econ ONE

Competitive Effects of Fixed Wireless Access on Wireline Broadband Technologies

June 2023

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Abstract

In this research paper, we present original estimates of the likely penetration rate of fixed wireless access (FWA) at different price points and speed combinations in a world absent of any wireless spectrum[2] capacity constraints, as well as the annual savings to both defecting wireline broadband subscribers (to FWA) and remaining wireline broadband customers. Our estimation strategy involves the use of a choice-based conjoint[3] (CBC) survey, which allows us to measure the preferences of existing cable modem subscribers. The survey tool also enables us to simulate the market shares of existing broadband and potential FWA packages under different scenarios. For any given cable modem market share loss, we can estimate the revised (lower) cable modem price consistent with the new equilibrium using the standard dominant firm/fringe pricing model.

We find that at current prices, full FWA entry to a cable-only market, which constitutes approximately 30 percent of all cable modem subscribers in the United States, would convert 18 percent of cable-only households to FWA, creating at least $369 million in consumer surplus[4] for these households per year. An 18 percent defection and loss of cable modem market share would generate a 37 percent reduction in the price of cable modem service, generating at least $5.7 billion in annual consumer savings for those who remain subscribed to cable modem service. In cable/fiber markets, we find that full FWA entry would convert 2 percent of households from cable modem to FWA, creating $27 million in consumer surplus for these households. Such defection would generate a 1.1 percent reduction in the price of cable modem service, generating $220 million in annual consumer

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[2] "Spectrum," as used in telecommunications, refers to the invisible radio frequencies that wireless signals travel over, enabling all the functions of a smartphone. Portions of electromagnetic spectrum are grouped in "bands" depending on their wavelengths, which are the distance over which the wave's shape repeats. The full electromagnetic spectrum ranges from three Hz (extremely low frequency) to 300 EHz (gamma rays). Within that, the portion used for wireless communication ranges from about 20 KHz to 300 GHz. *(CTIA)*

[3] Conjoint analysis is a form of statistical analysis used in market research to understand how customers value different components or features of their products or services.

[4] Consumer *surplus* occurs when the price that consumers pay for a product or service is less than the price they're willing to pay. Consumer *savings* are direct dollar savings relative to what consumers pay now.

savings. The paper concludes with policy implications that explain the nexus between the potential consumer benefits of broadly available FWA and the U.S. wireless spectrum policy needed to achieve those benefits.

I. Background on Fixed Wireless Inroads to Date

For over a decade, economists have been debating the issue of "wireless substitution,"[5] or whether wireless technologies can serve as a substitute for wireline technologies. Wireless has demonstrated it has the capability to handle internet connectivity for *mobile* applications, particularly on smartphones. The question now is if wireless technology has reached a point where it can serve as a functional and economic substitute for traditional *wireline* household broadband, which connects household devices like computers and tablets to the internet.

Before exploring evidence of the competitive impact of FWA, we briefly review how FWA works. FWA is a "last mile," or "access network," broadband technology, meaning it provides internet access between individual households and businesses and the rest of the broader internet, connecting the consumer's home network (typically a WiFi or Ethernet local area network) to a wireless base station owned by an Internet Service Provider (ISP).[6] Just like traditional wireline technologies, the base station is connected to the broader internet via high-speed fiber-optic lines. However, instead of laying physical cable all the way to each individual household (the "last mile") to transmit data, FWA uses the wireless spectrum as the conduit. Businesses and homes rely on either inside-the-home gateway modems (similar to traditional wireline modems), or they use high-gain antenna receivers to reach longer distances.[7] To ensure quality service, the user typically must reside within three to five miles of the main access point and ideally have a line-of-sight connection.[8]

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[5] *See, e.g.*, Kevin Caves, *Quantifying price-driven wireless substitution in telephony*, 35(11) TELECOMMUNICATIONS POLICY 984-998 (2011), *available at* https://www.sciencedirect.com/science/article/abs/pii/S0308596111001388.

[6] Rikin Thakker, *Fixed Wireless Access (FWA): A Competitive and Growing Broadband Technology,* WIRELESS INFRASTRUCTURE ASSOCIATION, Dec. 20, 2022, *available at* https://wia.org/fixed-wireless-access-fwa-a-competitive-and-growing-broadband-technology/.

[7] *Fixed wireless access: Using 5G to bring better broadband to more people,* NOKIA, accessed Mar. 24, 2023, *available at* https://www.nokia.com/networks/fixed-networks/fwa-fastmile/?did=D00000001096.

[8] Roslyn Layton, *Five Things About Fixed Wireless Access (FWA), The Future Of Broadband,* Forbes, Apr. 24, 2022, https://www.forbes.com/sites/roslynlayton/2022/04/24/five-things-about-fixed-wireless-access-fwa-the-future-of-broadband/?sh=6ca39db09310 ("FWA is emerging as solution for suburban and rural areas with speeds as high as 1 Gbps (1000 gigabits) over four miles."); *Bridging the digital divide with FWA,* ERICSSON, accessed Apr. 24, 2023, *available at* https://www.ericsson.com/en/cases/2022/bridging-the-digital-divide-with-fwa-uscc ("With the innovative mmWave extended range functionality, coverage is significantly extended – pushing the effective range out from typically around 600–900 m to over 5 km."); *How Does a Fixed Wireless Network…Work?,* NCTA, Nov. 27, 2018, *available at* https://www.ncta.com/whats-new/how-does-a-fixed-wireless-networkwork ("Data travels over a pre-existing hard-wired network to a 'fiber backhaul tower' where it then travels over the air up to five miles away.").

The data speeds delivered over 5G-based FWA are generally between 100 and 300 megabits per second (Mbps), comparable to many cable and fiber offerings but typically lower than premium 1,000 Mbps ("gigabit" internet) offered by fiber and cable modem services.[9] Relative to fiber, the tradeoff for speed is ease of access and lower cost of deployment. Verizon's CEO Hans Vestberg noted that "[i]t took us 22 years to pass 17 million households with fiber. 22 years. That's how hard it is. We basically had 30 million households covered with fixed wireless access in less than one year."[10]

A. Early Evidence on Penetration

Industry surveys estimate that approximately 90 percent of U.S. households receive some form of fixed broadband internet service.[11] The term "broadband" generally refers to higher-speed internet access and is used in contrast to traditional dial-up internet over a phone line. "Fixed" means supplied to an unmoving location, used in contrast to "mobile" broadband received by smartphones and similar devices. Fixed broadband refers to a collection of high-speed internet access technologies that are always "on," such as digital subscriber line (DSL, which uses copper telephone wires), cable modem (which uses television coaxial cables), fiber (which uses fiber optic cables), satellite (which uses a sky-oriented outdoor receiver to communicate with satellites), broadband over powerline (a technology that transmits over power lines), and FWA (which uses an antenna or gateway to connect to existing 5G networks).[12]

FWA that leverages recent advances in 5G networks is a relatively new technology that appears poised to take over new broadband growth. While there are other technologies that can be used to provide FWA, 5G-based offerings are generating significant attention for their competitive impact in the broadband market and are the focus of our research here. Recent data from March 2023 shows that 5G FWA accounted for 90 percent of all new broadband subscriptions in 2022, and that 2022 FWA subscription rates had more than quadrupled compared to 2021.[13] In May 2022, Wells Fargo issued an equity research note

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[9] Although one Verizon FWA package advertises 1000 Mbps rates in certain areas. Diana Goovaerts, *Verizon execs take a page from cable in latest FWA pitch*, FIERCE TELECOM, Jan. 4, 2023, *available at* https://www.fiercetelecom.com/broadband/verizon-execs-take-page-cable-latest-fwa-pitch. *See* Appendix 1.

[10] *Id.* (quoting Hans Vestberg).

[11] *US Home Broadband Penetration Reaches 90% - Study,* LIGHT READING, Dec. 22, 2022, *available at* https://www.lightreading.com/broadband/us-home-broadband-penetration-reaches-90-study-/d/d-id/782492#:~:text=Broadband%20accounts%20for%2099%25%20of,increase%20from%2085%25%20in%202017; Ani Petrosyan, *Percentage of population using the internet in the United States from 2000 to 2023*, STATISTA, Feb. 20, 2023, *available at* https://www.statista.com/statistics/209117/us-internet-penetration/.

[12] *Types of Broadband Connections,* FEDERAL COMMUNICATIONS COMMISSION, June 23, 2014, *available at* https://www.fcc.gov/general/types-broadband-connections; David Anders & Sean Jackson, *Cable, fiber, 5G and more: The different internet connection types and how they work,* CNET, Sept. 13, 2021, *available at* https://www.cnet.com/home/internet/internet-connection-types/.

[13] *About 3,500,000 Added Broadband From Top Providers in 2022*, LEICHTMAN RESEARCH GROUP, Mar. 2 2023, *available at* https://www.leichtmanresearch.com/about-3500000-added-broadband-from-top-providers-in-2022/. *See also LRG: FWA Continues to Displace All Others for Broadband Growth*, Telecompetitor, Nov. 17, 2022, at https://www.telecompetitor.com/lrg-fwa-continues-to-displace-all-others-for-broadband-growth/. (showing FWA accounted for 90% of annual broadband net adds, and more that 100% in some recent quarters).

asserting that 5G FWA is a "viable competitive threat, particularly in rural areas," and "the biggest disrupter" in the broadband marketplace in the near term, capturing a full 60 percent of broadband "net adds" or new subscribers through 2024.[14] An April 2023 note claimed that FWA would drive 90 percent of broadband adds in 2023.[15] Wells Fargo also expects cable modem's share of net adds to fall by 60 percentage points, from 94 percent over the past three years to 30 to 35 percent. Along with fiber-to-the-home (FTTH) connections, the bank predicts that FWA "permanently slows gross adds and depresses valuations" of cable service providers.[16] Moreover, early industry survey data shows that consumers are more satisfied with FWA internet service providers than traditional wireline providers.[17]

The leading 5G fixed wireless providers to date are Verizon (marketed under the name "5G Home")[18] and T-Mobile (marketed under the name "5G Home Internet").[19] The two mobile operators forecast ten to twelve million net subscriber adds via fixed wireless through 2025. T-Mobile announced it reached one million fixed wireless subscribers in April 2022.[20] Wells Fargo expects the technology to take hold as mid-band spectrum, ideal for 5G because it can carry plenty of data while also traveling significant distances,[21] is rolled out to more markets. T-Mobile ended 2022 with 2.6 million FWA subscribers (2.4 million of which was post-pay), with two thirds of the additions coming from the largest 100 markets across the United States.[22] Wells Fargo expects T-Mobile to reach 8 million FWA subscribers by 2025.[23]

FWA was originally expected to achieve its highest penetration in rural areas or spaces otherwise outside the current wireline footprints of cable and telco providers. But even inside the existing wireline footprints, FWA offers price-sensitive customers an alternative lower-cost option to wireline broadband. Evidence shows its appeal across all areas—

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[14] *Fiber vs. FWA vs. Cable—Let the Games Begin, Cry 'Havoc!' and Let Slip the Dogs of Connectivity,* WELLS FARGO, May 19, 2022 [hereafter *Let the Games Begin*].

[15] *The Download: Wireless Q1'23 Outlook,* WELLS FARGO, Apr. 5, 2023 ("FWA Continues to Eat into Home Broadband Share - While subscriber growth is starting to plateau at TMUS/VZ, we still expect fixed wireless to account for over 90% of industry broadband adds in 2023.").

[16] *Id*.

[17] Trey Paul, *Yikes, Americans Really Despise Their Internet Service Providers,* CNET, June 23, 2022, *available at* https://www.cnet.com/home/internet/americans-hate-their-internet-service-providers/ ("One other standout from the report is newcomer T-Mobile Home Internet, which hit the market in 2021 and debuted at second on the list with a score of 71. That bodes well for the fixed wireless option, which uses its 5G and 4G LTE networks to connect homes to the internet and aims to be a disruptor to traditional broadband providers [the tagline on its site is 'Free yourself from internet BS']. If these scores are any indication, it and other newcomers might have a shot at success.").

[18] *Get 5G Home Internet and Save,* VERIZON, accessed Mar. 22, 2023, *available at* https://www.verizon.com/5g/home/.

[19] *5G Home Internet,* T-MOBILE, accessed Mar. 22, 2023, *available at* https://www.t-mobile.com/home-internet.

[20] David Lumb, *5G is capable of so much more*, CNET, July 22, 2022, *available at* https://www.cnet.com/tech/mobile/5g-only-fraction-of-best-innovations-heres-what-were-waiting-for/.

[21] *5G spectrum banks explained*, NOKIA, accessed Mar. 24, 2023, *available at* https://www.nokia.com/networks/insights/spectrum-bands-5g-world/.

[22] *TMUS: Beat-and-Raise + Share Buyback Underpin Fundamental Story into 2023,* WELLS FARGO, Feb. 2, 2023.

[23] *TMUS: Clean as a Whistle in Q3—Beat, Raise, and Repeat,* WELLS FARGO, Oct. 27, 2022.

urban, suburban, and rural. Wells Fargo expects FWA to be "disruptive" even in urban areas "due to its low price points and bundling discounts with existing mobile subscribers."[24] The bank estimates there were 7.7 million fixed wireless subscribers nationwide as of May 2022, which should rise to 17.5 million by 2027. CoBank expects that wireless operators will target urban and suburban markets "where the upside in customer additions is more attractive than in smaller rural markets."[25] However, this growth can only occur in areas where FWA service providers currently have excess spectrum capacity for FWA.[26] Whether new full-power licensed spectrum will be made available to support broad FWA penetration is currently an actively discussed policy issue that we discuss later in Part IV (Policy Implications).

B. Early Evidence on Price Effects

FWA's increasing availability appears to put downward pressure on the price of existing cable modem services. FWA is a functional substitute for wireline broadband in that it provides comparable speed and reliability for home internet. However, *functional substitutability* is only a starting point for determining *economic substitutability*, which is whether a product or service can affect other offering's prices. (A bus is a functional substitute for a car, but buses don't discipline the price of cars and are thus not economic substitutes.) Early data indicates that as FWA expands, prices on existing cable modem services fall in response to the new competition.

FWA plans are typically offered at a lower price point than cable modem or fiber services. Wells Fargo found that FWA can be as much as 50 percent cheaper than a lower-tier cable plan over multiple years.[27] For existing (post-paid, premium, unlimited) mobile subscribers of Verizon and T-Mobile, the incremental cost of adding FWA home internet service is currently between $25 and $30 per month. Wells Fargo estimates that, as of May 2022, there were nearly 50 million customers enrolled in post-paid, premium, and unlimited wireless plans that could take advantage of those bundled discounts.

There is already evidence that cable service providers are responding to FWA by reducing the price of cable modem service, indicating that there is what economists call "cross-price elasticity" between the two offerings. Part of cable service providers response to FWA entails the bundling of mobile plans with their (wireline) broadband products. For example, in mid-2022, Comcast dropped the price of its 300 Mbps internet plan by $20 per month (for a new price point of $30 per month) for a two-year contract for Comcast (Xfinity) mobile customers. This offering suggests that Comcast felt pressure from Verizon's and T-Mobile's comparable bundle that includes FWA for home-based internet. According to CoBank, Comcast has responded to the threat of fixed wireless by offering a 75Mbps plan on a two-year contract for $25 per month, while Charter introduced a plan (Spectrum One)

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[24] *Let the Games Begin*, *supra*.
[25] *Cable Companies Losing Their Grip on Home Internet Market*, COBANK, Nov. 15, 2022, *available at* https://www.globenewswire.com/en/news-release/2022/11/15/2556633/0/en/Cable-Companies-Losing-Their-Grip-on-Home-Internet-Market.html [hereafter *Losing Their Grip*].
[26] *Losing Their Grip*, *supra*.
[27] *Let the Games Begin*, *supra*.

that includes a single mobile line and internet service (300 Mbps speed plan) for $49.99 per month.[28]

Complicating cable service providers responses' to FWA is the fact that cable service providers are also fending off inroads by fiber-to-the-home offerings. According to Wells Fargo, fiber companies typically undercut cable on price by roughly 20 percent.[29] In response to telco-based fiber entry offers (and only in these markets), Comcast and Charter dropped their prices for gigabit speeds to $80 per month—$29 below Comcast's and $35 below Charter's standard prices—and extended the promotion from one to two years.[30] These reports of competitive responses due to new entry into cable markets are consistent with the downward trend in wireline internet access prices recorded by the Bureau of Labor Statistics (BLS). The BLS's Producer Price Index (PPI) measures "the average change over time in the selling prices received by domestic producers for their output. The prices included in the PPI are from the first commercial transaction for many products and some services."[31] Notably, the PPI category titled "Wired telecommunications-carriers-Internet access services" has modestly declined since January 2020, a departure from the inflationary patterns experienced in the rest of the economy.[32]

II. Conjoint Survey Design

There is no doubt that consumers *without* a current broadband service provider will experience welfare gains from the option to purchase broadband FWA. Our research seeks to quantify FWA's effects on consumer welfare for those customers *with* an existing wireline broadband provider. Our primary research questions are:

1. What percentage of existing cable modem customers would switch if presented with a lower cost fixed wireless alternative?
2. How would the price of existing cable modem services change in response to new FWA competition?
3. What would be the welfare effects for both customers who switch to FWA and those who remain with cable modem services at a lower price point?

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[28] *Losing Their Grip*, *supra*.
[29] *Let the Games Begin*, *supra*.
[30] Hal Singer, *Is Fixed Wireless Ready To Take On Cable? It's Early, But The Initial Data Seem Promising*, FORBES, July 25, 2022, https://www.forbes.com/sites/halsinger/2022/07/25/is-fixed-wireless-ready-to-take-on-cable-its-early-but-the-initial-data-seem-promising/?sh=30acbe4525a1.
[31] *Producer Price Indices*, BUREAU OF LABOR STATISTICS, accessed Mar. 22, 2023, *available at* https://www.bls.gov/ppi/; *PPI industry data for Wired telecommunications carriers-Internet access services, not seasonally adjusted*, BUREAU OF LABOR STATISTICS, accessed Apr. 24, 2023, *available at* https://data.bls.gov/pdq/SurveyOutputServlet; PPI industry data for Wired telecommunications carriers, not seasonally adjusted, BUREAU OF LABOR STATISTICS, accessed Apr. 24, 2023, *available at* https://data.bls.gov/pdq/SurveyOutputServlet.
[32] PPI industry data for Wired telecommunications carriers-Internet access services, not seasonally adjusted, Series ID PCU5173115173116, *available at* https://beta.bls.gov/dataViewer/view/timeseries/PCU5173115173116;jsessionid=99C87AE8A3E9236C6DCCA9FB2C2727EA.

To answer these questions, we employ a choice-based conjoint (CBC) survey among existing cable modem customers to assess FWA's economic substitutability. CBC surveys are experiments that objectively measure individual respondent's preferences through a series of choice tasks, where a respondent is asked to select between a set number of purchase options.[33] CBC analysis is grounded in economic modeling techniques pioneered by (among others) Nobel Prize-winning economist Daniel McFadden, among others.[34] The economic modeling frameworks that provide the underpinning for CBC analysis have been widely used by economists to study markets for differentiated consumer products and services, in applications ranging from merger analysis to the competitive effects of introducing new products and services.[35]

In this case, we use CBC to measure the competitive effects of introducing a new service, FWA, to a population of consumers who are currently purchasing cable modem services.

Our survey contains three separate modules: The "Screener" module; the "Attributes" module; and the "Conjoint" module. The Screener module filters survey respondents to ensure they are in the relevant target population of cable modem subscribers. The Attributes module describes to eligible respondents the product at issue in the Conjoint module—an internet service package—as well as all of the possible features that compose it. The Conjoint module asked respondents to complete ten choice tasks. Each choice task presented the respondent with three randomized internet service packages and a "no purchase" option, and asked respondents to choose which of the packages (or the "no purchase" option) they would purchase in real life if these three options were the only home internet options available to them. Respondents were asked to do this exercise ten times each.[36] Doing so develops each respondent's "utility model," or their individual valuation of the attributes that underlie the packages.

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[33] A "choice task" asks respondent to select one of multiple alternative options. Typically, respondents choose between multiple products and a "no buy" option. *See, e.g.,* McFadden et al. (2013) at 2 ("Respondents to CBC surveys must typically perform between 12 and 20 "choice tasks," depending on the complexity of the product. In the cola example above, each choice task requires a respondent to choose his preferred alternative from among a "choice set" of four alternative product profiles. Each respondent choice provides a data point for the analysis. Hence, if 400 respondents take the survey and each respondent makes 20 choices, there will be 8,000 data points in the analysis.").

[34] *See, e.g.,* Daniel McFadden, *The Choice Theory Approach to Market Research*, 5(4) MARKETING SCIENCE 275-297 (1986); *see also* McFadden et al. (2013); Paul Green & V. Srinivasan *Conjoint Analysis in Marketing: New Developments with Implications for Research and Practice* 54 JOURNAL OF MARKETING 3-19 (1990).

[35] *See, e.g.,* Aviv Nevo, *Mergers with Differentiated Products: The Case of the Ready-to-Eat Cereal Industry,* 31 RAND JOURNAL OF ECONOMICS (2000); *see also* Amil Petrin, *Quantifying the Benefits of New Products: The Case of the Minivan* 110 (4) JOURNAL OF POLITICAL ECONOMY (2002). Conjoint analysis has been widely adopted by the private sector. As of the early 1980s, one study determined that there were hundreds of commercial applications of conjoint analysis each year. Green & Srinivasan, *supra*, at 3, citing Dick Wittnick & Phillippe Cattin, *Commercial Use of Conjoint Analysis: An Update* 53 JOURNAL OF MARKETING 91-96 (1989).

[36] CBC survey respondents generally perform at most 30 "choice tasks" within the Conjoint module. *See* Kirk Bansak, Jens Hainmueller, Daniel J. Hopkins, and Teppei Yamamoto, *The Number of Choice Tasks and Survey Satisficing in Conjoint Experiments*, 26 POLITICAL ANALYSIS 112-119 (2018).

The relevant population is existing cable modem customers in the United States. We focus on cable modem subscribers because FWA speeds are most comparable to mid-tier cable modem offerings, and because cable providers are the dominant provider of home internet services nationwide.[37] To target this population, we contracted with the survey firm Qualtrics to provide the sample respondents for the survey.[38] The sampling frame consisted of individuals who met the following eligibility requirements:

- Reside within the United States;
- Are over the age 18;
- Currently pay for cable modem home broadband internet.

In addition, we asked respondents to self-classify the following characteristics to allow for more granular analysis:

- Age, Sex, Race, and Ethnicity;
- If they self-described their location as Urban, Suburban, or Rural;
- Whether or not fiber is currently an option at their location (including an "I don't know" option);
- Whether or not FWA is currently an option at their location (including an "I don't know" option);
- The number of alternative wireline broadband companies, in addition to their cable modem service company, available at their location (including an "I don't know" option).

Having qualified to take the survey, respondents were told that the topic of the survey was internet service packages. The survey then explained the key attributes that would comprise the packages they would be shown in the Conjoint module of the survey.

In a CBC survey, a "feature" is a category, which is composed of "levels," or values, that each feature can take. For example, the feature "Color" may have three levels: Red, Blue,

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[37] Global Data estimates that cable modem internet connections account for 70 percent of all broadband connections in 2022. *Cable will continue to dominate US residential broadband market with 65% share in 2027 driven by expanding broadband coverage, says GlobalData,* GLOBAL DATA, July 22, 2022, *available at* https://www.globaldata.com/media/technology/cable-will-continue-dominate-us-residential-broadband-market-65-share-2027-driven-expanding-broadband-coverage-says-globaldata/.

[38] The conjoint survey was administered by Qualtrics, which regularly conducts such surveys on behalf of business schools and large corporations. *See Conjoint Analysis Software Tool*, QUALTRICS, *available at* https://www.qualtrics.com/core-xm/conjoint-analysis/. Qualtrics is an industry standard survey platform that has been relied upon by over 16,000 brands and 75 percent of the Fortune 100. *The Operating System for XM trusted by over 16,000 brands and 75% of the Fortune 100*, Qualtrics, *available at* https://www.qualtrics.com/customers/. *See, e.g.*, William G. Zikmund et al., BUSINESS RESEARCH METHODS (with Qualtrics Printed Access Card) (Cengage Learning 9th ed. 2012).

and Green.[39] We described each feature and its levels before beginning the Conjoint Module. This allows respondents to understand the entire array of potential options in the survey. If a respondent did not assert that they understood the features described to them, they were disqualified from the survey.

The features and levels in the survey were modeled to simulate the common broadband offerings from the major cable modem and FWA providers.[40] For FWA, we looked to Verizon and T-Mobile as the two primary firms providing FWA access as of this writing.[41] For cable modem broadband, we looked to packages offered by Comcast (under the Xfinity brand) and Charter Communications (under the Spectrum brand), which are the two major cable modem broadband providers in the United States. We also reviewed fiber offerings from Verizon, AT&T, and CenturyLink.[42] Although we reviewed some legacy DSL services provided by AT&T and CenturyLink, we did not include DSL packages in the Conjoint, because DSL does not offer comparable speeds to cable modem service, and because DSL is being deprioritized by AT&T and CenturyLink in favor of fiber.[43]

Prices, speeds, terms, and hardware requirements as of March 2023 from each provider are reviewed in Appendix 1. From our review of the available FWA, cable modem, and fiber packages, we constructed the following attributes to capture the most commonly advertised features:

- **Price**: Prices are listed on a per-month basis. We use *unbundled* prices—that is, prices where the consumer is not bundling home internet with another service such as cell phone service or television. For the purposes of the Conjoint, we instruct the respondent to assume that this price is inclusive of all fees (such as equipment

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[39] In a survey design context, the term "attribute" is used to refer to a feature and all of its levels, collectively. In practice, the terms "feature" and "attribute" may be used synonymously with little loss of clarity. *Step 1: Defining Conjoint Features & Levels,* QUALTRICS (accessed Oct. 2022), *available at* https://www.qualtrics.com/support/conjoint-project/getting-started-conjoints/getting-started-choice-based/step-1-defining-conjoint-features-levels/.

[40] Petroc Taylor, *Number of broadband internet subscribers in the United States from 1st quarter 2011 to 3rd quarter 2021, by cable provider,* STATISTA, Jan. 18, 2023, *available at* https://www.statista.com/statistics/217348/us-broadband-internet-susbcribers-by-cable-provider/#:~:text=With%20more%20than%2031%20million,subscriptions%20in%20the%20United%20States; Daniel Frankel, *Comcast and Other Cable Operators Control 67% of U.S. Broadband Market,* NEXTTV, Mar. 6, 2020, *available at* https://www.nexttv.com/news/comcast-and-other-cable-operators-control-67-of-us-broadband-market.

[41] Trey Paul, *What Is 5G Home Internet and Could It Be the Solution for Your Broadband Needs?,* CNET, Mar. 8, 2023, *available at* https://www.cnet.com/home/internet/what-is-5g-home-internet/ [hereafter *What is 5G Home Internet*].

[42] *Id.*

[43] Rob Pegoraro, *AT&T shelving DSL may leave hundreds of thousands hanging by a phone line,* USA TODAY, Oct. 3, 2020, *available at* https://www.usatoday.com/story/tech/columnist/2020/10/03/att-dsl-internet-digital-subscriber-line-outdated/5880219002/; Trey Paul, *CenturyLink Home Internet Review: Say Bye to DSL, but Hello to Quantum Fiber,* CNET, Feb. 5, 2023, *available at* https://www.cnet.com/home/internet/centurylink-internet-review/ [hereafter *CenturyLink Home Internet Review*]; Trey Paul, *AT&T Home Internet Review: Fiber's Nice, but if You Get DSL, Think Twice,* CNET, Jan. 14, 2023, *available at* https://www.cnet.com/home/internet/att-internet-review/ [hereafter *AT&T Home Internet Review*].

rental) and discounts (such as autopay). We opt not to include any upfront fees, as most plans offer free installation of equipment. As shown in Appendix 1, typical prices for FWA, cable, and fiber range from $25 to $90 per month for speeds ranging from 75 Mbps to 1000 Mbps. To keep steps between prices even, we chose to show prices of $30, $40, $50, $60, $70, $80 and $90 in the survey, all of which correspond to actual package prices paid by consumers.

- **Connection Type**: All broadband internet services connect to the household through a technology medium. For cable modem and fiber, this takes the form of physical cable that connects the home to the grid. For FWA, the connection is the wireless spectrum. In each case, the connection type requires a certain set of home equipment. For the survey, we describe three connection types and the required equipment for Cable, Fiber, and FWA. We capitalize these terms when we refer to the Connection Type option in the conjoint. (The "Cable" option in the Conjoint versus cable modem subscribers generally.)

- **Download Speed:** Download speeds are measured in Mbps, with the fastest cable modem offers reaching one gigabit per second (1000 Mbps or 940 Mbps). Cable modem speed ranges from 75 Mbps to 1 Gbps, and FWA clocks in typically between 100 and 300 Mbps for basic packages, with Verizon offering max speeds of 1000 Mbps in some locations. We include the most common advertised speeds in the survey: 75 Mbps, 100 Mbps, 200 Mbps, 300 Mbps, 500 Mbps, and 1000 Mbps. Respondents were briefly given examples of what internet speeds are required for certain activities, such as casual browsing, streaming video, gaming, telecommunicating, or downloading files.[44]

- **Upload Speed:** Upload speeds are also measured in Mbps. While download speeds are important for downloading files and streaming videos, upload speeds play an important role in video communications and file sharing. Upload speeds are either equal (or nearly equal) to the download speed (as is the case with fiber internet and some FWA offerings) or, more common among cable modem services, a fraction of the download speed. To compare with the Download Speed feature, we display upload speed as a fraction of the download speeds: As fast as download, half as fast as download, one-tenth or less of download speed with a 5 Mbps minimum.

In addition to the above features, we considered and rejected three additional features in the survey:

- **Brand**: While a company's reputation is often a key factor in an internet purchase decisions, we elected not to include a variable for brands in the survey and instead instructed the respondent to assume that the packages were all being offered by the same company (that is, keeping the company offering the service equal.) We did

[44] *Broadband Speed Guide,* FEDERAL COMMUNICATIONS COMMISSION, accessed Mar. 22, 2023, *available at* https://www.fcc.gov/consumers/guides/broadband-speed-guide?kbid=120594*; Compare Fiber Internet vs. Broadband Speeds,* FASTMETRICS, accessed Mar. 22, 2023, *available at* https://www.fastmetrics.com/how-fast-is-fiber-optic-internet.php.

this to avoid creating counterfactual plans in the conjoint design (T-Mobile does not offer Cable or Fiber options, nor does Xfinity offer FWA) which would potentially confuse respondents or require exclusion from the survey design.

- **Promotional Price Period**: Some firms use a "promotional pricing" tactic, where the consumer pays an initial advertised price for a set period of time (typically one to three years), which is followed by a price hike after the promotional period.[45] We opted not to include a promotional term (or lack thereof) as a feature because it adds unnecessary complexity to a consumer's calculation of "true" prices, and because no FWA offering uses promotional prices.[46]

- **Internet Quality:** Internet quality, or reliability, is a catch-all term that can include a number of different elements such as service uptime (how often the internet cuts out entirely), latency (the time it takes a home computer to communicate with a website), jitter (the variation of latency), packet loss (how much data does not reach the destination), and congestion (download/upload speeds slowing down during peak usage hours.)[47] We opted not to include a measure of internet quality because (1) we have not seen evidence that, holding upload and download speeds constant, cable modem or FWA technologies are inherently more or less reliable than one another; and (2) introduction of additional terms may add unnecessary complexity to the survey, and a lay-term of "good" or "bad" quality may mean different things to different respondents.[48]

We summarize these features and levels in Table 1 below.

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[45] Consumers, generally speaking, dislike this tactic. *See, e.g.,* Sheelah Kolhatkar, *Why We Despise Cable Providers,* THE NEW YORKER, July 31, 2017, *available at* https://www.newyorker.com/magazine/2017/08/07/bad-ratings.

[46] Verizon offers a 2- and 3- year "Price Guarantee," however it is unclear if this is a promotional price. *Verizon 5G Home Internet service & plans FAQs | Ultra-fast Home Internet,* VERIZON, accessed Mar. 22, 2023, *available at* https://www.verizon.com/support/5g-home-faqs/ [hereafter *Verizon 5G Home Internet*].

[47] *Speed Test,* CLOUDFLARE, accessed Mar. 22, 2023, *available at* https://speed.cloudflare.com/; *What is Network Congestion,* VERIZON, accessed Mar. 22, 2023, *available at* https://www.verizon.com/info/internet-congestion/#:~:text=Network%20or%20internet%20congestion%20is,internet%20connection%20can%20become%20sluggish.

[48] Other researchers have encountered similar issues. One recent conjoint graded internet quality as "low," "medium," and "high" as defined terms instead of introducing latency, jitter, and packet loss. Rabbani, Maysam and Bogulski, Cari and Eswaran, Hari and Hayes, Corey, *Willingness to Pay for Internet Services,* Feb. 27, 2023, *available at* https://ssrn.com/abstract=4372210.

TABLE 1: CBC FEATURES AND LEVELS

Features	Description	Levels
Monthly Price	All-inclusive monthly price of the service in USD	• $30 • $40 • $50 • $60 • $70 • $80 • $90
Connection Type	The technology and equipment used to connect the home to the internet.	• **Cable Modem:** Service is provided over existing cable television wires. Cable Modem equipment in your home must be connected by a physical cable to the network infrastructure outside. The equipment placed in your home is approximately the size of a half-foot cube. • **Fiber:** Provided over single-purpose fiber optic cables. Fiber equipment in your home must be connected by a physical cable to the network infrastructure outside. The equipment placed in your home is approximately the size of a half-foot cube. • **Fixed Wireless**: Provided over a wireless network, often using new 5G connections. Depending on your location, Fixed Wireless equipment would be a single integrated unit placed in your home at a location where it receives a good wireless signal. Typically, this is on a shelf in a central location in your home, or next to a window. In some cases, a standalone wireless antenna is attached to an interior window, or mounted to the exterior of your home where it receives a better wireless signal. A cable is run from the antenna to a separate indoor router. The equipment placed in your home is approximately the size of a half-foot cube, and the antenna unit (if required) is approximately the size of a paperback book.
Download Speed	The rated internet download speed, expressed in Mbps	• 75 Mbps • 100 Mbps • 200 Mbps • 300 Mbps • 500 Mbps • 1 Gbps
Upload Speed	The rated internet upload speed, expressed as a fraction of the Download Speed	• As fast as the Download Speed • Half as fast as the Download Speed • One-tenth or less as fast as the Download Speed (5 Mbps minimum)

Having qualified for the survey and asserted they understood the attributes described to them, respondents were moved to the Conjoint module of the survey. In addition to the Screener module, our survey employed a commitment check, an attention check, and removed any respondents who exhibited bot-like or low-quality behaviors (such as speeding or answer straight-lining). We also performed a pretest of 50 respondents who were asked post-test questions about their experience to ensure their understanding of the survey was consistent with our intention. The survey was administered in March of 2023

and yielded a total of 500 valid respondents after dropping low quality responses.[49]

III. Empirical Results

A. Survey Results

The respondents' demographics are broadly representative of the American population in terms of their age, geography, sex, race, and ethnicity. Summary statistics of the respondents' demographics are available in Appendix Table 1.

Having completed the choice tasks in the Conjoint module, we used an industry standard Hierarchical Bayesian model to calculate the "utility" of every level of every feature for each individual respondent based on their choices.[50] The net utility of a product package is the sum of all of the individual utilities (and disutilities) of its components. Economic theory suggests that when presented with multiple internet plans in the Conjoint module (including a "none of these options" package, which also has its own utility scores), a respondent selects the package with the highest net utility to them. The Hierarchical Bayesian model reverse-engineers these preferences based on a respondent's observed choices.[51]

We first compare the relative importance of the features offered for the various internet plans. Table 2 shows the results across all respondents, scaled in importance, with scores adding up to 100. Of the four features considered in our survey, Download Speed and Monthly Price are the most important features, with Download Speed being slightly more important. Upload speed is approximately half as important as Download Speed and Monthly Price, and the Connection Type is approximately a third as important as Download Speed. These results track with our internal expectations, as users typically download more than they upload, and internet users are typically price-sensitive.

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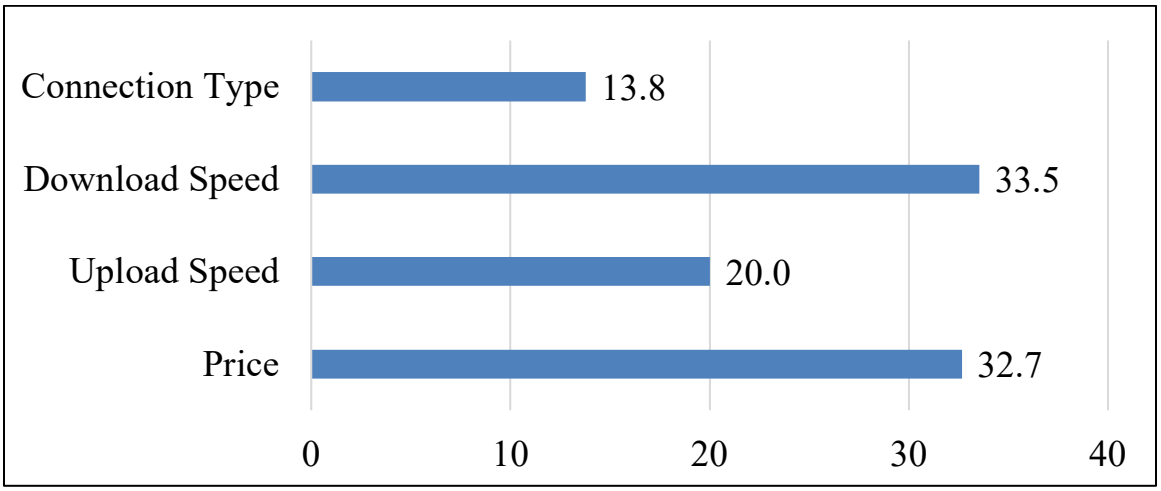
[49] 3,127 respondents started the survey but did not qualify for various reasons. A report of these terminations is available in Appendix Table 2.

[50] *Conjoint Analysis White Paper,* QUALTRICS, accessed Nov. 2022, *available at* https://www.qualtrics.com/support/conjoint-project/getting-started-conjoints/getting-started-choice-based/conjoint-analysis-white-paper/. Although we contracted with Qualtrics to provide the survey respondents (and Qualtrics provides its own Hierarchical Bayesian model), we used the Hierarchical Bayesian model included in Sawtooth Software's Lighthouse Studio as it allows for the creation of more complex simulation models. *See CBC Hierarchical Bayes,* SAWTOOTH SOFTWARE, accessed Apr. 24, 2023, *available at* https://sawtoothsoftware.com/advanced-analytical-tools/cbc-hierarchical-bayes.

[51] Orme at 44 ("Hierarchical Bayes estimation (HB) offers a powerful way of borrowing information from every respondent in the data set to improve the accuracy and stability of each individual's part-worth estimates. It has consistently proven successful in reducing the IIA problem and in improving the predictive ability of both individual level models and market simulation share results. HB estimation can employ either main-effects-only models or models that also include interaction terms.").

TABLE 2: FEATURE IMPORTANCE



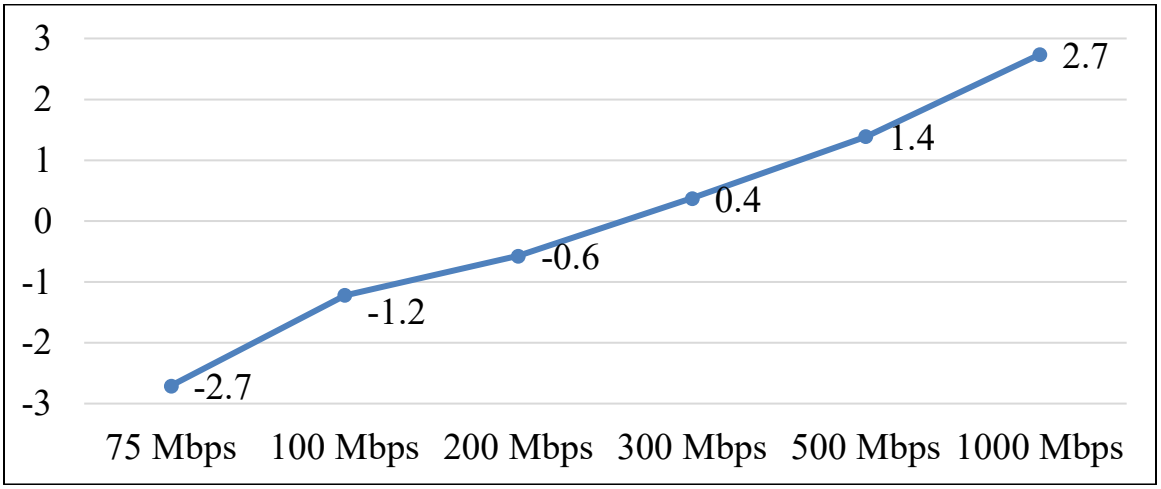
NOTES: The measurement of influence a feature has when the respondent is choosing their preferred bundle. The higher the score, the more weight it carries in the decision-making process. (Scores add up to 100).

Table 6 below shows the utilities of the individual features and levels in the survey. Survey respondents generally favored the Cable Connection Type over Fiber and FWA, all other features held equal, which follows expectations, as the sampling frame consists of current cable modem customers and would naturally prefer a Connection Type they are already familiar with. Cable modem subscribers typically favored Fiber over FWA. This indicates that cable modem subscribers have a preference for sticking with their existing technology or something that they know (Fiber) over a relatively new technology (FWA). However, the standard deviations for these attributes (see Table 6) are all larger than the averages, meaning that there is substantial individual variation in respondents' preferences. Moreover, because the total importance of the Connection Type feature is the smallest of the four features available, consumers' mild preferences for a Cable Connection Type on average is often outweighed by their stronger preferences for better Download Speeds and lower Monthly Prices.

Table 3 shows the average utility level for the Download Speed feature. As expected, respondents typically prefer higher speeds over lower speeds, with the utility relationship being approximately linear between 100 Mbps and 1,000 Mbps.[52] Interestingly, the 25 Mbps jump between 75 Mbps and 100 Mbps generates the highest single lift in utility, despite being the smallest amount of speed gained between options. This may indicate that consumers view 75 Mbps plans as sub-premium plans.

[52] Some users (N=21) displayed an *inverse* ("irrational") utility to download speeds. Although this second group may appear potentially "irrational" (in that they derive greater utility from a worse feature), following best practices we leave these respondents in the model. We discuss this further in Appendix I. A robustness check of the model (excluding potentially "irrational" responses) yields similar results as our primary model.

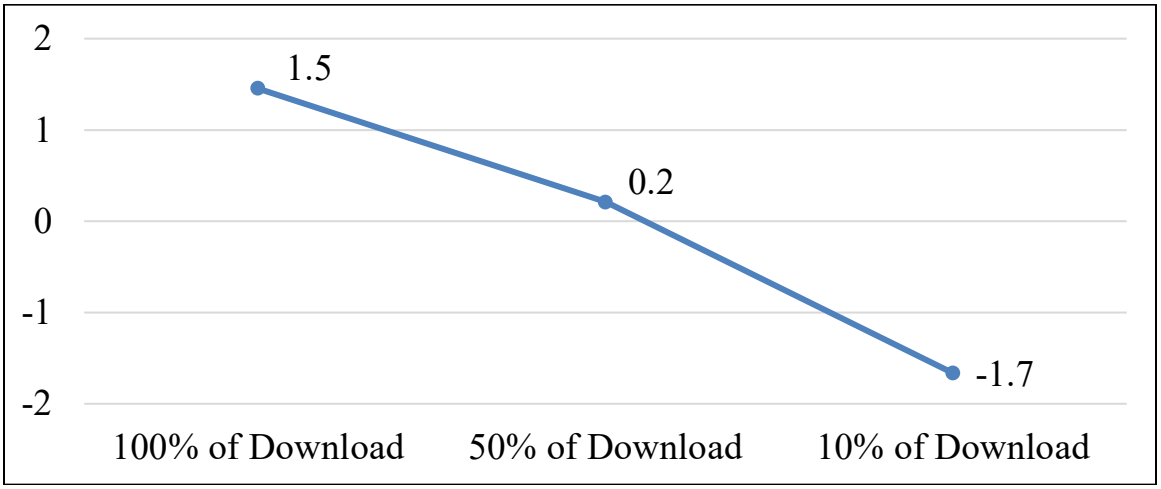
TABLE 3: AVERAGE LEVEL UTILITY: DOWNLOAD SPEED



NOTES: The average calculation across respondents' individual utility scores. These values are normalized and additive, meaning they can be compared to utilities from other attributes and show how significant a level is in contributing to a plan's overall utility.

Table 4 shows the average utility level for the Upload Speed feature. As expected, respondents typically prefer higher upload speeds over lower upload speeds, with the utility relationship being approximately linear between the three levels offered.[53]

TABLE 4: AVERAGE LEVEL UTILITY: UPLOAD SPEED

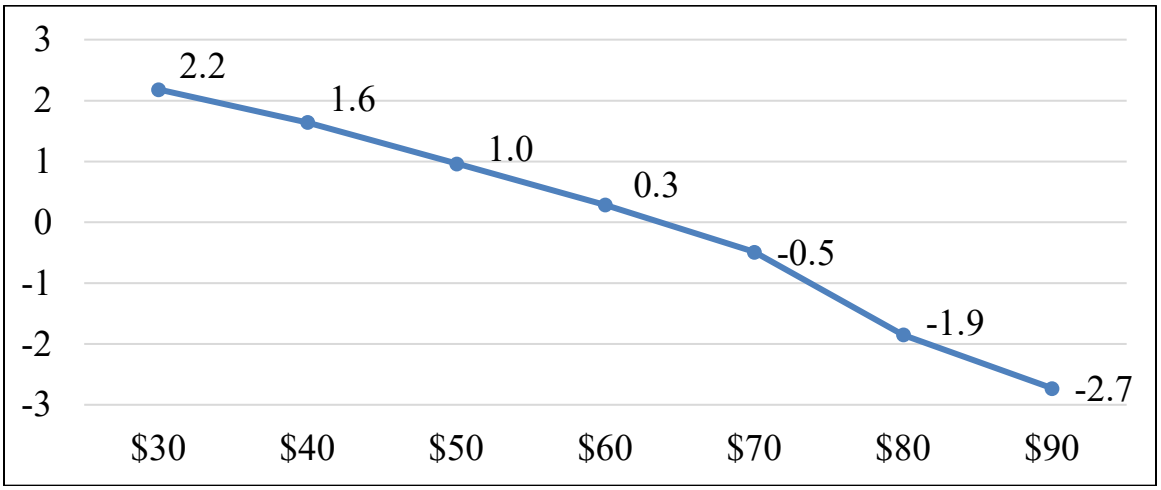


NOTES: The average calculation across respondents' individual utility scores. These values are normalized and additive, meaning they can be compared to utilities from other attributes and show how significant a level is in contributing to a plan's overall utility.

[53] Some users (N=39) displayed an *inverse* ("irrational") utility to Upload Speeds.

Table 5 shows the average utility level for the Price per Month feature. As expected, respondents typically prefer lower prices to higher prices.[54] The relationship between price and utility is approximately linear, with higher prices showing slightly more disutility per $10 increase than lower priced $10 increases.

TABLE 5: AVERAGE LEVEL UTILITY: PRICE PER MONTH



NOTES: The average calculation across respondents' individual utility scores. These values are normalized and additive, meaning they can be compared to utilities from other attributes and show how significant a level is in contributing to a plan's overall utility.

Table 6 below shows the utility level averages, standard deviations, and confidence intervals (CI) for each feature and level. The results of the survey are consistent with standard economic intuition with respect to Speed and Price. Importantly, these results demonstrate that the cable modem population has an inherent bias towards their current Connection Type. Put differently, most respondents would not switch to a different Connection Type unless that internet plan has markedly superior Speed (faster) or Price (lower).

[54] Some users (N=35) displayed an *inverse* ("irrational") utility to Price per Month.

TABLE 6: SURVEY UTILITIES

Connection Type	Utility	Std Deviation	Lower 95% CI	Upper 95% CI
Cable	0.66	1.02	0.57	0.75
Fiber	-0.15	0.82	-0.22	-0.07
Fixed Wireless	-0.51	0.80	-0.58	-0.44
Download Speed	**Utility**	**Std Deviation**	**Lower 95% CI**	**Upper 95% CI**
75 Mbps	-2.71	1.29	-2.82	-2.59
100 Mbps	-1.22	1.08	-1.31	-1.12
200 Mbps	-0.57	0.55	-0.62	-0.53
300 Mbps	0.37	0.39	0.34	0.41
500 Mbps	1.39	0.83	1.31	1.46
1000 Mbps	2.74	1.71	2.59	2.89
Upload Speed	**Utility**	**Std Deviation**	**Lower 95% CI**	**Upper 95% CI**
100% of Download	1.45	1.12	1.35	1.55
50% of Download	0.21	0.38	0.18	0.24
10% of Download	-1.66	1.15	-1.77	-1.56
Price	**Utility**	**Std Deviation**	**Lower 95% CI**	**Upper 95% CI**
$30	2.18	1.77	2.03	2.34
$40	1.64	1.22	1.54	1.75
$50	0.96	0.72	0.90	1.03
$60	0.28	0.41	0.25	0.32
$70	-0.49	0.83	-0.56	-0.42
$80	-1.85	1.47	-1.98	-1.72
$90	-2.73	1.51	-2.86	-2.60
None Option	-2.91	3.39	-3.21	-2.62

Notes: N=500.

Robustness tests show that the model is internally consistent and has meaningful predictive power of consumer behavior. The Hierarchical Bayesian model is run twice to evaluate its predictive ability using a standard holdout profile and hit rate methodology.[55] The primary model is run on all ten responses from each of the 500 respondents. The results and calculations below are from this primary model. As a robustness check of the primary model, we also ran the model on a subset of the data—the first nine of the ten responses, and asked the model to predict what the user would select for the tenth holdout profile. If the model correctly predicts the tenth profile choice, we score a "hit" for that user. If it incorrectly predicts the tenth profile, we score a "miss" for that user. We then calculate the "hit rate" of the model by dividing the hits by all hits and misses. The hit rate of our model is 60 percent, compared to a baseline "random guess" model, which would yield a hit rate of only 25 percent.[56]

[55] Orme at 195-196 (discussing hit rates and holdout questions).

[56] Because each choice task has four options (including a None option), a randomly guessing model would successfully pick the actual respondent's preference one out of four times.

The combination of the CBC model's internal validity, coupled with the respondent sample being a collection of individuals who resemble typical cable modem subscribers, leads us to believe that the results of our analyses are externally valid. Put differently, the data indicate that the results of our competitive market share simulation performed on the sample of 500 respondents can be extrapolated to the general population of cable modem subscribers in the United States.[57]

B. Market Simulations

Using the utility models generated above, we next use conjoint market simulations to assess how the entry of FWA would affect market shares, consumer surplus, and prices.[58] We assess two types of cable modem markets: cable-only markets and cable/fiber markets.

FCC data indicate that as of December 2021, approximately 85 percent of U.S. households have access to cable modem internet, 48 percent of U.S. households have access to fiber, and 85 percent have access to FWA.[59] DSL reaches 88 percent of households, while satellite technology theoretically reaches every household in the United States. However, the "take rate" of these technologies (the share of households with access who actually utilize that technology) varies. Table 7 shows what households selected out of their available options, with approximately 65 percent of households opting for cable modem, 13 percent for DSL, 39 percent for fiber, 1.3 percent for satellite, and 2.4 percent for FWA. Approximately 11 percent of all households (12.1 million households) did not opt for any broadband service.[60]

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[57] Orme at 190.

[58] Orme at 89 ("The simulator converts raw conjoint (part-worth utility) data into something much more managerially useful: simulated market choices. Products can be introduced within a simulated market scenario and the simulator reports the percentage of respondents projected to choose each product. A market simulator lets an analyst or manager conduct what-if games to investigate issues such as new product design, product positioning, and pricing strategy.").

[59] FCC 2022 Communications Marketplace Report, FCC-22-103, released Dec. 30, 2022, available at https://docs.fcc.gov/public/attachments/FCC-22-103A1.pdf, at Figure II.A.1, para. 17.

[60] Benton Institute, FCC: Broadband Market is on the Cusp of Generational Change, Jan. 6, 2023, *available at* https://www.benton.org/blog/fcc-broadband-market-cusp-generational-change [hereafter *Benton Institute Study*].

TABLE 7: BROADBAND TECHNOLOGY ACCESS AND TAKE RATES (DECEMBER 2021)

Technology	Deployment (Access)		Residential Connections	Residential Take Rate
	Households	Percent	Households	Percent
Cable	110.0	84.8%	71.8	65.3%
Copper (Incl. DSL)	114.0	88.0%	15.2	13.3%
Fiber	62.2	48.0%	24.2	38.8%
Satellite	129.7	100.0%	1.7	1.3%
Fixed Wireless	110.1	84.9%	2.7	2.4%
Total	**129.7**	--	**115.5**	**89.1%**

Source: FCC 2022 Communications Marketplace Report, FCC-22-103, released Dec. 30, 2022, available at https://docs.fcc.gov/public/attachments/FCC-22-103A1.pdf, at Figure II.A.1
Note: Household and residential values in millions. Based on FCC Form 477 data as of December 31, 2021.

We then calculate the market shares for these technologies in Table 8 using this FCC data. We first calculate the market share of each technology in the full national broadband market, inclusive of all technologies. Next, we calculate market shares only among the high-speed broadband technologies (cable modem, fiber, FWA), which omits both DSL and satellite technologies that typically speeds below 100 Mbps. Among high-speed broadband connections, cable modem has a 73 percent share of all connected households, compared to fiber's 25 percent share and FWA's 2.7 percent share.

TABLE 8: HIGH SPEED BROADBAND MARKET SHARES

Technology	High-Speed Residential Connections	
	Households	Percent of Connections
Cable	71.8	72.8%
Fiber	24.2	24.5%
Fixed Wireless	2.7	2.7%
Total Connections	**98.6**	**100.0%**

Source: FCC 2022 Communications Marketplace Report, FCC-22-103, released Dec. 30, 2022, available at https://docs.fcc.gov/public/attachments/FCC-22-103A1.pdf, at Figure II.A.1.
Note: Household and residential values in millions.

We first focus on the cable-only markets. FCC data indicate that as of December 2021, 30.5 percent of the 129.7 households in the FCC study were beholden to a single wireline internet service provider of broadband capable of achieving 100 Mbps down.[61] Assuming that this single broadband provider is a cable modem provider (100 Mbps is typically too fast for DSL, and instances where a home receives fiber but not cable modem are rare), and making the conservative assumption that the take rate for cable modem is the same in cable-only vs. cable/fiber markets, this implies that there are approximately 39.6 million households beholden to a single cable modem provider (equal 129.7 total households from Table 7 times 30.5 percent). Because cable modem has a 65 percent take rate among households with cable modem access, we calculate the number of current cable modem connections beholden to a single provider to be 25.8 million (equal to 39.6 times 65 percent).[62] We term these customers as residing in cable-only markets.

We then focus on cable/fiber markets, which include cable modem subscribers who have access to a fiber option, but nonetheless purchase cable modem internet service. We calculate the size of the cable/fiber market to be 34.5 million cable modem households (equal 71.8 cable modem connected households from Table 7 times fiber's penetration rate of 48 percent.)[63]

For each of the two market types, we consider three alternative pricing scenarios. First, we consider FWA's entry at its currently offered FWA prices, which typically mirror the price of cable modem packages at a given Download Speed. We then consider two scenarios where FWA enters at a $10 and $20 per month discount, respectively, compared to cable modem prices. These discounted prices simulate both the discounts received by existing (post-paid, premium, unlimited) mobile subscribers of Verizon and T-Mobile. These plans also simulate potential prices where FWA is able to achieve economies of scale and compete aggressively on price.

For each scenario considered, we calculate the total improvement in consumer welfare from the competitive entry of FWA. We first calculate the change in market share from FWA's entry and the resulting direct, short-run consumer welfare effects for customers

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[61] FCC 2022 Communications Marketplace Report, FCC-22-103, released Dec. 30, 2022, available at https://docs.fcc.gov/public/attachments/FCC-22-103A1.pdf, at APPX. B-3 (out of 129.7 million households). This figure is limited to "fixed terrestrial" services, meaning it excludes satellite and FWA.

[62] This figure is very conservative, as the take rate for cable modem services would very likely be higher in a market with cable-only access, relative to the national average that includes competition from fiber services. To the extent there are more households in the cable-only market than our figures above imply, this makes our latest estimates of consumer welfare and savings conservative.

[63] This leaves 11.5 million cable modem subscribers (71.8 – 25.8 – 34.5) outside of our two markets. Some of these households have cable modem access only, but through multiple Cable modem providers. FCC data from December 2016 indicate that approximately 4 percent of households with cable modem access have access to two or more cable modem providers. *See* Jon Brodkin, *FCC report finds almost no broadband competition at 100Mbps speeds,* ARS TECHNICA, Feb. 12, 2018, available at https://arstechnica.com/information-technology/2018/02/fcc-report-finds-almost-no-broadband-competition-at-100mbps-speeds/. This would equate to approximately 2.9 of the 11.5 million. It is likely that the remaining households outside of our two markets are actually part of the cable-only market for the reasons given in footnote 61.

who switch Connection Types to FWA. We then calculate the long-run consumer welfare effects for consumers who remain with Cable, by calculating the new (lower) profit-maximizing price cable modem providers would charge at their reduced market share. The combination of short-run consumer welfare gains (for those who switch) and long-run gains (for those who remain in a Cable plan at a lower price) yields the total improvement in consumer welfare.

These simulations show that the entry of FWA generates modest consumer welfare for consumers who switch to FWA, and substantial consumer welfare for those customers who passively benefit from the lower prices caused by the entry of a new competitive broadband option. The total consumer surplus generated under each scenario, and the resulting consumer savings from the long-run price reduction of Cable prices, is summarized in Table 9. We describe the methods that produce these results in detail below.

TABLE 9: CONSUMER SURPLUS AND PRICE SAVINGS SUMMARY

Simulation	Consumer Surplus Created for FWA Switchers ($Millions)	Price Savings for Remaining Cable Modem Customers ($Millions)
Cable Market, Current Prices	$ 369.2	$ 5,734.8
Cable/Fiber Market, Current Prices	$ 26.7	$ 218.8
Total	**$ 395.8**	**$ 5,953.6**
Cable Market, $10 FWA Discount	$ 602.8	$ 6,392.2
Cable/Fiber Market, $10 FWA Discount	$ 108.5	$ 507.8
Total	**$ 711.3**	**$ 6,900.0**
Cable Market, $20 FWA Discount	$ 1,306.4	$ 7,172.9
Cable/Fiber Market, $20 FWA Discount	$ 245.6	$ 969.5
Total	**$ 1,552.1**	**$ 8,142.4**

1. FWA Entry Into Cable-Only Markets

We first simulate FWA's entry into cable-only markets. We simulate a cable modem market with broadband plans available, ranging from a 75 Mbps cable modem option at $30 per month (comparable to Xfinity's real-world lowest cost plan) to a 1,000 Mbps cable modem plan at $90 per month (a simulated premium option of Charter Communications' Spectrum plan). Each cable modem package is set to 10% upload speed. After simulating the market shares of those Cable plans, we then introduce two new FWA packages, which correspond to Verizon's $50 FWA plan that advertises 85–300 Mbps download, along with Verizon's $70 FWA plan that advertises speeds of 300–1000 Mbps download. For the purposes of these simulations, we take a midpoint value of these advertised speeds and simulate a 200 and 500 Mbps FWA package. Each package is set to 10% upload speed. When we simulate the discount scenarios, we drop each list price by $10 and $20 respectively. Table 10 details the simulated packages.

TABLE 10: CABLE-ONLY SIMULATED PLANS

Internet Plan	Connection Type	Download Speed	Upload	Price
Cable 75	Cable	75 Mbps	10% of Download	$30
Cable 200	Cable	200 Mbps	10% of Download	$40
Cable 300	Cable	300 Mbps	10% of Download	$50
Cable 500	Cable	500 Mbps	10% of Download	$70
Cable 1000	Cable	1000 Mbps	10% of Download	$90
FWA 200	Fixed Wireless	200 Mbps	10% of Download	$50 / $40 / $30
FWA 500	Fixed Wireless	500 Mbps	10% of Download	$70 / $60 / $50

Note that at current prices, the FWA 200 plan at $50 is technically inferior to the Cable 300 plan, while the FWA 500 plan and the Cable 500 plan are tied on technical specs for the same $70 price point. Thus, any switches from the Cable to FWA Connection Type at current price points would only occur among those respondents who have a distaste for Cable relative to FWA.[64] In the Appendix 2, we simulate a world where all Cable package prices are $20 higher, which is reflective of cable service operators' non-promotional prices. In that scenario, the FWA 200 plan is no longer technically inferior.[65]

a. Market Share Change

We first simulate the market shares (also known as preference shares) these plans would generate using the Conjoint model.[66] The results of this simulation are shown in Table 11. Before the introduction of FWA, the Cable plans capture 87.6 percent of the respondents, with 12.4 percent electing for a "No Buy" option when faced with this set of choices. When the two FWA packages are introduced, FWA captures a 16.1 percent market share, with 15.7 percent defecting from an existing Cable plan and 0.4 percent coming from previous "No Buy" customers without a Cable plan.[67]

[64] Even though respondents on average prefer cable modem over FWA, there exist a substantial minority of respondents who would choose another Connection Type over cable modem given identical price and technical specs.

[65] This scenario shows that FWA's market share changes jump by ten additional percentage points relative to the $20 discount scenario. (FWA's share is 39.6 percent in the $20 cable price premium scenario compared to 30.2 percent in the $20 FWA price discount scenario.

Appendix Table 3. This demonstrates that our model is conservative to the extent our models are using lower average cable prices then reality (which includes a blend of promotional and non-promotional prices).

[66] Orme at 89. We use the "Randomized First Choice" method of simulation, which allows individual error in respondents' answers to calculate the probability that each respondent would select a particular plan. When making individual welfare calculations, we use a "First Choice" method to constrain each respondent to a single selection. The results of the simulations do not change materially under alternative simulation methodologies. *See Randomized First Choice,* SAWTOOTH SOFTWARE, accessed Apr. 24, 2023, *available at* https://legacy.sawtoothsoftware.com/help/lighthouse-studio/manual/hid_randomizedfirstchoice.html.

[67] Although the survey respondents are all current cable modem subscribers, we allow for the "No Buy" option to simulate their ability to leave the market entirely when presented with a choice set that did not equal the utility generated by their current internet plan.

TABLE 11: CABLE-ONLY MARKET SIMULATION
CURRENT FWA PRICES

	[1]	[2]	[3] = [2]-[1]
Internet Plan	**Shares of Preference Pre-FWA**	**Shares of Preference With FWA**	**Change**
Cable 75	9.1%	8.1%	-1.0%
Cable 200	20.5%	17.4%	-3.1%
Cable 300	22.1%	19.0%	-3.1%
Cable 500	20.1%	14.4%	-5.7%
Cable 1000	15.9%	13.0%	-2.8%
FWA 200		4.8%	4.8%
FWA 500		11.4%	11.4%
None	12.4%	11.9%	-0.4%
All Cable	87.6%	71.9%	-15.7%
All FWA	0.0%	16.1%	16.1%
None	12.4%	11.9%	-0.4%

We then simulate how these market shares would increase if FWA prices were $10 lower per package and $20 lower per package. These lower prices provide a "what-if" scenario of FWA deployment should FWA offer its current subscriber discounted pricing. Table 12 and Table 13 display these results simulations respectively. In the $10 discount scenario (where FWA 200 is introduced at $40 rather than $50, and the FWA 500 plan is introduced at $60 rather than $70), FWA's ultimate share increases to 21.4 percent, with 20.4 percent defecting from a Cable plan and 0.9 percent coming from previous "No Buy" customers. In the $20 discount scenario (where FWA 200 is introduced at $30 rather than $50, and the FWA 500 plan is introduced at $50 rather than $70), FWA's ultimate share increases to 30.2 percent, with 28.6 percent defecting from a Cable plan and 1.6 percent coming from previous "No Buy" customers.

TABLE 12: CABLE-ONLY MARKET SIMULATION
$10 DISCOUNT FWA PRICES

	[1]	[2]	[3] = [2]-[1]
Internet Plan	**Shares of Preference Pre-FWA**	**Shares of Preference With FWA**	**Change**
Cable 75	9.1%	7.4%	-1.6%
Cable 200	20.5%	15.0%	-5.5%
Cable 300	22.1%	17.6%	-4.6%
Cable 500	20.1%	14.2%	-5.9%
Cable 1000	15.9%	13.0%	-2.8%
FWA 200		7.8%	7.8%
FWA 500		13.6%	13.6%
None	12.4%	11.4%	-0.9%
All Cable	87.6%	67.2%	-20.4%
All FWA	0.0%	21.4%	21.4%
None	12.4%	11.4%	-0.9%

TABLE 13: CABLE-ONLY MARKET SIMULATION
$20 DISCOUNT FWA PRICES

	[1]	[2]	[3] = [2]-[1]
Internet Plan	**Shares of Preference Pre-FWA**	**Shares of Preference With FWA**	**Change**
Cable 75	9.1%	6.4%	-2.7%
Cable 200	20.5%	12.4%	-8.1%
Cable 300	22.1%	15.3%	-6.9%
Cable 500	20.1%	12.8%	-7.2%
Cable 1000	15.9%	12.1%	-3.7%
FWA 200		10.7%	10.7%
FWA 500		19.6%	19.6%
None	12.4%	10.7%	-1.6%
All Cable	87.6%	59.0%	-28.6%
All FWA	0.0%	30.2%	30.2%
None	12.4%	10.7%	-1.6%

b. Short-Run Consumer Welfare Change for FWA Switchers

We next calculate how the market share changes simulated above improve consumer welfare for those consumers who switch from Cable to a FWA option, or from a "No Buy" option to a FWA option. The consumer surplus created for these consumers is the direct result of the new FWA offerings being more valuable to a consumer than the existing option set beforehand.

This calculation is performed by summing the total utility created in each FWA scenario relative to the pre-FWA scenario.[68] Recall that each broadband package, which is comprised of individual features, holds a total utility value to each and every respondent in the survey. By summing up the total utilities generated by the highest utility package for each respondent and dividing by the number of respondents, we determine the average utility created per respondent in each scenario. When FWA options are introduced, the utility for those respondents who elect to purchase a new FWA package increases relative to their previous election, which increases the average utility across all respondents. For each scenario, we calculate the difference in average utility between the pre-FWA scenario and the post-FWA scenario.

Because we included price as an attribute in the survey, we can convert unitless utility gain into a dollar value. This allows us to calculate an average dollar value per utility in our survey across all price levels.[69] On average across all respondents in the survey, the dollar per utility conversion ratio is $12.20 per month, per unit of utility. This conversion ratio allows us to directly translate the gain in utility from the introduction of FWA to switchers

[68] For these simulations, we use a First Choice simulation model, which restricts a respondent to a single plan choice to more clearly assess the welfare gains for switchers.
[69] Note as shown in Table 5, the utility and price relationship is approximately linear.

to a dollar value. Using our estimate of 25.8 million cable-only connected households in in the United States, Table 14 shows the results of these calculations for the cable-only market. In the base case, FWA's introduction generates over $369 million in consumer welfare gains per year. This increases to $602 million and $1.3 billion per year in the two discount scenarios, or approximately $1.95 and $4.22 per subscriber per month.

TABLE 14: SHORT-RUN CONSUMER SURPLUS CREATED
CABLE-ONLY MARKET

	[1]	[2]	[3] = [1]*[2]	[4]	[5] = [3]*[4] *12
Simulation	**Avg. Utility Change Per Respondent**	**$/Util**	**$/Respondent**	**Households in Market (Millions)**	**Yearly Consumer Surplus Created ($Millions)**
Cable Market, Current Prices	0.10	$12.20	$1.19	25.8	$369.2
Cable Market, $10 Discounts	0.16	$12.20	$1.95	25.8	$602.8
Cable Market, $20 Discounts	0.35	$12.20	$4.22	25.8	$1,306.4

c. Long-Run Consumer Welfare Change for Non-Switching Cable Modem Subscribers

Economic literature recognizes that a dominant firm with high market shares and market power will set price at the point that maximizes the firm's profit.[70] As the "competitive fringe" in the market increases its market share, it depresses the dominant firm's ability to charge prices above marginal cost.[71] Put differently, the competitive pressure of a new entrant makes it economically rational for a once-dominant firm to lower prices, as doing so becomes profit-maximizing as market shares decline.

This framework, as explained in Landes and Posner's seminal paper on market power, can be readily applied to calculate the long-run price effects of FWA's entry on existing cable modem plan prices. This can be shown using a two-step process. *First*, we calculate how a cable modem firm's own-price elasticity shrinks due to the entry of FWA, as given by the equation: [72]

$$E_{own} = \frac{E_{market}}{S_{own}} + \frac{E_{rival}(1 - Share_{own})}{Share_{own}}$$

[70] *See, e.g.,* William Landes & Richard Posner, *Market Power in Antitrust Cases,* 94(5) Harvard Law Review 937-996, 947 (1981) [hereafter Landes & Posner].
[71] *Id.* at 947 ("Hence the demand elasticity for firm i will be lower the smaller the market share of the competitive fringe is. Intuitively, it is cheaper to raise price by curtailing output if fringe sellers have a lower market share since the same percentage increase by the fringe will yield a smaller absolute increase in their output"). Economic theory suggests that firms with pricing power increase prices until the markup of price over marginal cost is equal to the inverse of the firm's own-price elasticity. *Id.* at 937. Thus, decreasing a firm's own-price elasticity demand decreases markup.
[72] Landes & Posner at 944-945.

where E_{own} is the cable provider's own-price elasticity of demand, E_{market} is the elasticity of demand for the entire market, S_{own} is the firm's share of that market, and E_{rival} is this elasticity of supply for the firm's rivals—or the percentage increase in quantity supplied by rivals given a one percent increase in the provider's price.

The own-price elasticity of demand E_{own} can be readily converted into a profit-maximizing price, as given by the standard inverse elasticity formula:[73]

$$\frac{P - C}{P} = \frac{1}{E_{own}}$$

where *P* is the price of the product and *C* is the marginal cost of the product.

To apply this model to the case of a cable-only market, we calclulate a scenario where a local cable modem provider has a 100 percent market share (a monopoly) over households in this defined market (the 23 million cable modem customers who have no additional wireline broadband providers, including other cable modem firms.) We assume that the elasticity of supply for FWA's as cable service operators' rival is approximately 4.0, an assumption we vary as a robustness check in Appendix 2.[74] We estimate that the price cost-margin of providing cable modem service is approximately 58 percent, as indicated by the revenues and costs of goods sold of the two largest cable modem internet providers, Comcast and Charter.[75] We use a base case cable package of $50 per month.[76] Cable modem's market shares after FWA's entry are provided by the simulations above. For the purposes of these calculations, we omit the "No Buy" market share, and express Cable's market share only as a share of actual purchases made. Accordingly, in the cable-only market, cable modem accounts for a 100-market share of purchases before the introduction of FWA.

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[73] Landes & Posner at 939-940. *See also* Jerry Hausman & Greg Leonard, *Efficiencies from the Consumer Viewpoint,* 17(3) GEORGE MASON LAW REVIEW 707, 709 (1999).

[74] We test alternate elasticities of 3.0 and 2.0. These yield smaller price percentage reductions in the cable-only market and slightly larger price reductions in the cable/fiber market. The literature of the supply elasticity of the fringe seller ranges, depending on the industry. *See, e.g.,* Stephen J. Rassenti and Bart J. Wilson, *How Applicable is the Dominant Firm Model of Price Leadership?*, George Mason University, Interdisciplinary Center for Economic Science, 18 (2003) ("the tested low and high elasticity of fringe supply ≈ 1.7 and 3.4"); Valerie Y. Suslow, *Estimating Monopoly Behavior with Competitive Recycling: An Application to Alcoa*, 17(3) Rand Journal of Economics 389-403, 399 ("The actual case reveals $\hat{n} = -1.67$. With fringe supply horizontal and P_s fixed, $\hat{n}\bar{P}_S = -2.08$"); Simran Kahai, David Kaserman & John Mayo, *Is the "Dominant Firm" Dominant? An Empirical Analysis of AT&T'S Market Power*, 39 Journal of Law & Economics 499-517 (1996) (the supply elasticity of AT&T's competitors was estimated at 4.38 when AT&T lost its monopoly in long-distance telephone service).

[75] Comcast yields a price-cost margin of 55.7 percent, and Charter yields a price cost margin of 60.9 percent in 2022. *Comcast 2022 10k,* CMCSA, accessed Apr. 24, 2023, *available at* https://www.cmcsa.com/static-files/156da323-653e-4cc6-9bb4-d239937e9d2f; *2022 Annual Report,* Charter Communications, accessed Apr. 24, 2023, *available at* https://ir.charter.com/static-files/e3d00dfc-b3d6-4cf6-bbd0-309423830907. We use Comcast's revenues and EBITAS for its Cable Communications segment. Charter does not break out its segments, so we use its revenues and operating expense for the entire firm.

[76] The denomination is arbitrary given the marginal cost is computed as a function of price and the percentage margin.

Table 15 shows the results of these calculations. The entry of FWA competition to a cable-only market yields a substantial price decrease to cable prices, ranging from a 37 percent decrease under current prices to a 46 percent price decrease using the $20 FWA discount scenario.

TABLE 15: LONG-RUN CONSUMER SURPLUS CREATED
CABLE-ONLY MARKET

	Current State	FWA Entry Current Price	FWA Entry $10 Discount	FWA Entry $20 Discount
Market Demand Elasticity	1.72	1.72	1.72	1.72
Cable Market Share	100%	82%	77%	67%
Competitor Supply Elasticity	4.00	4.00	4.00	4.00
Own-Firm Demand Elasticity	1.72	2.96	3.45	4.49
Price-Cost Margin	58%	34%	29%	22%
Product Price ($50 Base)	$50.00	$31.50	$29.37	$26.85
Price Reduction	**0.0%**	**-37.0%**	**-41.3%**	**-46.3%**
Cable-Only Yearly Cable Revenues ($Billion)	**$15.50**	**$9.76**	**$9.10**	**$8.32**
Yearly Consumer Savings Generated ($Billion)	**--**	**$5.73**	**$6.39**	**$7.17**

Given that approximately 25.8 million cable modem households reside in cable-only markets, we calculate that cable modem internet revenues are approximately $15.5 billion in this market per year conservatively assuming a $50 per month average cable modem price.[77] By multiplying this figure by the estimated price discount from the model, we estimate that the savings to non-switching cable modem subscribers amounts to $5.7 billion per year for full FWA entry. The savings increase to $6.4 billion if FWA prices enter at a $10 discount to current new-customer levels, and to $7.2 billion in savings if FWA enters at $20 discounted prices.

2. FWA Entry into Cable/Fiber Markets

We next simulate FWA's entry into a market with both Cable and Fiber packages present. Using the primary model and all responses, we simulate a market with the same five options available as before, but add in three Fiber packages. These packages approximate Verizon's 300, 500, and 1,000 Mbps offerings at $50, $70, and $90 respectively. We set the upload speed for these Fiber packages to 100%, consistent with their real-world counterparts. We then introduce the two FWA packages as before. Table 16 reviews these

[77] Equal to 25.8 million cable modem subscribers multiplied by an average cable modem internet price of $50. Actual average cable modem prices may be higher: Xfinity reports that its residential broadband internet revenues were $23 billion in 2021, and that it had 29.6 million customers. This yields approximately $777 dollars in revenue per customer or year, or $65 dollars per month. *See* Comcast Corporation Form 10k, Fiscal Year Ended December 2022, *available at* https://www.cmcsa.com/static-files/156da323-653e-4cc6-9bb4-d239937e9d2f.

simulated plans. Note that at current prices, the FWA 200 plan at $50 is strictly inferior to the Cable 300 and Fiber 300 plan, while the FWA 500 and Cable 500, and Fiber 500 plan are tied on Download Speeds (Fiber 500 has a superior upload speed) for the same $70 price point. Thus, any switches from Cable or Fiber to FWA at current price points would only occur among those respondents who have a distaste for Cable or Fiber relative to FWA.

TABLE 16: CABLE/FIBER MARKET SIMULATED PLANS

Internet Plan	Connection Type	Download Speed	Upload	Price
Cable 75	Cable	75 Mbps	10% of Download	$30
Cable 200	Cable	200 Mbps	10% of Download	$40
Cable 300	Cable	300 Mbps	10% of Download	$50
Cable 500	Cable	500 Mbps	10% of Download	$70
Cable 1000	Cable	1000 Mbps	10% of Download	$90
Fiber 300	Fiber	300 Mbps	100% of Download	$50
Fiber 500	Fiber	500 Mbps	100% of Download	$70
Fiber 1000	Fiber	1000 Mbps	100% of Download	$90
FWA 200	Fixed Wireless	200 Mbps	10% of Download	$50 / $40 / $30
FWA 500	Fixed Wireless	500 Mbps	10% of Download	$70 / $60 / $50

a. Market Share Change

As before, we first simulate the market shares these plans would generate using the conjoint model. The results of this simulation are shown in Table 17. Before the introduction of FWA, the Cable plans only capture 28.3 percent of the respondents, with Fiber accounting for 65.7 percent respondents and 5.9 percent electing for a "No Buy" option when faced with this set of choices. When the two FWA packages are introduced, they capture a 2.5 percent market share, with 0.9 percent coming from Cable and 1.6 percent coming from Fiber.

TABLE 17: CABLE/FIBER MARKET SIMULATION
CURRENT FWA PRICES

	[1]	[2]	[3] = [2]-[1]
Internet Plan	**Shares of Preference Pre-FWA**	**Shares of Preference With FWA**	**Change**
Cable 75	5.2%	5.1%	-0.1%
Cable 200	9.4%	9.0%	-0.4%
Cable 300	7.3%	7.2%	-0.2%
Cable 500	3.3%	3.1%	-0.1%
Cable 1000	3.1%	3.1%	-0.1%
Fiber 300	27.5%	26.8%	-0.8%
Fiber 500	22.9%	22.2%	-0.6%
Fiber 1000	15.3%	15.1%	-0.2%
FWA 200		1.3%	1.3%
FWA 500		1.2%	1.2%
None	5.9%	5.9%	0.0%
All Cable	28.3%	27.5%	-0.9%
All Fiber	65.7%	64.1%	-1.6%
All FWA	0.0%	2.5%	2.5%
None	5.9%	5.9%	0.0%

We then simulate how these market shares would increase if FWA prices were $10 lower per package and $20 lower per package. Table 18 and Table 19 display these results simulations respectively. In the $10 discount scenario, FWA's share increases to 4.8 percent. In the $20 discount scenario, FWA's market share increases to 9.1 percent. These lower FWA market shares in the cable/fiber market (relative to the introduction of FWA in the cable-only market) demonstrates that the existence of existing cable competition (Fiber) mutes the impact of FWA's entrance, given that these customers already have an outside option in Fiber.

TABLE 18: CABLE/FIBER MARKET SIMULATION
$10 DISCOUNT FWA PRICES

	[1]	[2]	[3] = [2]-[1]
Internet Plan	**Shares of Preference Pre-FWA**	**Shares of Preference With FWA**	**Change**
Cable 75	5.2%	4.9%	-0.3%
Cable 200	9.4%	8.3%	-1.1%
Cable 300	7.3%	7.0%	-0.4%
Cable 500	3.3%	3.0%	-0.2%
Cable 1000	3.1%	3.0%	-0.1%
Fiber 300	27.5%	26.1%	-1.4%
Fiber 500	22.9%	22.0%	-0.9%
Fiber 1000	15.3%	15.0%	-0.3%
FWA 200		2.4%	2.4%
FWA 500		2.3%	2.3%
None	5.9%	5.8%	-0.1%
All Cable	28.3%	26.2%	-2.1%
All Fiber	65.7%	63.2%	-2.6%
All FWA	0.0%	4.8%	4.8%
None	5.9%	5.8%	-0.1%

TABLE 19: CABLE/FIBER MARKET SIMULATION
$20 DISCOUNT FWA PRICES

	[1]	[2]	[3] = [2]-[1]
Internet Plan	**Shares of Preference Pre-FWA**	**Shares of Preference With FWA**	**Change**
Cable 75	5.2%	4.4%	-0.8%
Cable 200	9.4%	7.2%	-2.2%
Cable 300	7.3%	6.6%	-0.8%
Cable 500	3.3%	2.9%	-0.3%
Cable 1000	3.1%	3.0%	-0.2%
Fiber 300	27.5%	24.9%	-2.6%
Fiber 500	22.9%	21.5%	-1.3%
Fiber 1000	15.3%	14.8%	-0.5%
FWA 200		4.8%	4.8%
FWA 500		4.3%	4.3%
None	5.9%	5.6%	-0.4%
All Cable	28.3%	24.0%	-4.3%
All Fiber	65.7%	61.3%	-4.4%
All FWA	0.0%	9.1%	9.1%
None	5.9%	5.6%	-0.4%

b. Short-Run Consumer Welfare Change for FWA Switchers

We next calculate how the market share changes simulated above improve consumer welfare for those consumers who switch from a Cable, Fiber, or "No Buy" option to a FWA plan.

Using the same calculations as explained in the previous section, we estimate that FWA's introduction generates about $2.1 million in consumer welfare per year, or approximately $0.06 per household per month. These values increase to $8.5 million and $19.2 million per year in the two discount scenarios, or approximately $0.26 and $0.59 per household per month.

TABLE 20: SHORT-RUN CONSUMER SURPLUS CREATED
CABLE/FIBER MARKET

	[1]	[2]	[3] = [1]*[2]	[4]	[5] = [3]*[4]
Simulation	**Avg. Utility Change Per Respondent**	**$/Util**	**$/Respondent**	**Cable Subscribers in Market**	**Consumer Surplus Created**
Cable/Fiber Market, Current Prices	0.01	$12.20	$0.06	32,488,443	$2,095,301
Cable/Fiber Market, $10 Discounts	0.02	$12.20	$0.26	32,488,443	$8,523,454
Cable/Fiber Market, $20 Discounts	0.05	$12.20	$0.59	32,488,443	$19,299,543

c. Long-Run Consumer Welfare Change for Non-Switching Cable Modem Subscribers

As before, we apply the Landes and Posner model to the case of cable/fiber markets. We make the simplifying assumption that for each household, there is only a single cable modem provider and a single fiber prover that offers service (a duopoly). As before, we assume that the elasticity of supply for cable's rivals is approximately 4.0 and the price cost-margin of providing cable modem service is approximately 58 percent. Using the FCC household data review in Table 8, we estimate cable modem's initial market share in the cable/fiber market at 59 percent.[78]

Table 21 shows the results of these calculations. The entry of FWA competition to a cable-monopoly market yields a substantial price decrease to cable prices, ranging from a 1.1 percent decrease under current prices to a 4.7 percent price decrease using the $20 FWA discount scenario.

[78] We calculate that there are 34.5 million households in the cable/fiber market, and the FCC data report that there are 24.2 million households with fiber. Assuming that all fiber households have a cable modem option, we calculate cable modem's market share as 34.5 / (34.5 + 23.2) = 58.8 percent.

TABLE 21: LONG-RUN CONSUMER SURPLUS CREATED CABLE/FIBER MARKET

	Current State	FWA Entry Current Price	FWA Entry $10 Discount	FWA Entry $20 Discount
Market Demand Elasticity	1.72	1.72	1.72	1.72
Cable Market Share	59%	57%	54%	50%
Competitor Supply Elasticity	4.00	4.00	4.00	4.00
Own-Firm Demand Elasticity	5.73	6.03	6.50	7.46
Price-Cost Margin	17%	17%	15%	13%
Product Price ($50 Base)	$50.00	$49.47	$48.77	$47.66
Price Reduction	**0.0%**	**-1.1%**	**-2.5%**	**-4.7%**
Cable/Fiber Yearly Cable Revenues ($Billion)	**$20.67**	**$20.46**	**$20.17**	**$19.71**
Yearly Consumer Savings Generated ($Billion)	**--**	**$0.22**	**$0.51**	**$0.97**

Given that approximately 34.5 million cable modem households reside in cable/fiber markets, we estimate that that cable modem internet revenues in the cable/fiber market are approximately $20.7 billion in this market per year.[79] The savings to non-switching cable modem subscribers amounts to $220 million per year for full FWA entry. The savings increase to $510 million if FWA prices enter at a $10 discount to current new customer levels, and to $970 million in savings if FWA enters at $20 discounted prices.

IV. Policy Implications

FWA is already bringing real benefits to consumers today as wireless providers roll out service alongside their 5G mobile networks. Its ability to scale up to a wider market, continue future growth, and fully respond to demand, however, is dependent on sufficient capacity being available to provide potential subscribers with a high quality of service. This in turn depends on the amount of licensed spectrum available to a provider in a given area. Thus, there is a direct relationship between spectrum availability (particularly mid-band spectrum) and the intensity of FWA competition for home broadband.[80] The most effective way to increase FWA competition and ensure the full promise of expected consumer benefits is by allocating more full-power, licensed, mid-band spectrum for 5G. Mike

[79] Equal to 34.5 million cable modem subscribers multiplied by an average cable modem internet price of $50.

[80] Mid-band spectrum blends good signal reach and penetration, with high data throughput rates. Full power mid-band licensed spectrum offers wireless operators the opportunity to maximize the performance of their networks for reliable, robust mobile and FWA service.

Sievert, T-Mobile's CEO, made this connection clear, having urged Congress in late April to restore the FCC's spectrum auction authority to support FWA expansion.[81]

One plausible explanation for why FWA providers in the United States have been reluctant to further undercut extant cable pricing is the potential for FWA to approach capacity limitations due to the relative dearth of 5G spectrum availability in the United States.[82] Per CoBank, FWA providers are only offering service where they have sufficient capacity to maintain quality of service for both mobile and fixed subscribers.[83] Because wireless networks are more susceptible to congestion than wired networks and FWA is a relatively data-intensive offering, wireless operators will likely face a critical decision point of how broadly to offer FWA and at what price, especially if FWA traffic starts to degrade mobile performance. FWA has the potential to scale and intensify competition for home broadband access, but only if FWA providers can obtain sufficient full-power licensed spectrum to satisfy the demand for FWA alongside 5G mobile wireless service and related offerings.

As our results indicate, a lower price point for FWA would mean substantial defection from cable to FWA in cable-DSL markets, and more modest substitution from cable to FWA in cable-fiber markets. To the extent that FWA suppliers are already capacity constrained, they may be reluctant to compete aggressively on price to draw in greater numbers of subscribers for fear the additional load would mean lower quality of service. According to the GSM Association (GSMA), a coalition of global mobile operators, the "FWA business case is highly dependent on the number of connections that can be supported per cell tower," which in turn depends on "the amount of spectrum that can be deployed on a cell tower."[84] GSMA estimates that an additional 2 GHz of upper mid-band spectrum is needed to sustain FWA delivering a download data rate of 100 Mbps in rural communities in the longer term.[85] The natural policy implication is clear: If the government wants to enhance competition among high-speed broadband providers, the key is getting more full-power licensed mid-band spectrum into the hands of FWA providers.

Cable companies, among other groups, are advocating for more unlicensed spectrum, or spectrum otherwise only made available through low-power sharing mechanisms, to support services such as WiFi.[86] If one is not cognizant of the tradeoffs between licensed

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[81] Ahmad Hatout, *T-Mobile Reiterates Need for FCC Spectrum Auction Authority, Touts 5G for Home Internet*, BROADBAND BREAKFAST, Apr. 27, 2023, *available at* https://broadbandbreakfast.com/2023/04/t-mobile-reiterates-need-for-fcc-spectrum-authority-touts-5g-for-home-internet/?utm_source=rss&utm_medium=rss&utm_campaign=t-mobile-reiterates-need-for-fcc-spectrum-authority-touts-5g-for-home-internet.

[82] Analysys Mason, Comparison of Total Mobile Spectrum in Different Markets, Sept. 2022, *available at* https://api.ctia.org/wp-content/uploads/2022/09/Comparison-of-total-mobile-spectrum-28-09-22.pdf (finding that the United States lags its peers by an average of 378 MHz in mid-band spectrum access).

[83] *Losing Their Grip*, *supra*.

[84] GSM Association, Estimating the Mid-Band Spectrum Needs in the 2025-2030 Time Frame: A Report by Coleago Consulting, at 37, *available at* https://www.gsma.com/spectrum/wp-content/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf [hereafter *GSMA Study*].

[85] *Id*. at 38.

[86] *See, e.g.*, The Future of Using (and Reusing) Spectrum, NCTA, Aug. 2, 2022, *available at* https://www.ncta.com/whats-new/the-future-of-using-and-reusing-spectrum (" The majority of Americans

and unlicensed spectrum, or of the downsides of spectrum made available only at lower power levels, cable's policy position sounds reasonable. But because there is barely any spectrum available for new uses, spectrum designated as unlicensed comes at the expense of making licensed spectrum available, and unlicensed users already have seven times what licensed users have in the valuable mid-band range.[87] Commercial FWA networks will need additional full-power and licensed spectrum to both support demand and achieve the requisite economies of scale, which would reduce their incremental costs and thereby permit more aggressive FWA pricing.[88] The results of our study provide one explanation for cable's advocacy for more unlicensed spectrum and thus implicit resistance to more licensed spectrum—that full FWA penetration into home broadband markets would mean cable margin compression and lost cable modem subscribers. Broadband subscribers, however, would enjoy lower prices and higher savings.

Regulators should take note of these developments. The agencies charged with overseeing competition in these areas, particularly the Federal Communications Commission and the National Telecommunications and Information Administration, should quickly establish a spectrum pipeline that can expand the capacity and reach of mobile broadband networks so that FWA can proliferate and bring even more competition to cable. Creating a spectrum pipeline will expand the capacity and reach of mobile broadband networks so that FWA can proliferate and bring even more competition to cable. As demonstrated by the findings above, doing so would help drive down prices, providing much-needed relief for the consumers that are facing other cost of living and inflationary pressures in today's economic environment.

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use Wi-Fi to connect these devices, making the role of unlicensed spectrum increasingly vital."); The Future of Commercial Spectrum: Spectrum and WiFi, NCTA, *available at* https://www.ncta.com/positions/spectrum-wifi_("Unlicensed bands offer the most room to innovate, lowering barriers to entry for new technologies and creating more economic activity and new services."). WiFi Forward, a group backed by Charter, Comcast, and NCTA, similarly advocates for unlicensed spectrum. *See* About Page, WiFi Forward, *available at* https://wififorward.org/about/#partners; Unlicensed Spectrum at Work, WiFi Forward, *available at* https://wififorward.org/issues/unlicensed-spectrum-at-work/ ("Allowing Wi-Fi and other unlicensed technologies to operate in the 5.9 and 6 GHz bands will contribute $183 billion to U.S. economy by 2025.").

[87] Accenture, Spectrum Allocation in the United States, *available at* https://newsroom.accenture.com/news/three-mid-band-spectrum-bands-offer-greatest-potential-to-meet-5g-demand-in-the-us-study-finds.htm.

[88] *GSMA Study*, at 38 (showing that with an addition 2 GHz of mid-band spectrum, a FWA supplier could support 540 households per site, compared to just 90 households per site with 400 MHz of spectrum).

Appendix 1: Survey Design

FWA Packages

Verizon advertises FWA prices at $50 per month for max speeds between 85-300 Mbps with 10 Mbps upload speeds. Their "plus" package costs $70 per month for max speeds between 300-1000 Mbps with 50 Mbps upload speeds. Verizon offers 2- and 3-year price guarantees.[89] This does not appear to be a promotional pricing tactic. Verizon offers both an "indoor" and "outdoor" equipment setup, with the former only requiring a gateway modem (placed inside the home) while the latter requires an antenna placed on the roof.[90] Verizon also offers discounted plans of $25 and $40 per month if the customer has a qualifying Verizon phone plan.

T-Mobile advertises its FWA "Home Internet" plan at $50 per month for max speeds between 33-182 Mbps with upload speeds between 6-23 Mbps.[91] T-Mobile advertises a lifetime price guarantee. T-Mobile only offers an indoor Gateway modem and does not offer an external antenna option.[92]

Cable Modem Packages

Xfinity's cable internet offerings vary by region. Typical prices include $20-$25 per month for 75 Mbps, $25-$40 for 200 Mbps, $30-$55 for 400 Mbps, $60-80 for 800mbps, $60-75 for 1000 Mbps, $70-80 for 1200 Mbps, and $120 for 2000 Mbps.[93] Upload speeds are typically a tenth or less of the rated download speed: only 10 Mbps for plans under 400 Mbps, 15 Mbps for the 800 Mbps plan, and 20 Mbps for the 1000 Mbps plan. Xfinity infamously practices promotional rate pricing in which advertised prices typically increase by $20-25 after the first two years.

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[89] Trey Paul, *Verizon 5G Home Internet vs. T-Mobile Home Internet: Is There a Clear Winner for Your Home?,* CNET, Feb. 2, 2023, *available at* https://www.cnet.com/home/internet/verizon-5g-home-internet-vs-t-mobile-home-internet/ [hereafter *Verizon 5G vs. T-Mobile*]; *Verizon 5G Home Internet, Supra.*

[90] *Verizon 5G Home Internet professional setup FAQs,* VERIZON, accessed Mar. 22, 2023, *available at* https://www.verizon.com/support/5g-home-installation-faqs/ ("Your 5G Home Internet equipment setup (i.e., indoor, outdoor) depends on your location's 5G signal strength. If your setup is: Indoors: We use the 5G Internet Gateway as an all-in-one router and receiver. Outdoors: We use the 5G Internet Gateway as your outdoor receiver and the Verizon Router is used Indoors.").

[91] *Verizon 5G vs. T-Mobile, Supra; Get high-speed 5G home internet service. $30/month.,* T-MOBILE, accessed Mar. 22, 2023, *available at* https://www.t-mobile.com/home-internet.

[92] *Id.* ("You receive service through a 5G Gateway device (which combines the capabilities of a router and a modem), the Gateway device then converts the 5G signal to Wi-Fi, and provides a Wi-Fi signal accessible by all the devices in your home.").

[93] Trey Paul, *Xfinity Home Internet Review: Ah, the Complexities of Cable,* CNET, Dec. 1, 2022, *available at* https://www.cnet.com/home/internet/xfinity-internet-review/; *Xfinity Internet Plans, Prices, And Speeds,* CABLETV, accessed Mar. 22, 2023, *available at* https://www.cabletv.com/xfinity/internet. Authors confirmed prices using their own address at *Planbuilder,* XFINITY, accessed Mar. 22, 2023, *available at* https://www.xfinity.com/digital/offers/plan-builder. (For example, while third party internet sources list Xfinity's basic offering at $25 for 75 Mbps, it was advertised to the author's address at $20.).

Spectrum's cable internet offerings come in three standard packages, a $50 option for 300 Mbps, a $70 option for 500 Mbps, and a $90 option for 940 Mbps.[94] Upload speeds are 10Mbps, 20Mbps, and 35 Mbps respectively. These prices are for the first-year promotional rate, after which each price increases by $30.

Fiber Packages

AT&Ts fiber offerings are $55 for 300 Mbps, $65 for 500 Mbps, $80 for 940 Mbps, $110 for 2 Gbps, and $180 for 5 Gbps. [95] Upload speeds are symmetrical to download speeds. AT&T appears not to employ promotional pricing tactics for its fiber services.

Verizon's fiber internet is offered at $50 for 300 Mbps, $70 for 500 Mbps, and $90 for 940 Mbps.[96] Upload speeds are symmetrical to download speeds. Verizon guarantees prices for 2, 3, and 4 years respectively, although this does not appear to be a promotional pricing tactic. [97]

CenturyLink's fiber options are $30 for 200 Mbps or $70 for 940mbps.[98] Upload speeds are symmetrical to download speeds. CenturyLink does not employ promotional pricing tactics for its fiber services.

Irrational Responses

In many surveys, some number of respondents may express preferences counter to expectations. For example, there may be some subset of respondents who express a preference for a higher price, all else equal. The academic literature explains that some purportedly "irrational" responses are to be expected in real-world surveys. Economists recognize that real-world survey participants sometimes provide responses that appear to deviate from the textbook economic model of a rational consumer. Nobel Laureate Daniel McFadden and his co-authors explain that "[c]onsumer choices from repeated menus in laboratory and market experiments often deviate from strict neoclassical theory."[99] The presence of such responses is hardly surprising, just as the residuals around a regression line do not invalidate the underlying relationships among economic variables. The

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[94] Trey Paul, *Spectrum Home Internet Review: Cable Internet Made Simple,* CNET, Dec. 16, 2022, *available at* https://www.cnet.com/home/internet/spectrum-internet-review/.
[95] *AT&T Home Internet Review, Supra.*
[96] Trey Paul, *Verizon Fios Home Internet Review: Simply the Best?,* CNET, Mar. 24, 2023, *available at* https://www.cnet.com/home/internet/verizon-internet-review/ [hereafter *Verizon Fios Home Internet Review*]; *Get Fios Home Internet and save.,* VERIZON, accessed Mar. 22, 2023, *available at* https://www.verizon.com/home/fios-fastest-internet/ [hereafter *Get Fios Home Internet*].
[97] *Get Fios Home Internet, Id.*
[98] *CenturyLink Home Internet Review, Supra.*
[99] McFadden et al. (2019) at 37 (emphasis added). *See also* McFadden et al. (2013) at 3 ("Irrational responses occur when a consumer makes a decision that violates one or more of economists' standard assumptions about consumer preferences. For example, a consumer makes an irrational choice if he prefers a good that costs more over the same good that costs less or if he chooses an inferior good over a superior good at the same price. Of course, irrational choices occur in other contexts, and they are a subject of study and debate among economists.").

literature cautions against disregarding seemingly irrational responses from CBC surveys as potentially counterproductive.[100] Doing so "may result in the removal of valid preferences; induce sample selection bias; and reduce the statistical efficiency and power of the estimated choice models"[101] For that reason, we do not exclude any of the respondents in the survey for deviating from what an economist would consider strictly rational response patterns.

[100] Emily Lancsar and Jordan Louviere, *Deleting 'irrational' responses from discrete choice experiments: a case of investigating or imposing preferences?*, 15 HEALTH ECONOMICS 797–811, 797 (2006) [hereafter Lancsar and Louviere] ("This paper outlines a number of reasons why deleting responses from DCEs may be inappropriate after first reviewing the theory underpinning rationality, highlighting that the importance placed on rationality depends on the approach to consumer theory to which one ascribes. The aim of this paper is not to suggest that all preferences elicited via DCEs are rational. Instead, it is to suggest a number of reasons why it may not be the case that all preferences labelled as 'irrational' are indeed so. Hence, deleting responses may result in the removal of valid preferences; induce sample selection bias; and reduce the statistical efficiency and power of the estimated choice models."). *See also* Mandy Ryan, Verity Watson, and Vikki Entwistle, *Rationalising the 'Irrational': A Think Aloud Study of Discrete Choice Experiment Responses,* 18 HEALTH ECONOMICS 321–336 (2009) [hereafter Ryan et al.] ("Following an examination of adherence to the axioms of utility theory, the question is raised of what to do with respondents who fail such tests. Individuals may be dropped from further analysis, or analyse the response data with and without 'irrational' respondents. Lanscar and Louviere (2006) discuss a number of reasons why deleting 'irrational' responses is not appropriate, arguing that removal of such respondents may also result in removal of valid responses. McFadden (1999) stated that to define responses as truly 'irrational', additional information about respondents' perceptions and beliefs (that inform the decision process) as well as attitudes, motives, and preferences is required. When this additional information is considered, apparently 'irrational' responses may be shown to be rational.").

[101] Lancsar and Louviere at 797 ("Results of this nature that might be considered irrational are known to occur in the experimental setting. In many cases, they can reflect a specific behavioral response to the choice scenarios and may in fact be valid; thus, simply discarding them would be inappropriate. Indeed, the attribute non-attendance literature tells us that utility would be unaffected if respondents were simply ignoring certain attributes, so it is likely we are seeing some specific behavior here. Further, the notion of rational consumption in the case of risky health behaviors has been questioned."). *See also* John Buckell & Jody L. Sindelar, *The impact of flavors, health risks, secondhand smoke, and prices on young adults' cigarette and e-cigarette choices: a discrete choice experiment*, 114(8) ADDICTION 1427-35 (2019).

As a robustness check, we remove all "irrational" responses from the survey and re-run the model. This drops 84 respondents, leaving a final count of 416 respondents. These utilities are displayed in APPENDIX TABLE 4

APPENDIX TABLE 3: CABLE-ONLY MARKET SIMULATION
CURRENT FWA PRICES, $20 CABLE NON-PROMOTIONAL PRICE PREMIUM

	[1]	[2]	[3] = [2]-[1]
Internet Plan	**Shares of Preference Pre-FWA**	**Shares of Preference With FWA**	**Change**
Cable 75	7.6%	5.0%	-2.6%
Cable 200	26.4%	14.2%	-12.2%
Cable 300	23.0%	8.8%	-14.2%
Cable 500	4.6%	2.2%	-2.4%
Cable 1000	16.2%	9.4%	-6.8%
FWA 200		12.8%	12.8%
FWA 500		26.8%	26.8%
None	22.2%	20.8%	-1.4%
All Cable	77.8%	39.6%	-38.2%
All FWA	0.0%	39.6%	39.6%
None	22.2%	20.8%	-1.4%

APPENDIX TABLE 4. The average utilities generated from the smaller model are approximately equivalent to the primary model, and do not generate meaningfully different market share simulations.

Appendix 2: Appendix Tables

APPENDIX TABLE 1: RESPONDENT DEMOGRAPHICS

Number of Alternate Providers	Respondents
0	21.0%
1	34.2%
2	21.0%
Not Sure	23.8%

Note: N = 500. Alternate providers classified as the number of other companies that offer either Cable Modem or Fiber internet to the respondent's home, aside from their current provider.

Age	Respondents
Median	48
Average	49.4
Max	87
Min	19

Note: N = 500

Gender	Respondents
Male	35.2%
Female	64.4%
Non-binary / third gender	0.4%

Note: N = 500

Race	Respondents
White	85.3%
Black or African American	7.7%
American Indian or Alaska Native	2.4%
Asian	2.8%
Native Hawaiian or Pacific Islander	0.0%
Other	2.0%

Note: Since respondents were able to select more than one race, there are 509 responses from the 500 respondents.

Ethnicity	Respondents
Hispanic	8.2%
Non-Hispanic	91.6%
Prefer Not to Say	0.2%

Note: N = 500

State	Respondents	Percent
New York	41	8.2%
Florida	41	8.2%
California	36	7.2%
Pennsylvania	35	7.0%
Ohio	34	6.8%
Michigan	29	5.8%
Texas	28	5.6%
Illinois	27	5.4%
Massachusetts	18	3.6%
Arizona	16	3.2%
Georgia	12	2.4%
North Carolina	12	2.4%
New Jersey	12	2.4%
Wisconsin	12	2.4%
Washington	12	2.4%
Indiana	10	2.0%
Minnesota	10	2.0%
Colorado	10	2.0%
Alabama	9	1.8%
Kentucky	9	1.8%
Maryland	7	1.4%
Nevada	7	1.4%
Missouri	6	1.2%
Utah	6	1.2%
Oklahoma	6	1.2%
Oregon	6	1.2%
Kansas	5	1.0%
Connecticut	4	0.8%
Louisiana	4	0.8%
South Carolina	4	0.8%
Hawaii	4	0.8%
Virginia	3	0.6%
Arkansas	3	0.6%
Maine	3	0.6%
New Mexico	3	0.6%
South Dakota	3	0.6%
Tennessee	2	0.4%
Iowa	2	0.4%
Nebraska	2	0.4%
North Dakota	2	0.4%
West Virginia	2	0.4%
New Hampshire	1	0.2%
Rhode Island	1	0.2%
Mississippi	1	0.2%
TOTAL	**500**	**100%**

APPENDIX TABLE 2: TERMINATION REPORT

Entrants	**3627**	**100.0%**
Q2 Cable	1756	48.4%
Q1	766	21.1%
Q5 Cable Owner	120	3.3%
OV Start	112	3.1%
Q6 Cable Owner Shopper	91	2.5%
Q3 Cable Modem	71	2.0%
Q21 Consent	49	1.4%
QFC 1	36	1.0%
OV End	33	0.9%
Q6 Consent	22	0.6%
Speeder	13	0.4%
Q18 Consent	9	0.2%
Q12 Consent	3	0.1%
Q14 Consent	2	0.1%
Q16 Consent	2	0.1%
Q15 Consent	1	0.0%
Q17 Consent	1	0.0%
Q20 Consent	1	0.0%
Q23 Consent	1	0.0%
Total Rejected	**3089**	**85.2%**
Remaining	**538**	**14.8%**
Manual	**38**	**1.0%**
Final Sample	**500**	**13.8%**

APPENDIX TABLE 3: CABLE-ONLY MARKET SIMULATION
CURRENT FWA PRICES, $20 CABLE NON-PROMOTIONAL PRICE PREMIUM

	[1]	[2]	[3] = [2]-[1]
Internet Plan	**Shares of Preference Pre-FWA**	**Shares of Preference With FWA**	**Change**
Cable 75	7.6%	5.0%	-2.6%
Cable 200	26.4%	14.2%	-12.2%
Cable 300	23.0%	8.8%	-14.2%
Cable 500	4.6%	2.2%	-2.4%
Cable 1000	16.2%	9.4%	-6.8%
FWA 200		12.8%	12.8%
FWA 500		26.8%	26.8%
None	22.2%	20.8%	-1.4%
All Cable	77.8%	39.6%	-38.2%
All FWA	0.0%	39.6%	39.6%
None	22.2%	20.8%	-1.4%

APPENDIX TABLE 4: FULL VS IRRATIONAL SURVEY UTILITIES

Connection Type	Full Model Utility	No-Irrational Model Utility	Difference
Cable	0.66	1.02	0.57
Fiber	-0.15	0.82	-0.22
Fixed Wireless	-0.51	0.80	-0.58

Download Speed	Full Model Utility	No-Irrational Model Utility	Difference
75 Mbps	-2.71	-3.15	0.44
100 Mbps	-1.22	-1.35	0.14
200 Mbps	-0.57	-0.67	0.10
300 Mbps	0.37	0.37	0.00
500 Mbps	1.39	1.60	-0.21
1000 Mbps	2.74	3.21	-0.47

Upload Speed	Full Model Utility	No-Irrational Model Utility	Difference
100% of Download	1.45	1.72	-0.27
50% of Download	0.21	0.28	-0.07
10% of Download	-1.66	-2.00	0.34

Price	Full Model Utility	No-Irrational Model Utility	Difference
$30	2.18	2.47	-0.29
$40	1.64	1.87	-0.23
$50	0.96	1.11	-0.15
$60	0.28	0.24	0.05
$70	-0.49	-0.66	0.18
$80	-1.85	-1.93	0.08
$90	-2.73	-3.11	0.38

None Option	-2.91	-3.21	0.30

Note: Full model N=500, No-Irrational Model N=416.

APPENDIX TABLE 5: LONG-RUN CONSUMER SURPLUS CREATED
CABLE-ONLY MARKET (ALTERNATE COMPETITOR SUPPLY ELASTICITY OF 3)

	Current State	FWA Entry Current Price	FWA Entry $10 Discount	FWA Entry $20 Discount
Market Demand Elasticity	1.72	1.72	1.72	1.72
Cable Market Share	100%	82%	77%	67%
Competitor Supply Elasticity	3.00	3.00	3.00	3.00
Own-Firm Demand Elasticity	1.72	2.75	3.15	4.00
Price-Cost Margin	58%	36%	32%	25%
Product Price ($50 Base)	$50.00	$32.82	$30.58	$27.82
Price Reduction	**0.0%**	**-34.4%**	**-38.8%**	**-44.4%**
Cable-Only Yearly Cable Revenues ($Billion)	**$15.50**	**$10.17**	**$9.48**	**$8.62**
Yearly Consumer Savings Generated ($Billion)	**--**	**$5.32**	**$6.02**	**$6.87**

APPENDIX TABLE 6: LONG-RUN CONSUMER SURPLUS CREATED
CABLE-ONLY MARKET (ALTERNATE COMPETITOR SUPPLY ELASTICITY OF 2)

	Current State	FWA Entry Current Price	FWA Entry $10 Discount	FWA Entry $20 Discount
Market Demand Elasticity	1.72	1.72	1.72	1.72
Cable Market Share	100%	82%	77%	67%
Competitor Supply Elasticity	2.00	2.00	2.00	2.00
Own-Firm Demand Elasticity	1.72	2.53	2.85	3.52
Price-Cost Margin	58%	40%	35%	28%
Product Price ($50 Base)	$50.00	$34.53	$32.17	$29.16
Price Reduction	**0.0%**	**-30.9%**	**-35.7%**	**-41.7%**
Cable-Only Yearly Cable Revenues ($Billion)	**$15.50**	**$10.70**	**$9.97**	**$9.04**
Yearly Consumer Savings Generated ($Billion)	**--**	**$4.79**	**$5.52**	**$6.46**

APPENDIX TABLE 7: LONG-RUN CONSUMER SURPLUS CREATED
CABLE/FIBER MARKET (ALTERNATE COMPETITOR SUPPLY ELASTICITY OF 3)

	Current State	FWA Entry Current Price	FWA Entry $10 Discount	FWA Entry $20 Discount
Market Demand Elasticity	1.72	1.72	1.72	1.72
Cable Market Share	59%	57%	54%	50%
Competitor Supply Elasticity	3.00	3.00	3.00	3.00
Own-Firm Demand Elasticity	5.02	5.28	5.66	6.45
Price-Cost Margin	20%	19%	18%	15%
Product Price ($50 Base)	$50.00	$49.41	$48.64	$47.39
Price Reduction	**0.0%**	**-1.2%**	**-2.7%**	**-5.2%**
Cable/Fiber Yearly Cable Revenues ($Billion)	**$20.67**	**$20.43**	**$20.11**	**$19.60**
Yearly Consumer Savings Generated ($Billion)	**--**	**$0.24**	**$0.56**	**$1.08**

APPENDIX TABLE 8: LONG-RUN CONSUMER SURPLUS CREATED
CABLE/FIBER MARKET (ALTERNATE COMPETITOR SUPPLY ELASTICITY OF 2)

	Current State	FWA Entry Current Price	FWA Entry $10 Discount	FWA Entry $20 Discount
Market Demand Elasticity	1.72	1.72	1.72	1.72
Cable Market Share	59%	57%	54%	50%
Competitor Supply Elasticity	2.00	2.00	2.00	2.00
Own-Firm Demand Elasticity	4.32	4.52	4.83	5.45
Price-Cost Margin	23%	22%	21%	18%
Product Price ($50 Base)	$50.00	$49.35	$48.48	$47.07
Price Reduction	**0.0%**	**-1.3%**	**-3.0%**	**-5.9%**
Cable/Fiber Yearly Cable Revenues ($Billion)	**$20.67**	**$20.41**	**$20.05**	**$19.46**
Yearly Consumer Savings Generated ($Billion)	**--**	**$0.27**	**$0.63**	**$1.21**

Appendix 3: Survey

Q1
Have you taken any surveys in the last 30 days on these topics? (Select all that apply.)

- ☐ Clothing
- ☐ Advertisements on TV
- ☐ Video Games
- ☐ Internet Services
- ☐ Cosmetics
- ☐ Other Category
- ☐ ⊗ I have not taken any surveys

Q2 Does your home have an **active home internet connection**? If yes, how is your home connected to the internet?

Common connection types are:

DSL connection is provided over existing telephone wires and generally offers relatively slow speeds. DSL is offered in some locations by traditional telephone companies, like AT&T, Verizon, or Lumen (CenturyLink).

Cable Modem connection is provided over existing cable television wires by cable companies like Comcast (Xfinity), Charter, or Cox.

Fiber connection is provided over newly installed fiber optic cable, and offers relatively fast speeds. It is offered in some locations by companies like AT&T, Verizon, Lumen (CenturyLink), or Google Fiber.

Satellite broadband connection is provided using a satellite dish, and is generally used in remote areas lacking other infrastructure. It is offered by companies like HughesNet, Viasat, or Starlink.

Fixed Wireless (sometimes called Home 5G) connection is provided over a wireless network, often using new 5G connections. It is offered by wireless companies like T-Mobile and Verizon.

- ○ Yes, but I am unsure what kind of connection type it is
- ○ Yes, DSL connection
- ○ Yes, Cable Modem connection
- ○ Yes, Fiber connection
- ○ Yes, Satellite connection
- ○ Yes, Fixed Wireless (Home 5G) connection
- ○ Yes, my home has internet through another connection type: _____
- ○ No, my home does not have internet

Q3 Is your home **wired** for any of these home internet connection types? That is, does an internet service provider (including your current provider) currently offer service to your

home through any of the following connection types?

	Yes	No	Not Sure
DSL	○	○	○
Cable Modem	○	○	○
Fiber	○	○	○

Q4 **Aside from your current internet connection provider**, how many **other companies** offer either **Cable Modem** or **Fiber** internet to your home?

- ○ Zero, I know my current Cable/Fiber company is the only option
- ○ I know at least 1 other company offers cable or fiber
- ○ I know at least 2 other companies offer cable or fiber
- ○ I am not sure

Q5 Do you, yourself, currently pay for your Cable Modem home internet connection?

- ○ Yes, I pay for home internet, and I am the account holder
- ○ Yes, I pay for home internet, but I am not the account holder
- ○ No, I do not pay for my home internet
- ○ Not sure

Q6 You indicated you are not the account holder for your home internet connection plan. Did you participate with the account holder in the purchase of your home internet connection plan?

- ○ Yes, I shopped for home internet with the account holder
- ○ No, I did not participate in purchasing my home internet
- ○ Other: _____

Q7 You have indicated that **you pay for home internet through a Cable Modem connection**, and that **you made (in full or in part) this purchase decision**. Is this correct?

- ○ Yes, that is correct
- ○ No, that is not correct

Q8
You have been selected to participate in our survey about **home internet plans**.

We care about the quality of our survey data. For us to get the most accurate measures of your opinions, it is important that you provide thoughtful answers to each question in this survey. We ask that you do so without help from anyone else, and that you complete the survey in one sitting and without stopping in the middle.

Do you commit to doing this?

- ○ I can't promise either way
- ○ Yes, I will
- ○ No, I will not

Q9 In which state do you currently reside?

▼ Alabama ... I do not reside in the United States

Q10 What is your age?

_____

Q11 How do you describe yourself?

- ○ Male
- ○ Female
- ○ Non-binary / third gender
- ○ Prefer to self-describe _____
- ○ Prefer not to say

Q12 Are you of Hispanic or Latino origin?

- ○ Yes
- ○ No
- ○ Prefer not to say

Q13 Please choose one or more races that you consider yourself to be:

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White
- ☐ Other _____
- ☐ ⊗ Prefer not to say

Q14
For the remainder of this survey, please assume you are shopping for **home internet connection plans.**

You will be asked to perform a set of ten "choice tasks". In each choice task, you will be shown three **home internet connection plans**, which correspond to typical Cable Modem, Fiber, and Fixed Wireless home internet plans. Each plan will come with different prices and features, which will be described to you in a moment.

For each individual choice task, **please assume these are the only Cable Modem, Fiber, and Fixed Wireless** plans available. After carefully considering the options available to you, **please select the home internet connection plan that you would actually purchase in real life.** If you would not select any of the plans shown to you, please select the fourth option ("I would not select any of the plans shown here"). Doing so means that you would either not purchase home internet given those available options, or you would seek out and purchase home internet from a much slower or much more expensive outside option (such as DSL or Satellite, which is not considered in this survey).

Please assume that if a plan is offered to you in the survey, your home is eligible to receive that plan. (Even that type of plan is not offered to your home at the moment in real-life.)

After you have performed ten choice tasks, the survey will end and ask for your feedback.

- ○ I understand
- ○ I DO NOT understand

Q15 Each home internet connection plan will come with a **connection type**. In this survey, we will offer you plans with one of three **connection types**: **Cable Modem**, **Fiber**, or **Fixed Wireless**. Each **connection type** uses a different technology and comes with its own set of home equipment to connect to the internet. These three **connection types** will be explained to you in a moment.

Please assume this equipment and its installation is included in the price of the plan, and that all equipment in this survey also enables WiFi connectivity to connect your own

devices.

- ○ I understand
- ○ I DO NOT understand

Q16 One possible **connection type** is **Cable Modem**.

Cable Modem service is provided over existing cable television wires. **Cable Modem** equipment in your home must be connected by a physical cable to the network infrastructure outside. The equipment placed in your home is approximately the size of a half-foot cube.

- ○ I understand
- ○ I DO NOT understand

Q17 One possible **connection type** is **Fiber**.

Fiber service is provided over single-purpose fiber optic cables. **Fiber** equipment in your home must be connected by a physical cable to the network infrastructure outside. The equipment placed in your home is approximately the size of a half-foot cube.

- ○ I understand
- ○ I DO NOT understand

Q18 One possible **connection type** is **Fixed Wireless**.

Fixed Wireless service is provided over a wireless network, often using new 5G connections. Depending on your location, **Fixed Wireless** equipment would be a single integrated unit placed in your home at a location where it receives a good wireless signal. Typically, this is on a shelf in a central location in your home, or next to a window. In some cases, a standalone wireless antenna is attached to an interior window, or mounted to the exterior of your home where it receives a better wireless signal. A cable is run from

the antenna to a separate indoor router. The equipment placed in your home is approximately the size of a half-foot cube, and the antenna unit (if required) is approximately the size of a paperback book.

- ○ I understand
- ○ I DO NOT understand

Q19 Each home internet connection plan will have a rated **download speed** in **megabits per seconds (Mbps)**. This is the maximum download of the plan. The speeds in this survey will range from 75 Mbps to 1,000 Mbps.

Typically, a single device use a minimum of 1 Mbps for general browsing and between 5-10 Mbps for each individual HD video stream or teleconference. Greater download speeds also directly reduce the time it takes to download files or content from the internet.

- ○ I understand
- ○ I DO NOT understand

Q20 Each home internet connection plan will have a rated **upload speed** in **megabits per seconds (Mbps)**. This is the maximum upload speed of the plan. In most internet service plans, the upload speed is a fraction of the download speed, as most users generally consume more data than they produce. The upload speeds considered in this survey will either be **as fast as the download speed**, will be **half the download speed**, or will be **a tenth as fast as the download speed**.

Typically, a single device uses between 3-10 Mbps for streaming video up to the internet, such as when on a teleconference. Greater upload speeds also reduce affect the time it takes to upload files or content to the internet.

- ○ I understand
- ○ I DO NOT understand

Q21 Each home internet connection plan will come with a **monthly price**. For purposes of this survey, consider this the all-inclusive price of the internet plan, meaning there are no additional hidden fees, setup cost, or potential discounts.

- ○ I understand
- ○ I DO NOT understand

Q22 Finally, please note that there are no brands displayed in this survey. When making your selection, please assume that all plans on display are offered by a generic internet service provider.

- ○ I understand
- ○ I DO NOT understand

Q23 Please select "I DO NOT understand" to show you are paying attention to this question.

- ○ I understand
- ○ I DO NOT understand

End of Block: ScreenerBlock

Conjoint Choice Task Examples

(1/10) Choose your preferred internet service plan below:

Plan 1	Plan 2	Plan 3	
Connection Type: Fiber	Connection Type: Cable Modem	Connection Type: Cable Modem	None of these options
Download Speed: 200 Mbps	Download Speed: 75 Mbps	Download Speed: 500 Mbps	
Upload Speed: 10% of Download Speed	Upload Speed: 50% of Download Speed	Upload Speed: 100% of Download Speed	
Monthly Price: $40.00	Monthly Price: $70.00	Monthly Price: $30.00	

(2/10) Choose your preferred internet service plan below:

Plan 1	Plan 2	Plan 3	
Connection Type: Fiber	Connection Type: Fixed Wireless	Connection Type: Cable Modem	None of these options
Download Speed: 100 Mbps	Download Speed: 1,000 Mbps	Download Speed: 1,000 Mbps	
Upload Speed: 10% of Download Speed	Upload Speed: 50% of Download Speed	Upload Speed: 50% of Download Speed	
Monthly Price: $90.00	Monthly Price: $30.00	Monthly Price: $50.00	

(3/10) Choose your preferred internet service plan below:

Plan 1	Plan 2	Plan 3	
Connection Type: Fixed Wireless	Connection Type: Cable Modem	Connection Type: Cable Modem	None of these options
Download Speed: 500 Mbps	Download Speed: 100 Mbps	Download Speed: 300 Mbps	
Upload Speed: 100% of Download Speed	Upload Speed: 10% of Download Speed	Upload Speed: 100% of Download Speed	
Monthly Price: $40.00	Monthly Price: $90.00	Monthly Price: $50.00	