	0.00			-0.04	0.56	0.09	0.24			0.01	0.68	0.35	1032.08
19e	0.24	0.00			-0.02	0.72							0.35	1111.42
19f							-0.11	0.03			0.02	0.21	0.35	1110.66
20a	-0.10	0.88	0.75	0.20			0.68	0.30	0.66	0.32			0.23	7.54
20b	-0.69	0.11	0.33	0.51									0.23	8.40
20c							0.85	0.05	0.23	0.70			0.22	8.36
20d	-0.76	0.33			-0.78	0.26	0.72	0.30			0.20	0.13	0.20	6.10
20e	-1.03	0.08			-0.54	0.43							0.20	6.65
20f							1.00	0.06			0.16	0.22	0.20	6.75

9.1.6. Monthly fees incl. bundle discounts, dollars / ln(data cap GB) (models 21 – 24)

Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
21a	0.11	0.07	-0.10	0.07			0.01	0.83	-0.12	0.03			0.38	1106.70
21b	0.12	0.00	-0.04	0.37									0.38	1182.81
21c							-0.10	0.01	-0.03	0.51			0.38	1182.33
21d	0.29	0.00			0.07	0.31	0.01	0.89			-0.02	0.18	0.37	944.92
21e	0.26	0.00			0.06	0.35							0.37	1010.03
21f							-0.16	0.00			0.00	0.90	0.37	1009.09
22a	-0.63	0.13	-0.11	0.77			-0.15	0.72	0.31	0.47			0.38	14.20
22b	-0.56	0.04	-0.19	0.55									0.38	15.88
22c							0.34	0.23	0.29	0.45			0.38	15.70
22d	-0.71	0.16			0.02	0.97	-0.17	0.71			-0.07	0.48	0.36	11.24
22e	-0.66	0.10			-0.07	0.89							0.36	12.56
22f							0.22	0.52			-0.11	0.29	0.35	12.44
23a	0.08	0.17	-0.13	0.02			0.01	0.93	-0.10	0.06			0.38	1237.02
23b	0.10	0.01	-0.08	0.07									0.38	1331.99
23c							-0.09	0.02	0.00	0.93			0.38	1331.28
23d	0.27	0.00			0.14	0.05	-0.02	0.79			-0.02	0.19	0.38	1043.90
23e	0.27	0.00			0.12	0.08							0.38	1124.13
23f							-0.16	0.00			0.00	0.92	0.38	1123.05
24a	-0.58	0.17	-0.09	0.82			-0.08	0.85	0.31	0.47			0.38	14.74
24b	-0.57	0.04	-0.18	0.56									0.38	16.60
24c							0.38	0.19	0.28	0.46			0.38	16.44
24d	-0.67	0.19			-0.03	0.96	-0.09	0.83			-0.07	0.49	0.36	11.69
24e	-0.65	0.10			-0.09	0.85							0.35	13.17
24f							0.26	0.46			-0.10	0.30	0.35	13.05

9.2. Market-level results ("full" UBA price, i.e. UCLL and UBA base price combined)

9.2.1. Price models (models 1 – 12)

Model	Full UBA coef.	Full UBA p-val	Full UBA lag coef.	Full UBA lag p-val	Full UBA lead coef.	Full UBA lead p-val	R-squared	F-stat
1a	0.92	0.03	0.16	0.66			0.17	462.32
1b	0.94	0.05			0.71	0.71	0.16	394.38
2a	0.65	0.90	0.35	0.94			0.18	9.79
2b	1.44	0.79			0.24	0.24	0.19	9.34
3a	0.88	0.04	0.12	0.74			0.17	504.00
3b	0.88	0.07			0.76	0.76	0.16	431.89
4a	0.47	0.93	0.62	0.90			0.18	9.70
4b	0.71	0.90			0.22	0.22	0.19	9.67
5a	0.78	0.02	0.21	0.47			0.28	959.30
5b	0.85	0.02			0.94	0.94	0.28	851.36
6a	1.39	0.74	0.19	0.96			0.24	14.74
6b	4.55	0.32			0.96	0.96	0.22	11.86
7a	0.76	0.02	0.23	0.45			0.28	1071.22
7b	0.82	0.02			0.99	0.99	0.28	937.05
8a	1.48	0.73	0.33	0.93			0.23	14.31
8b	4.11	0.37			0.96	0.96	0.21	12.15
9a	0.63	0.05	0.15	0.60			0.29	925.03
9b	0.73	0.05			0.72	0.72	0.28	770.20
10a	0.41	0.92	-1.33	0.71			0.26	15.25
10b	3.49	0.43			0.86	0.86	0.23	11.84
11a	0.63	0.05	0.15	0.59			0.29	1019.76
11b	0.70	0.06			0.69	0.69	0.28	843.13
12a	0.59	0.89	-1.11	0.77			0.25	14.72
12b	2.95	0.51			0.86	0.86	0.23	12.03

9.2.2. Quality-adjusted price models (models 13 – 24)

Model	Full UBA coef.	Full UBA p-val	Full UBA lag coef.	Full UBA lag p-val	Full UBA lead coef.	Full UBA lead p-val	R-squared	F-stat
13a	0.26	0.00	-0.17	0.04			0.28	752.50
13b	0.29	0.01			0.26	0.26	0.27	621.14
14a	-0.10	0.93	1.32	0.16			0.18	5.74
14b	-1.43	0.21			0.07	0.07	0.19	5.23
15a	0.27	0.00	-0.17	0.03			0.28	823.86
15b	0.28	0.01			0.21	0.21	0.27	684.30
16a	-0.04	0.97	1.37	0.15			0.18	6.10
16b	-1.42	0.21			0.06	0.06	0.19	5.57
17a	0.10	0.10	-0.15	0.00			0.33	1069.98
17b	0.18	0.01			0.55	0.55	0.34	989.95
18a	0.19	0.74	0.95	0.06			0.22	7.84
18b	0.07	0.92			0.45	0.45	0.19	5.99
19a	0.10	0.08	-0.15	0.01			0.34	1224.08
19b	0.17	0.02			0.37	0.37	0.35	1110.66
20a	0.25	0.67	0.98	0.05			0.22	8.35
20b	0.13	0.84			0.41	0.41	0.19	6.43
21a	0.06	0.24	-0.15	0.00			0.38	1182.76
21b	0.12	0.04			0.58	0.58	0.37	1008.62
22a	-0.29	0.44	0.21	0.52			0.38	15.63
22b	-0.35	0.41			0.46	0.46	0.35	12.46
23a	0.06	0.22	-0.15	0.00			0.38	1331.97
23b	0.11	0.07			0.79	0.79	0.38	1122.47
24a	-0.23	0.53	0.23	0.47			0.38	16.32
24b	-0.29	0.50			0.45	0.45	0.35	13.04

9.3. Retailer-specific results

The following tables show the coefficients of models 1, 3, and 9 when estimated using each retailer's data separately.

9.3.1. Total bill excl. "other"; Dollars; Fibre & copper; All customers (model 1)

Retailer	Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
Spark	1a	[													
	1b														
	1c														
	1d														
	1e														
	1f														
Vodafone	1a														
	1b														
	1c														
	1d														
	1e														
	1f														
Vocus	1a														
	1b														
	1c														
	1d														
	1e														
	1f														]CI

9.3.2. Total bill excl. “other”; Dollars; Copper only; All customers (model 3)

Retailer	Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
Spark	3a	[													
	3b														
	3c														
	3d														
	3e														
	3f														
Vodafone	3a														
	3b														
	3c														
	3d														
	3e														
	3f														
Vocus	3a														
	3b														
	3c														
	3d														
	3e														
	3f														]CI

9.3.3. Monthly fee incl. bundle discounts; Dollars; Fibre & copper; All customers (model 9)

Retailer	Model	UCLL coef.	UCLL p-val	UCLL lag coef.	UCLL lag p-val	UCLL lead coef.	UCLL lead p-val	UBA coef.	UBA p-val	UBA lag coef.	UBA lag p-val	UBA lead coef.	UBA lead p-val	R-squared	F-stat
Spark	9a	[													
	9b														
	9c														
	9d														
	9e														
	9f														
Vodafone	9a														
	9b														
	9c														
	9d														
	9e														
	9f														
Vocus	9a														
	9b														
	9c														
	9d														
	9e														
	9f														]CI