Quantifying the relative risk differences between FTTP and FTTC

Prepared for
BT Group plc

14 January 2021

Final: public

www.oxera.com

compelling economics

Contents

Boxes, figures and tables

1 Introduction

Oxera has been instructed by BT Group to assess Ofcom's analysis and proposals in the Wholesale Fixed Telecoms Market Review (WFTMR) 2021–26, regarding the disaggregation of BT Group's asset beta and the relative systematic demand risk differentials between fibre to the premises (FTTP), fibre to the cabinet (FTTC) and copper services.[1]

In WFTMR, Ofcom proposes to reclassify FTTC services from the 'Other UK Telecoms' component of BT Group's weighted average cost of capital (WACC) into the 'Openreach' component, together with copper services. This reflects Ofcom's view that the systematic demand risks for FTTC are likely to have converged to those of copper.

Furthermore, Ofcom proposes to classify FTTP services to the Other UK Telecoms component of BT Group's WACC. This relies on FTTP having higher operating leverage and systematic demand risk than legacy services. The asset beta differential between FTTP and legacy services implied by Ofcom's proposals is 0.08, corresponding to the difference between the Openreach asset beta of 0.57 and the Other UK Telecoms asset beta of 0.65.

In light of these proposals, BT has asked Oxera to undertake an independent analysis of whether Ofcom has appropriately accounted for and quantified the systematic demand risk differentials between FTTP and FTTC services. As such, our analysis focuses on quantifying the effect of differences in income elasticities between these products on their respective asset betas.

1.1 Summary of main findings

To quantify the effect of income elasticity differences, we have first estimated differentials in the income elasticity of demand for FTTP and FTTC based on the results of a conjoint survey conducted by BT. We then compiled a panel dataset on US industry and consumer data to estimate an empirical relationship between income elasticities and asset betas. Finally, we combined these two findings to estimate predicted asset beta differentials between FTTP and FTTC. Our results suggest that the overall asset beta wedge between FTTP and FTTC, accounting solely for differences in income elasticity, should be c. [✂].

The effect of operating leverage on asset betas has been quantified by BT in a separate report submitted to Ofcom.[2] BT's analysis suggests an asset beta wedge of c. [✂] to account for differences in operating leverage. We have reviewed BT's adjustment to the asset beta for operating leverage. This adjustment builds on standard corporate finance theory (as set out in Brealey and Myers), and has merit in providing a reasonable approach for adjusting for operating leverage, compared to Ofcom's approach, which has not attempted a direct quantification of the impact of higher operating leverage on the asset beta.[3]

Overall, the analysis of the effect of operating leverage and income elasticity on asset risk suggests that the current asset beta differential of 0.08 proposed

[1] Ofcom (2020), 'Promoting competition and investment in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26'.
[2] BT (2021), 'BT supplementary report to Ofcom's consultation on promoting competition and investment in fibre networks – Wholesale Fixed Telecoms Market Review 2021-26 – The WACC for FTTP', January.
[3] See Brealey, R.A., Myers, S.C. and Allen, F. (2010), *Principles of Corporate Finance* (10th edition), McGraw-Hill Education, p. 223.

by Ofcom is unlikely to be sufficient to account for the increased systematic risk faced by FTTP relative to legacy services.

1.2 Structure of the report

The rest of the report is structured as follows:

- section 2 provides a brief overview of Ofcom’s proposals in relation to BT’s WACC and the theoretical support for the existence of systematic risk differentials between copper, FTTC and FTTP;
- section 3 presents our analysis of the effect of income elasticities on asset betas;
- section 4 provides an overall conclusion.

2 Ofcom's proposals on WACC and relative systematic risk differentials

In this section we provide a brief overview of Ofcom's proposals in relation to BT's WACC and the theoretical support for the existence of relative systematic risk differentials between copper, FTTC and FTTP.

2.1 Theoretical support for differences in systematic risk

In general terms, an asset or project's risk has two components: systematic risk and non-systematic risk.

- Systematic risk refers to risk that is correlated with the broader macroeconomic environment, and which investors cannot address by diversifying their investments.
- Non-systematic risks are project-specific risks such as cost and technical risks, as well as certain types of demand and competition risk.

In this report we focus on systematic risks, which are captured in the asset beta parameter of the capital asset pricing model (CAPM) framework, and feed into the calculation of the WACC.

There are three main drivers of why systematic risk may differ within NGA networks. A report by Brattle Group commissioned by the European Commission highlights different types of systematic risks.[4]

1. **Higher capital leverage (operating leverage**)—the presence of a large capital spending commitment that must be made on the basis of expected revenues shrinks the gap between expected earnings and costs. As a result, a fall in expected revenues can create a large drop in expected earnings. This effect is similar to the impact of higher operating leverage, which arises when fixed operating costs make up a large proportion of total costs.
2. **Higher systematic demand risk (income elasticities)**—demand for NGA services is likely to be more sensitive to income; therefore, it seems reasonable to view NGA services as more of a 'luxury' product compared to legacy services. In other words, services with higher income elasticities of demand are expected to have higher systematic demand risk, all else being equal.
3. **Longer asset lives (long-term pay-offs)—**investments that take a longer time to pay off are riskier as their cash flows are less certain and the WACC has a greater impact.

In this report we focus specifically on quantifying the effect of systematic demand risk differences, whereas BT has separately quantified the impact of higher operational leverage on asset beta. This is not to say that the third source of risk does not play a role; it was previously recognised by Ofcom as a reason to place FTTC in a higher risk category than Openreach.[5] However,

[4] The Brattle Group (2016), 'Review of approaches to estimate a reasonable rate of return for investments in telecoms networks in regulatory proceedings and options for EU harmonization', pp. 95–99. The Brattle Group notes that the term 'NGA networks' includes a variety of different technologies, which includes both FTTC and FTTP. See The Brattle Group (2016), 'Review of approaches to estimate a reasonable rate of return for investments in telecoms networks in regulatory proceedings and options for EU harmonization', p. 3

[5] Ofcom (2018), 'Wholesale Local Access Market Review: Statement', Annex A20.235, p. 136.

Ofcom has recently noted that the effect of longer-term pay-offs is likely to overlap to an extent with the two other effects.[6]

We briefly elaborate further on the economic intuition for why higher capital/operating leverage and higher income elasticities are expected to have an impact on asset betas, before summarising Ofcom's analysis.

2.1.1 Higher capital leverage (operating leverage)

Operating leverage can be defined as the ratio of fixed costs to total costs, with a higher proportion of fixed costs constituting a higher operating leverage.

From a finance theory perspective, all else being equal, a higher (lower) operating leverage will lead to a higher (lower) asset beta. As stated by Berk and DeMarzo (2014):

> … [a] factor that can affect the market risk of a project is its degree of operating leverage, which is the relative proportion of fixed versus variable costs. Holding fixed the cyclicality of the project's revenues, a higher proportion of fixed costs will increase the sensitivity of the project's cash flows to market risk and raise the project's beta. To account for this effect, we should assign projects with an above-average proportion of fixed costs, and thus greater-than-average operating leverage, a higher cost of capital.[7]

Box 2.1 below reproduces a numerical example from Berk and DeMarzo (2014) to illustrate this point.

[6] Ofcom (2020), 'Promoting investment and competition in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26', Annex A21.44, Footnote 413, p. 224.
[7] Berk, J.B. and DeMarzo, P. (2014), *Corporate Finance*, third edition, Pearson, p. 420.

Box 2.1 Illustration of the relationship between operating leverage and systematic risk

Consider a project with expected annual revenues of £100 and costs of £10 in perpetuity. The costs are completely variable, so that the profit margin of the project will remain constant.

Suppose the project has a beta of 1.0, the risk-free rate is 1%, and the expected return of the market is 5%.

The expected cash flow of the project is then £100 - £10 = £90 per year. Given a beta of 1.0, the appropriate cost of capital is r = 1% + 1.0(5% - 1%) = 5%. Thus, the present value of the project if the costs are completely variable is £90/5% = £1,800.

If, instead, the costs are fixed, we can compute the value of the project by discounting the revenues and costs separately. The revenues still have a beta of 1.0, and thus a cost of capital of 5%, for a present value of £100/5% = £2,000. Fixed costs are assumed to have a beta of 0. Because the costs are fixed, we should discount them at the risk-free rate of 1%, so their present value is £10/1% = £1,000.

Thus, with fixed costs the project has a value of only £2,000 - £1,000 = £1,000. What is the beta of the project now?

We can think of the project as a portfolio that is long[1] the revenues and short[2] the costs. The project's beta is the weighted average of the revenue and cost betas, or:

$$\begin{aligned}\beta_{Project} &= \beta_{Revenues}\frac{Revenues}{Revenues - Costs} - \beta_{Costs}\frac{Costs}{Revenues - Costs}\\ &= 1.0\frac{2{,}000}{2{,}000 - 1{,}000} - 0\frac{1{,}000}{2{,}000 - 1{,}000}\\ &= 2.0\end{aligned}$$

Given a beta of 2.0, the project's cost of capital with fixed costs is WACC = 1% + 2.0(5% - 1%) = 9%. To verify this result, note that the present value of the expected profits is then £90/9% = 1,000.

As this example shows, increasing the proportion of fixed versus variable costs can significantly increase a project's beta—i.e. systematic risk (and reduce its value).

Note: [1] A long position—also known as long—is the buying of a stock, commodity or currency with the expectation that it will rise in value. [2] A short position is the selling of a stock, commodity or currency with the intent of buying it later at a lower price to realise a profit.

Source: Oxera analysis reproduced from Berk, J. and DeMarzo, P. (2014), *Corporate Finance*, Pearson, third edition, p. 420.

A large capital expenditure programme that must be made on the basis of expected revenues would have a similar effect. Indeed, in the presence of sizeable and relatively fixed capital obligations, a fall in the value of a project's expected benefits (i.e. its future cash flows) will prompt a disproportionately larger fall in the project NPV compared with an asset that does not face a similar level of fixed capital obligations. All else being equal, this will result in a higher asset beta.

This implies that an investment project such as FTTP will have the highest asset beta during the construction and growth phase due to a higher proportion of fixed costs (obligations and commitments to undertake CAPEX) relative to total costs. Over time, as construction is completed and the technology matures, operating leverage will decrease, leading to a decline in asset beta (assuming everything else remains the same).

It is important, however, that the regulatory framework takes account of the riskiness of these investments undertaken during the construction phase, and provides an appropriate lifetime return commensurate with these risks until these assets are fully depreciated. Such an approach would also be consistent with the fair bet framework which underpins Ofcom's approach to risky investments.[8]

[8] The fair bet framework aims to ensure that companies making risky investments are adequately compensated for both systematic and non-systematic risk.

2.1.2 Higher systematic demand risk (income elasticity)

A firm's fundamental asset risk, or asset beta, directly relates to business cycles.[9] A beta of 1 means that the firm's asset risk perfectly correlates with the market as a whole through expansions and recessions. Its assets are therefore exactly as risky as the market portfolio itself. A beta less than 1 implies that a firm's assets are safer than the market portfolio, and greater than 1 suggests that the firm's assets are riskier than holding the market portfolio.

Income elasticities have a similar intuition. The income elasticity of demand measures how consumer demand for a product changes as income changes. An inelastic good (elasticity of less than 1), means that consumer demand for the product changes less than proportionately when consumer income changes. An elastic good (elasticity greater than 1) means that consumer demand changes more than proportionately when consumer income changes.

Broadly speaking, we can think of an income-inelastic good as a **commodity** and an income-elastic good as a **luxury item**. For example, the demand for toothpaste changes very little in recessions, whereas the demand for luxury automobiles changes a great deal.

The asset beta for a hypothetical 'toothpaste industry' should be lower than the asset beta for the luxury auto industry. In the presence of systematic macroeconomic shocks (for example, a recession) demand for commodity products like toothpaste will remain relatively stable, whereas demand for luxury products would fall. These effects, which are explained by income elasticity differences between these products, would directly affect the correlation between an industry's asset risk and that of the market portfolio.

In the fixed broadband industry, there are a number of services that users can choose from to satisfy their connectivity needs. All of these services offer different speeds and functionalities. It is reasonable to expect that, as a new high-end technology, demand for full-fibre broadband services (FTTP) is likely to exhibit higher income elasticity than more mainstream and cheaper services like FTTC and copper. In other words, FTTP more closely resembles a luxury or premium service than other BT broadband services. All else being equal, we would expect this to translate into asset beta differentials for these services.

2.2 Overview of Ofcom's analysis and proposals

Ofcom's relative systematic risk analysis follows a similar conceptual framework to the one we have laid out above, assessing the effects of both systematic demand risk and operating leverage, while not considering long-term pay-offs as a separate source of risk.

2.2.1 Ofcom analysis of systematic demand risk

Ofcom considers that products with higher demand risk are associated with higher asset betas:

> services that exhibit more demand risk would be expected to have higher betas while products that have less demand risk (i.e. products and services that are 'necessity' items) would have lower betas[10]

[9] Equity beta is measured by calculating the co-movement between the firm's stock price and a market index. Asset beta is the firm's hypothetical equity beta if it carries no debt.
[10] Ofcom (2020), 'Promoting investment and competition in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26', Annex A21.44, p. 224.

Regarding the differences in risk between FTTC and copper, Ofcom considers that the systematic demand risk of FTTC would have reduced upon the completion of the FTTC roll-out.

Specifically, Ofcom expects that customers might upgrade or downgrade their FTTC package in response to macroeconomic conditions, as the different bandwidths offered within the FTTC umbrella of products allow them to do so; however, it regards a downgrade entirely to copper as unlikely and movement between speed tiers as limited where 40/10 FTTC acts as an ‘entry-level product’.[11] For example, Ofcom notes that:

> although there could be some revenue volatility due to the bandwidth gradient, this may be limited where the 40/10 FTTC variant represents the ‘entry-level product’ and customers rarely downgrade from SFBB to SBB.[12]

With respect to FTTP, Ofcom acknowledges that there may be larger demand risk:

> Speeds that can only be delivered via FTTP currently attract a retail premium. To the extent this means these services are currently perceived as a luxury product, this could imply a **higher income elasticity of demand and greater beta risk**.[13] (emphasis added)

In short, Ofcom accepts the view that FTTP may currently be perceived as a luxury good, with associated higher income elasticities and asset betas. However, it considers that both copper and FTTC are entry-level products and may therefore have similar systematic demand risk (which is lower than for FTTP).

2.2.2 Ofcom analysis of operating leverage

Ofcom also notes that operating leverage affects asset betas, acknowledging that the dynamics around significant upfront investments can be similar to those of fixed costs in general:

> services that have greater operational leverage (i.e. require significant upfront investments or have a higher proportion of fixed costs) are more exposed to systematic risk and thus would have higher betas.[14]

For FTTC, Ofcom does not view these risks as high, given that the roll-out of infrastructure is largely complete. However, Ofcom does note that copper and FTTC might have increased operating leverage during the transitional phase to FTTP:

> the transition to full-fibre could raise operating leverage risks for both FTTC and basic copper lines, e.g. additional cabinet provisioning for a small number of premises (e.g. where FTTC cabinet capacity is full), potential decommissioning costs for the copper network and running the copper/FTTC network in tandem with an FTTP network.[15]

[11] We note that no empirical evidence was presented to support this claim. On the contrary, there is evidence that despite 94% of premises having access to superfast services, only 54% of premises signed up. See Ofcom (2020), ‘Connect Nations 2019 – UK report’, 18 March, p. 19.
[12] Ofcom (2020), ‘Promoting investment and competition in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26’, Annex A21.47, p. 225.
[13] Ibid., Annex A21.54, p. 226.
[14] Ibid., Annex A21.44, p. 224.
[15] Ibid., Annex A21.44, p. 224.

Ofcom notes that FTTP is likely to have a higher operating leverage, specifically in the next control period while the FTTP network is in the build phase:

> FTTP capex is expected to be greater per premise passed compared to FTTC. Further, FTTP is in the build phase and will be throughout the next control period whereas the capital expenditure programme on FTTC is virtually complete. This would imply much higher operating leverage for FTTP during the build phase and hence a higher asset beta, other things equal.[16]

2.2.3 Summary of Ofcom's proposals

Ofcom's proposals are summarised in Table 2.1 below. In short, Ofcom has proposed to eliminate the asset beta differential between FTTC and copper, and to provide an uplift for the FTTP asset beta over copper of 0.08.

Table 2.1 Summary of Ofcom's proposals

	WACC category	Asset beta proposed	Uplift over copper	Ofcom view
FTTP	Other UK Telecoms	0.65	0.08	Higher operating leverage and uncertainty around take-up of FTTP connections
FTTC	Openreach	0.57	None	Lower operating leverage given that FTTC roll out is complete, and systematic demand risks converged with copper lines

Note: The latest proposal includes FTTC under Openreach, where copper lines are categorised, while FTTP is placed under Other UK Telecoms.

Source: Ofcom (2020), 'Promoting investment and competition in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26', Annex A21.44, pp. 224–226.

As explained above, Ofcom's analysis is qualitative, and while it accepts that FTTP has higher operating leverage and income elasticity than legacy services, the impact of these effects on the size of the asset beta uplift required to account for these risks has not been quantified.[17]

In the next section of this report we aim to provide quantitative evidence of the systematic demand risk differences between BT's products, and its impact on asset betas.

[16] Ofcom (2020), 'Promoting investment and competition in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26', Annex A21.56, p. 226.
[17] Differences in asset betas do not come about due to explicit calculations of risk differentials. Rather, they arise from the categorisation of products, where the justification for categorisation is largely qualitative. The asset betas of each product group are calculated as follows. Openreach is assigned an asset beta slightly above the midpoint of BT Group (0.68) and the listed UK network utility asset betas (0.39), which amounts to 0.57. The Other UK Telecoms asset beta (0.65) is estimated based on the mid-point of the range of a comparator exercise (range of 0.55 – 0.75). See Ibid., Annex A21.74–A21.75, p. 230.

3 Income elasticities and asset betas

As noted in section 2, one can view FTTP as a premium service with a higher income elasticity of demand than FTTC and copper. Furthermore, to the extent that copper is commoditised, it should have a lower income elasticity than FTTC. These elasticity differences should manifest themselves in the respective asset betas.

In this section, we use the intuition described above to infer wedges in asset betas between FTTC and FTTP, solely relating to differences in income elasticity of demand. Although we cannot directly observe the asset betas of these products, we have been able to estimate differentials in the income elasticity of demand for FTTP and FTTC based on the results of a conjoint experimental survey conducted by BT. We have also undertaken a detailed econometric study based on a panel dataset of US industry and consumer data to estimate an empirical relationship between income elasticities and asset betas.

The final step in our analysis has been to map the income elasticity differentials estimated for broadband products in the UK and use the regression coefficients obtained in the panel data to predict the difference in asset beta between broadband products attributable solely to income elasticity differentials.

3.1 BT consumer experiment and income elasticities

3.1.1 FTTP versus FTTC

A key challenge of estimating an income elasticity for FTTP is that the product does not yet generate revenues. However, BT commissioned a field experiment designed to analyse consumer choices between FTTC and FTTP. Specifically, participants were allowed to choose between different FTTP and FTTC products, with different combinations of speed, price and other characteristics. Further details of the experiment and its design are provided in Box 3.1.

Box 3.1 The field experiment commissioned by BT

BT commissioned DecTech to conduct an experiment designed to collect data on consumer broadband choice. 1,000 participants each (2,000 total) participated in either an FTTC or FTTP experiment. Each participant was presented with a variety of product choices and DecTech recorded the product choice as well as a variety of demographic statistics. The experimental data allows us to compare consumer income with the resulting consumer choices separately for FTTC and FTTP. This allows us to calculate income elasticities for both products.

Source: Oxera.

By examining the product selected by each participant and considering the participant's income, we can use the large sample to estimate income elasticities of demand for FTTC and FTTP. Specifically, we can estimate how much more speed is demanded by consumers as their income increases.

We estimate the following regressions for both FTTP and FTTC:

$$\ln Speed = \alpha + \beta \ln Income + \varepsilon$$

We use the natural logarithm because this allows us to interpret the results in terms of percentage changes in income and speed, consistent with the interpretation of income elasticity.

We obtain statistically significant coefficients of [✂] and [✂] on the income beta for FTTP and FTTC, respectively.[18] We show these regression results in Tables 3.1 and 3.2.

Table 3.1 FTTP regression coefficients

	ln speed
ln income	[✂]
t-statistic	[✂]
Constant	[✂]
t-statistic	[✂]
N Obs	[✂]

Source: BT/DecTech Data and Oxera analysis.

Table 3.2 FTTC regression coefficients

	ln speed
ln income	[✂]
t-statistic	[✂]
Constant	[✂]
t-statistic	[✂]
N Obs	[✂]

Source: BT/DecTech Data and Oxera analysis.

These coefficients directly capture the income elasticity of demand for bandwidth. To translate these into real numbers, increasing the average sample income of [✂] by 10% increases the demand for average FTTP speed from [✂] to [✂], an increase of [✂]. For FTTC, a similar change increases speed demanded from [✂] to [✂]. This demonstrates that the income elasticity for FTTP is higher than for FTTC. Note that these coefficients translate into increases in the percentage of speed demanded, meaning that these are unaffected by the absolute level of the speed tiers offered by FTTP versus FTTC in the experiment.[19]

These effects of changes in customer income on the demand for broadband speed are also not driven by the discrete nature of the jumps in speed tiers, as the higher gaps in FTTP speeds may prevent users from jumping as easily between tiers for a specific change in income.

Last, for robustness, we estimate a similar regression, but use ln *Speed x Price* on the left-hand side and obtain a similar tiering of income elasticities between FTTC and FTTP.[20]

[18] Note that the elasticities calculated in this section are proxies for the true economic meaning of income elasticity, which is quantity demanded.
[19] Following the traditional sense of elasticities, these are percentage changes. Therefore, if a specific change in income caused a consumer to change from 50mbps to 100mbps for FTTC, a change from 200mbps to 400mbps for FTTP would have the same income elasticity. Our results imply therefore that the percentage demanded is higher for a given change in income.
[20] Note that price is randomised in the experiment in order to determine thresholds of consumer choice, so we only use this version of the regression as a cross-check to verify that price differences do not drive our main result.

3.1.2 Projecting income elasticity for copper

In order to use these results and map them onto our US panel data regression we also need to estimate a value for the income elasticity for copper bandwidth, relative to FTTC and FTTP. This is required given that the current mix of revenues in the average US telecoms firm is also likely to include a proportion of copper services.

We use the relationship between the relative income elasticities of FTTP and FTTC to project the income elasticity for copper bandwidth. First, we note in Table 3.3 both the average speed and the income elasticity for both FTTP and FTTC, which allows us to derive a relationship between the average speed of a product and its income elasticity. We then use the average speed of copper to infer its income elasticity.

Table 3.3 Projection of income elasticity for copper

	FTTP	FTTC	Copper
Average speed (mbps)	[✂]	[✂]	[✂]
Income elasticity	[✂]	[✂]	[✂]

Note: Numbers are rounded; copper is [✂]. Calculated showing that a [✂] speed reduction between FTTP and FTTC maps to a [✂] reduction in income elasticity, implying that a [✂] reduction from FTTC to copper maps to a [✂] reduction in income elasticity, from [✂] to [✂].

Source: Oxera analysis. The average speed data for FTTP and FTTC comes from BT's experimental data outlined in Appendix A1; these are the averages from the speeds selected by participants in the study. A customer-weighted average of the maximum speeds of all copper products is roughly [✂], which we have rounded to [✂]. The use of [✂] does not materially change our final results.

3.2 Calculating the relationship between income elasticity and asset beta

The next step in our analysis is to determine how differences in income elasticity affect asset betas. We require both variation in asset betas and income elasticities to explore this relationship, so we turn to macroeconomic data on changes in industry demand and consumer income, as well as to industry-level data on asset betas. We have been able to construct a panel data composed of US data on industry-level asset betas, industry-level consumer demand, and aggregate consumer income.[21]

Data on asset betas is available from 1999 to 2019 and can be found on Professor Damodaran's website under the section 'Levered and Unlevered beta by Industry'. [22] Professor Damodaran's data contains asset betas for 95 unique industries. Given the sample period, we have 1,995 industry-year observations (95 industries* 21 years).

Next, as a proxy for changes in demand, we use data from the BEA (Bureau of Economic Analysis) on Gross Output, which is defined as a measure of an industry's sales or receipts, including sales to final users in the economy (GDP) and sales to other industries (intermediate inputs).[23]

[21] Note that our goal is to calculate the wedge in asset betas. Therefore the use of US industry-level data is appropriate as long as UK consumers do not have vastly different consumer preferences in terms of broadband speed. Our mapping in section 4.4 is also designed to deal with any differences in scale.
[22] Damodaran, A., 2020. Betas. [online] Betas by Sector (US). Available at: <http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/Betas.html> [Accessed 23 November 2020].
[23] Bea.gov. 2020. Gross Output By Industry | U.S. Bureau Of Economic Analysis (BEA). [online] Available at: <https://www.bea.gov/data/industries/gross-output-by-industry> [Accessed 23 November 2020].

Moreover, the BEA website provides information about US households' personal income.[24] This value represents the cumulative income of all households in billions of US dollars and gives an indication of the purchasing possibilities in each different industry compared to the actual realised sales.

We calculate a proxy variable for income elasticities[25] for each industry-year using the following formula:

$$\frac{\%\Delta Sales_{i,t}}{\%\Delta Personal\ Income_{i,t}} = Proxy\ Income\ Elasticity$$

We then regress each industry-year asset beta on the industry-year proxy income elasticity using a panel regression including industry and year fixed effects. It is important to note that these fixed effects control for any unobservable industry characteristics and time trends that could affect asset beta. We also note that changes in consumer preference may be realised by stock market participants with a delay, so we also include the lagged income elasticity:

$$Asset\ Beta_{i,t} = \alpha + \beta_1\ Income\ Elasticity_{i,t} + \beta_2\ Income\ Elasticity_{i,t-1} + \varphi_i + \gamma_t\ \ \varepsilon$$

where φ and γ represent industry and year fixed effects, respectively. The outcome of the above regression is reported in Table 3.4.

Table 3.4 US panel regression's results

Variable name	Coefficient	Std. err.	t-statistic	p-value
Income elasticity$_t$	0.007	0.003	2.27	0.024**
Income elasticity$_{t-1}$	0.007	0.003	2.22	0.027**
Constant	0.866	0.008	107.15	0.000***

Note: ***, **, * represent statistical significance at the 1%, 5%, and 10% level, respectively.

Source: Oxera analysis

For robustness, we also estimate the regression omitting the lagged income elasticity and note that the significance of *Income elasticity*$_t$ improves to significance at below 1%.

Our regression result is consistent with the economic intuition discussed in section 2. Notably, higher income elasticities increase the asset beta. This effect is over and above any general industry effect or time trend on asset betas. In other words, changes in consumer income directly affect a firm's systematic risk.

3.3 Predicting the asset beta wedge between FTTC and FTTP

The final step in our analysis is to use the income elasticity of demand for speed in combination with the empirical link between income elasticity and asset beta. The goal is to determine an estimate of the wedge between FTTC and FTTP that can be solely attributable to income elasticities.

The primary empirical challenge lies in mapping BT's microeconomic experimental data to the macroeconomic estimates linking income elasticity

[24] Bea.gov. 2020. Personal Income | U.S. Bureau Of Economic Analysis (BEA). [online] Available at: <https://www.bea.gov/data/income-saving/personal-income> [Accessed 23 November 2020].
[25] As with BT's data, these are proxies for income elasticity because we cannot directly observe quantity demanded as in a traditional economics theory textbook. Rather, we can only observe the total amount demanded by consumers in dollar terms. Our use of fixed effects controls for any time- or industry-level changes in prices.

and asset beta. We do this by mapping the income elasticities of demand for speed from BT's existing products (copper and FTTC), onto the aggregate macroeconomic industry-level elasticities used in our panel regression, and assuming that the relative differences in size between the income elasticities for speed will also map onto the macroeconomic income elasticities.

This allows us to rely on the wedges in income elasticities for speed to predict a wedge in asset betas between broadband products, attributable solely to income. Our results are shown in Table 3.5.

Table 3.5 Estimated asset beta wedge due to income elasticity

	Copper/FTTC	Copper	FTTC	FTTP
Income elasticity of demand for speed[1]	[✂]	[✂]	[✂]	[✂]
Income elasticity from macroeconomic industry data[2]	[✂]	[✂]	[✂]	[✂]
Predicted asset beta from regression[3]			[✂]	[✂]
Asset beta wedge relative to FTTC			-	[✂]

Notes: [1] Income elasticity of demand for speed comes from Table 3.1 and 3.2. [2] The 0.82 value is the income elasticity from macroeconomic data based on the 2019 estimate for the Telecoms industry, estimated from US industry sales and aggregate income data. The copper, FTTC and FTTP values are derived by assuming that the ratio of income elasticities for speed will map onto the income elasticities based on macroeconomic data. For example, the ratio of [✂] between FTTP and copper ([✂] divided by [✂]) is the same ratio as [✂] divided by [✂]. [3] We apply the derived macroeconomic income elasticity values to the regressions in Table 3.4 in order to obtain predicted asset beta values.

Source: Oxera analysis.

We first assume that BT's income elasticity is roughly evenly split between copper and FTTC. This gives an average income elasticity of demand for speed for FTTC and copper combined of [✂] (this is the simple average of [✂] from copper and [✂] from FTTC estimated in Tables 3.1 and 3.2, respectively).[26]

We then map this to the 0.82 aggregate macroeconomic income elasticity observed for the Telecoms industry in 2019 in our panel dataset.[27] Having done this, we are then able to predict what the corresponding macroeconomic income elasticity of demand for copper, FTTC and FTTP is by applying the same relative ratios based on each product's income elasticity of demand for speed.

Note again that the goal of the exercise is to estimate an asset beta wedge between FTTC and FTTP. After obtaining estimated macroeconomic income elasticities for each product line, we can therefore apply them to our regression in Table 3.4 in order to estimate this wedge of [✂]. Note that our use of panel data with industry and year fixed effects generates a within-industry estimator. We therefore only focus on the *wedge* between the two products, not the absolute values.

[26] Numbers have been rounded.
[27] The implicit assumption here is that the average US telecoms firm has a similar mix of copper and FTTC services as BT currently does.

3.4 Conclusions

In summary, our analysis has provided a quantitative estimate of how variance in income elasticities translates into differences in asset betas. We document a hierarchy in income elasticities of demand for FTTP and FTTC using empirical data on consumer choices.[28] We also find a significantly positive relationship between income elasticity of demand and asset beta at the industry-year level.

Mapping from the microeconomic (experimental) to macroeconomic data yields an estimated asset beta wedge of [✂] between FTTP and FTTC, attributable solely to the differences in income elasticity between these services.

[28] As noted in section 3.1.2, we have also made an out-of-sample extrapolation of the income elasticity difference between FTTC and copper in order to map these results onto our US panel data regression.

4 Conclusion

In this report, we have quantified the effect that systematic demand risk has on asset beta. We have first estimated differentials in the income elasticity of demand for FTTP and FTTC based on the results of a conjoint survey conducted by BT. We then combined these with an empirical relationship between income elasticities and asset betas derived from a panel data analysis of US industry and consumer data. Our results suggest that the overall asset beta wedge between FTTP and FTTC, accounting solely for differences in income elasticity, should be c. [✂].

The effect of operating leverage on asset betas has been quantified by BT in a separate report submitted to Ofcom.[29] BT’s analysis suggests an asset beta wedge of c. [✂] to account for differences in operating leverage. We have reviewed BT's adjustment to the asset beta for operating leverage. This adjustment builds on standard corporate finance theory (as set out in Brealey and Myers), and has merit in providing a reasonable approach for adjusting for operating leverage, compared to Ofcom's approach, which has not attempted a direct quantification of the impact of higher operating leverage on the asset beta.

Overall, the analysis of the effect of operating leverage and income elasticity on asset risk suggests that the current asset beta differential of 0.08 proposed by Ofcom is unlikely to be sufficient to account for the increased systematic risk faced by FTTP relative to legacy services.

[29] BT (2021), ‘BT supplementary report to Ofcom’s consultation on promoting competition and investment in fibre networks – Wholesale Fixed Telecoms Market Review 2021-26 – The WACC for FTTP’, January.

A1 Details of consumer choice experiment

The information about product types and incomes used to calculate the speed elasticity relative to BT's products has been collected through experiments using a sample of potential customers. Two separate surveys have been proposed to a different set of respondents: one for FTTC products and one for FTTP products. Both surveys ask about the participants' income and ask them to choose a BT product (with the associated product price and speed).

The following set of tables provides a representation of the composition of the data in the surveys. First, the proposed products and relative average prices and speed for FTTC and then for FTTP are reported, before analysing the information about respondents' income. These variables are particularly important because they are used to compute the speed elasticity relative to FTTC and FTTP products.

Table A1.1 FTTC's products summary statistics

Plan	Number of respondents selecting the plan	Percentage of the number of respondents	Average monthly expenditure	Speed
Fibre 100	[✂]	[✂]	[✂]	[✂]
Fibre 2	[✂]	[✂]	[✂]	[✂]
Fibre Essential	[✂]	[✂]	[✂]	[✂]

Source: Oxera analysis based on BT/DecTech Data.

The price/expenditure for each product (Fibre 100, Fibre 2 and Fibre Essential) is averaged because the experiment randomised prices for different participants. For example, in the case of Fibre Essential, one participant was proposed [✂] while another was offered the same package for [✂]. For this reason, we have averaged prices for representation. However, the speed data remains constant for any given product and is used in the cross-sectional regression to calculate the speed elasticity for FTTC.

We can also represent FTTP's data in a similar way (with similar averaging for different prices).[30]

Table A1.2 FTTP's products summary statistics

Plan	Number of respondents selecting the plan	Percentage of the number of respondents	Average monthly expenditure	Speed
Fibre Essential	[✂]	[✂]	[✂]	[✂]
Full Fibre 100	[✂]	[✂]	[✂]	[✂]
Full Fibre 300	[✂]	[✂]	[✂]	[✂]
Full Fibre 500	[✂]	[✂]	[✂]	[✂]
Full Fibre 900	[✂]	[✂]	[✂]	[✂]

Source: Oxera analysis based on BT/DecTech Data.

When combined with the respondents' income data, we can estimate the income elasticities described in section 3. The income data for the FTTC and FTTP experiments are presented below.

[30] Note that, as part of DecTech's experimental design, FTTP participants saw either Full Fibre 300 or Full Fibre 500, not both simultaneously. This does not significantly affect our income elasticity results, as our methodology uses a linear mapping of income on speed chosen.

Table A1.3 Respondents' income in FTTC survey

Survey code	Number of respondents	Percentage number of respondents	Income range	Average yearly income
1	[✂]	[✂]	[✂]	[✂]
2	[✂]	[✂]	[✂]	[✂]
3	[✂]	[✂]	[✂]	[✂]
4	[✂]	[✂]	[✂]	[✂]
5	[✂]	[✂]	[✂]	[✂]
6	[✂]	[✂]	[✂]	[✂]
7	[✂]	[✂]	[✂]	[✂]
8	[✂]	[✂]	[✂]	[✂]
9	[✂]	[✂]	[✂]	[✂]
10	[✂]	[✂]	[✂]	[✂]
11	[✂]	[✂]	[✂]	[✂]
12	[✂]	[✂]	[✂]	[✂]
13	[✂]	[✂]	[✂]	[✂]
14	[✂]	[✂]	[✂]	[✂]
15	[✂]	[✂]	[✂]	[✂]

Source: Oxera analysis based on BT/DecTech Data.

The table above shows how the survey's codes relate to the number of customers selecting a particular range, reported both in absolute values and in percentage terms. The last two columns contain the income ranges associated with the survey code, and the average yearly income computed using the upper and lower bounds of the range. When it comes to category 13 (more than [✂]) since there is not an upper bound to calculate the range, a working assumption of [✂] has been used.

Table A1.4 Respondents' income in FTTP survey

Survey code	Number of respondents	Percentage number of respondents	Income range	Average yearly Income
1	[✂]	[✂]	[✂]	[✂]
2	[✂]	[✂]	[✂]	[✂]
3	[✂]	[✂]	[✂]	[✂]
4	[✂]	[✂]	[✂]	[✂]
5	[✂]	[✂]	[✂]	[✂]
6	[✂]	[✂]	[✂]	[✂]
7	[✂]	[✂]	[✂]	[✂]
8	[✂]	[✂]	[✂]	[✂]
9	[✂]	[✂]	[✂]	[✂]
10	[✂]	[✂]	[✂]	[✂]
11	[✂]	[✂]	[✂]	[✂]
12	[✂]	[✂]	[✂]	[✂]
13	[✂]	[✂]	[✂]	[✂]
14	[✂]	[✂]	[✂]	[✂]
15	[✂]	[✂]	[✂]	[✂]

Source: Oxera analysis based on BT/DecTech Data.

www.oxera.com

compelling economics