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Residential and Business Broadband Prices Part 2: International Comparisons

Scott J. Wallsten
James Riso

TECHNOLOGY POLICY INSTITUTE
Studying the Global Information Economy

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Scott Wallsten and James L. Riso

1401 EYE STREET, NW ▫ SUITE 505 ▫ WASHINGTON, DC 20005
PHONE: 202.828.4405 ▫ E-MAIL: info@techpolicyinstitute.org ▫ WEB: www.techpolicyinstitute.org

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Abstract

For this project, we assemble a new dataset consisting of more than 25,000 residential and business broadband plans from all OECD countries from 2007–2009. We explore three issues: the relationship between plan components—such as metering—and consumer prices, price changes over time, and how broadband prices vary across countries.

This paper, part 2 of the project, studies prices and price changes over time in the United States and other OECD countries. We find that residential prices in the U.S. remained fairly stable overall in this time period for both standalone and triple play (voice, video, and data) plans, though prices for some speed tiers increased while others decreased. Business broadband prices in the U.S., however, appear to have decreased by 15-25 percent over the three years, with faster speeds showing bigger price decreases. Prices for standalone broadband plans in the U.S. are approximately in the middle of the range of prices across OECD countries. Prices for triple play plans in the U.S. are among the highest in the OECD. And while residential prices have on the whole remained constant in the U.S. they have been declining in most other countries.

[*] Wallsten is vice president for research and senior fellow at the Technology Policy Institute, where Riso is a research associate. The views expressed in this paper are those of the authors and not necessarily any of TPI's staff, board, or donors. We thank David Burstein, Shane Greenstein, Robert Hahn, Thomas Lenard, Gregory Rosston, and Amy Smorodin for helpful comments. The authors are responsible for all opinions, interpretations, and errors. All comments welcome. Contact: scott@wallsten.net.

Prologue

Most empirical analyses of broadband have focused on availability, adoption, and sometimes speeds.[1] A smaller literature examines household demand for Internet access,[2] and a few papers attempt to estimate the consumer benefits of broadband.[3] With few exceptions, analyses of prices have been relatively simplistic—and controversial—comparisons across countries, largely because broadband prices are complicated and little consistent data are available, especially across countries. In spite of these limitations, two aspects of broadband prices remain actively debated: (1) New pricing schemes, such as metered pricing and plans that include a base amount of data transfer and then impose usage charges or throttle speed beyond that base (i.e., data caps or bitcaps), and (2) Relative prices for broadband access in different countries.

We assemble a large dataset that allows us to address both of these issues. Part 1 of our project examines the effect of pricing schemes on consumer prices. Part 2—this paper—explores price levels and changes for different types of broadband service across countries. We also include an appendix that will provide detailed data for each OECD country.

I. Introduction

This paper uses a unique and detailed dataset of about 25,000 wireline broadband plans across OECD countries to examine price levels and changes from 2007–2009. We are able to incorporate many aspects of each broadband plan in order to provide a more accurate indicator of the true price consumers pay, rather than just the advertised monthly fee. For each plan we factor in promotional prices, the price consumers pay once a promotional period ends, extra fees such as installation, and any rebates.

Consistent with the U.S. Bureau of Labor Statistics and Greenstein and McDevitt (2010), we find that residential broadband prices in the U.S. have remained fairly constant since 2007. Business broadband prices, however, appear to have fallen by about 15-25 percent in the same time period. Moreover, among business plans, prices for faster speeds have decreased by more than prices for slower speeds.

We also compare quality-adjusted broadband prices across countries and over time. We find that U.S. standalone broadband plans (i.e., plans not bundled with voice or video services) compare favorably to other OECD countries, but that U.S. prices for triple play (i.e., plans bundled with voice and video) and very fast broadband connections tend to be higher than those in other OECD countries. In addition, while residential prices have remained unchanged in the U.S., they have been falling in most other OECD countries.

The paper proceeds as follows. In Section II we briefly discuss the data we use to investigate those questions. Section III constructs price indices for the U.S. Section IV compares price

[1] See, for example, Agarwal, Animesh, and Prasad (2009); Aron and Burnstein (2003); Chaudhuri and Flamm (2005); Faulhaber (2002); Flamm (2005); Flamm and Chaudhuri (2007); Hausman and Sidak (2004); Horrigan (2009); Prieger and Hu (2007).
[2] In particular, see Rosston, Savage, and Waldman (2010) and Savage and Waldman (2004).
[3] See Greenstein and McDevitt (2009) and Dutz, et al (2009).

levels across OECD countries and price changes within each country over time. Section V concludes.

II. Data

Part 1 of the project described the dataset and how we define prices in detail. For convenience, we reprint the portion of that paper discussing our dataset in the Appendix below. The Appendix also details data we used from other sources for each OECD country included in the paper. These materials explain how we constructed the dataset and provide some summary statistics.

The most important and complicated variable is price. Factors like promotions and miscellaneous fees mean that simply examining advertised monthly prices is likely to yield inaccurate and potentially misleading comparisons. Instead, we require a variable that is comparable across plans, companies, and countries.[4] We create such a variable by calculating the total price a consumer would pay for a year of service for each plan, as shown in equation (1) below.

(1) *Net price for one year = (promotional price * number of months promotion lasts) + (standard price * (12 – number of months promotion lasts)) + installation fee + activation fee + equipment charges + other and hidden fees – rebates*

The implicit assumption behind this variable is that consumers consider their total expected payments over a year when choosing a broadband plan. Certainly, not all consumers think that way. More practically, this variable overstates payments for consumers whose plans have contracts of less than one year or no contract and who aim to shop for a new service as soon as possible. Similarly, it understates payments for consumers whose contracts exceed one year. Nevertheless, we believe the variable is appropriate because it allows for a consistent and comparable measurement of prices that takes into account many of the factors included in the price a consumer pays.

Figures 1-3 below provide detailed summary information for residential standalone, residential triple play, and business standalone plans in each country. In particular, the figures show the median and range of prices, including outliers for each plan type.

The figures must be interpreted cautiously. They show information about the raw dataset, which does not immediately translate into meaningful observations about the real world for at least two reasons. First, the number of plans in a given country will affect the median and range of prices in that country. These simple summary statistics assume all of a country's plans are equally important and representative, which is not the case: they are often available to subsets of a country's population of varying size, and the popularity of different plans differs even when they are available to the same population. Notably, existing studies and sources of data on prices suffer from this problem: the prices they report may be based on plans that are not those to which consumers typically subscribe.

[4] Note that all currency values are converted to U.S. dollars at annual purchasing power parity (PPP). All discussion and figures are presented in dollars by PPP. Rates available from the OECD at http://stats.oecd.org/Index.aspx?datasetcode=SNA_TABLE4.

Second, the raw medians and ranges depicted fail to control for factors like speed, contracts, and data caps, which makes simple comparisons not always meaningful. We can partially correct for the first problem by combining our data with other information discussed below in order to draw more accurate conclusions about prices. We address the second through regression analysis.

Figure 1
Price Ranges for Residential Standalone Plans, 2007-2009

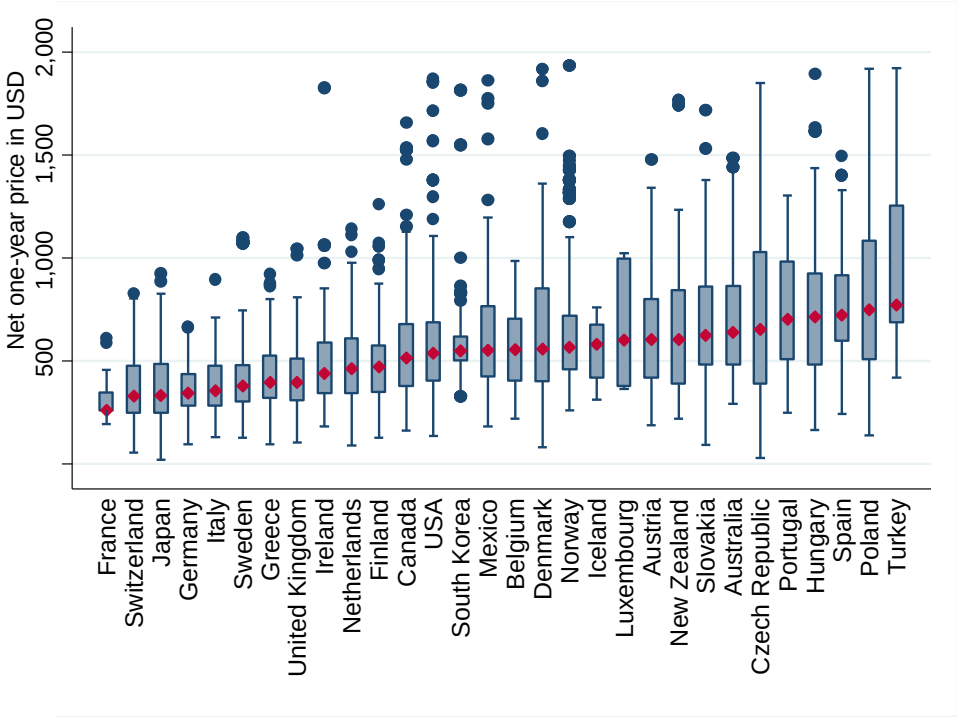


Figure 2
Price Ranges for Residential Triple Play Plans, 2007-2009

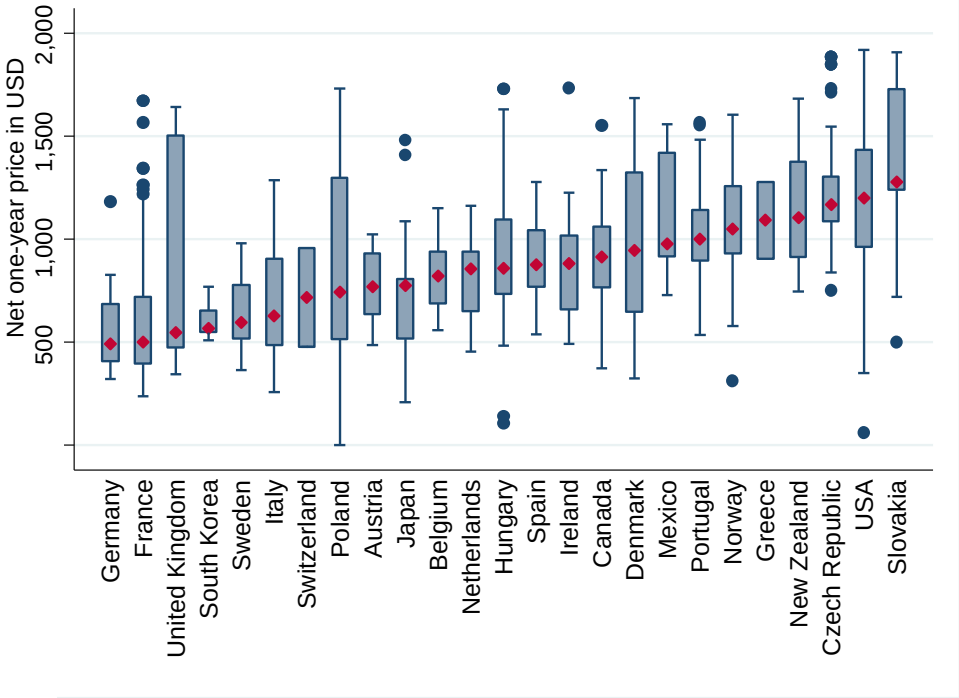
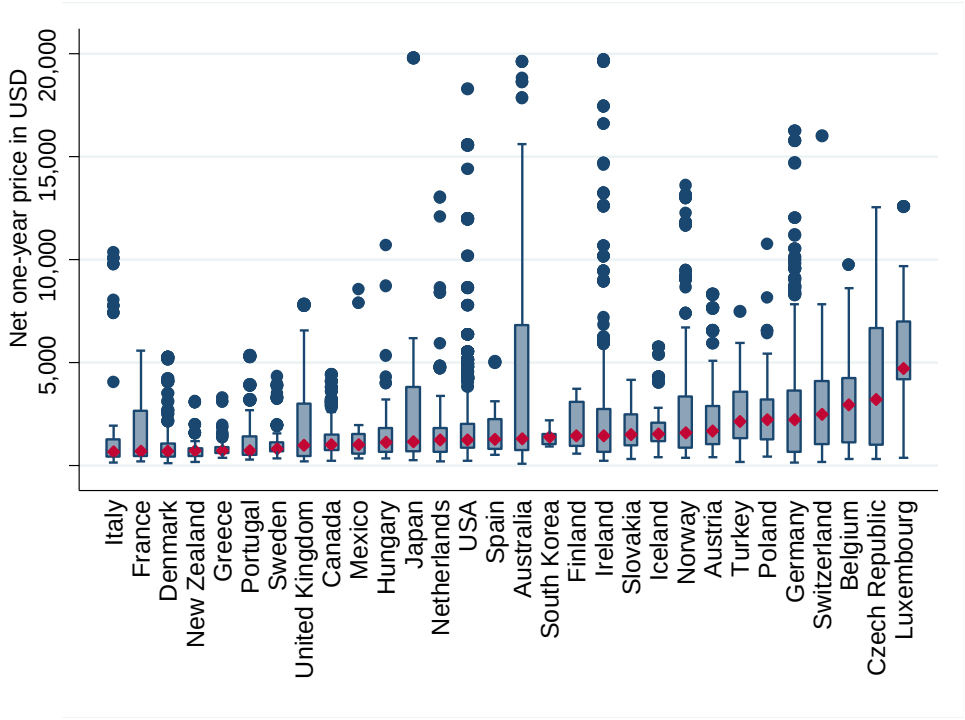


Figure 3
Price Ranges for Business Standalone Plans, 2007-2009



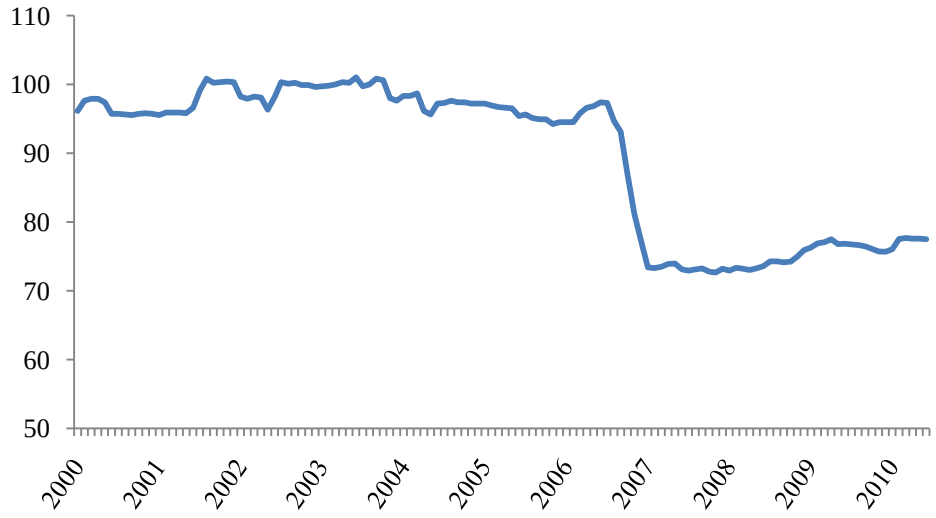
Note: Box plots show median (diamond), 25th to 75th percentiles or interquartile range (shaded box), values within 1.5 times the interquartile range (whiskers) and outliers (dots).

The next section uses the data for a detailed investigation of price changes in the U.S. Later, in Section IV, we will incorporate all of the OECD to compare prices across countries and for a separate analysis of price changes over time.

III. U.S. Price Trends

This section uses the data to explore how prices in the U.S. have changed since 2007. As discussed earlier, changes in broadband quality and the way in which people purchase broadband (that is, in bundles) make tracking price changes difficult. The U.S. Bureau of Labor Statistics (BLS) constructs monthly price indices for a large number of goods and services, including Internet service. Figure 4 shows the BLS price index from January 2000 through June 2010.

Figure 4
BLS Consumer Price Index for Internet Services and Electronic Information



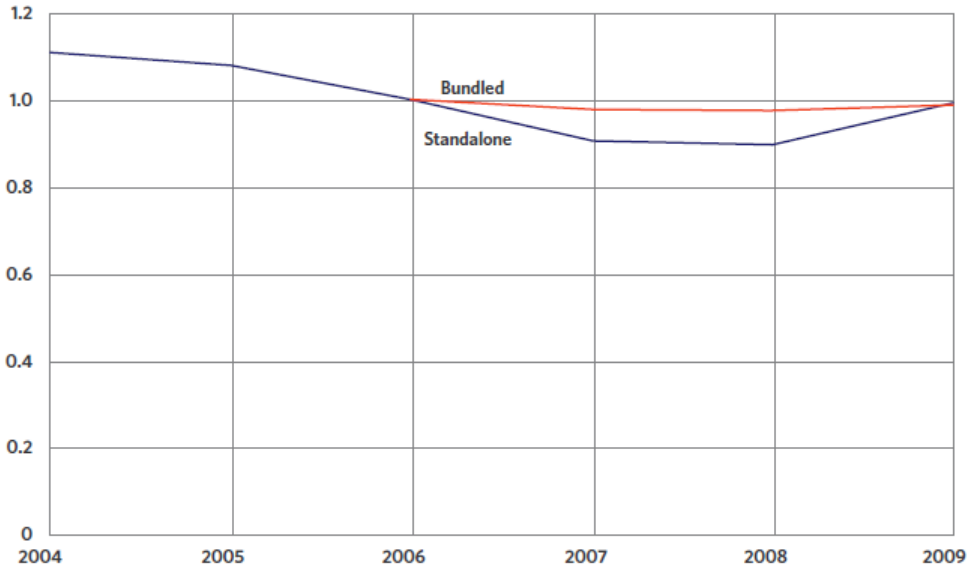
Source: U.S. Bureau of Labor Statistics[5]

The index shows fairly stable prices from 2000 through the middle of 2006, a dramatic decrease from mid-2006 to the end of 2006, and perhaps a slight increase since 2007. Greenstein and McDevitt (2010) note, however, that the BLS index has significant problems. Most importantly, it changes the relative weight of a given ISP only every four years. The apparent dramatic decrease in prices in 2006 is the result of a change in AOL's price for dial-up service, weighted in the index "as if AOL was a quarter of US households in the fall of 2006, which many industry reports suggest was not so."[6]

Greenstein and McDevitt (2010) build an original price index using data from Point Topic. They find, as the title of their paper suggests, a "modest" price decrease over the past few years when controlling for speed increases. An exhibit in the National Broadband Plan, reproduced below as Figure 5, shows the results of their research. The figure shows little change in quality-adjusted broadband prices since 2004.

[5] Series ID CUUR0000SEEE03, U.S. City Average, base date December 1997.
[6] Greenstein and McDevitt (2010, footnote 4).

Figure 5
"Price Indices for Broadband Advertised as a Standalone Service and as Part of a Bundle (2006 = 1)"



Source: National Broadband Plan, Exhibit 4-D (Federal Communications Commission 2010b).

Williams (2008) uses data collected by the BLS for its price index and adjusts for quality improvements. His method yields similar results—little change in prices over this time period.

In this paper we also use data derived from Point Topic and build on Greenstein and McDevitt in several ways. First, while Greenstein and McDevitt control for speed and region of the country in constructing their index, we also control for other factors that contribute to price, including bundle types, bundle characteristics (e.g., number of channels in a video package), contract length, information on bitcaps, and firm fixed-effects. Second, we have data on prices of business plans in addition to residential plans. Finally, we have data not only for the U.S., but also for all other OECD countries, allowing a more rigorous comparison of prices than has been possible in the past.

Empirical Method

We examine price trends in the U.S. in some detail by estimating versions of equation (1) below separately for residential standalone and triple play packages in different speed categories and for business standalone plans.

$$(2)\ \ln(Price_{it}) = f\begin{pmatrix} \ln(downloadspeed_{it}), bitcap_{it}, \ln(sizeof\ bitcap_{it} \mid bitcap_{it}), \\ contract_{it}, \ln(lengthof\ contract_{it} \mid contract_{it}), technologytype_{it}, \\ (\ln(numberof\ videochannels_{it} \mid videobundle_{it}), \gamma_i, \phi_t \end{pmatrix}$$

In this equation, $f(\bullet)$ is a linear function, *i* indicates the plan and *t* indicates the quarter-year in which the plan was advertised. γ_i are firm fixed effects to control for firm-specific factors that may affect price levels, and ϕ_t indicates time fixed effects to control for general trends and time-specific shocks.

This approach allows us to view quality-adjusted price changes for different types of plans and, when combined with data from the FCC, to construct Laspeyres, Paasche, and Fisher price indices for residential standalone and triple play plans as well as a price index for business plans.

The Laspeyres index is $P_L = \frac{\sum p_{c,t_n} * q_{c,t_0}}{\sum p_{c,t_0} * q_{c,t_0}}$ and the Paasche index is $P_P = \frac{\sum p_{c,t_n} * q_{c,t_n}}{\sum p_{c,t_0} * q_{c,t_n}}$

where p_{c,t_n} is the price of good *c* in time period *n* and q_{c,t_n} is the quantity of good *c* in time *n* (and in the case of P_L, $t_n = t_0$, which is the first year of the index). Laspeyres may overstate price changes because it shows how prices change relative to a fixed basket of goods. Paasche, meanwhile, takes into account how consumers may change their purchasing decisions as prices change but may understate price changes for those who do not change their purchases. The Fisher index, $P_F = \sqrt{P_L * P_P}$ is the geometric mean of the two.

Calculating these indices requires knowing quantities of products purchased. As we discussed earlier, we do not know the number of subscribers to each plan. The FCC, however, reports the number of U.S. broadband subscribers within particular speed groups on a biannual basis from ISP responses to "Form 477." We can group the plans in our data into those tiers and use the FCC's broadband line counts as our quantity weights.

The FCC data, while the best available, have two problems. First, the FCC changed the speed groupings beginning in the February 2010 report, which has data for December 2008. Second, the FCC did not separate residential from business connections by speed tier until the December 2008 data. Table 1 shows the FCC's speed tier classifications.

Table 1
Speed Tiers used in the FCC's 477 Reports

2007–June 2008		December 2008–Present	
At least	*Less than*	*At least*	*Less than*
200 kbps	2.5 Mbps	200 kbps	768 kbps
2.5 Mbps	10 Mbps	768 kbps	1.5 Mbps
10 Mbps	25 Mbps	1.5 Mbps	3 Mbps
25 Mbps	100 Mbps	3 Mbps	6 Mbps
100+ Mbps		6 Mbps	10 Mbps
		10 Mbps	25 Mbps
		25+ Mbps	

Because we have less than two years worth of data using the new, finer-grained speed groupings, we use the older tiers for all years of our data by regrouping the newer 477 data into the old tiers. Unfortunately, the new tiers of 200 kbps–768 kbps, 768 kbps–1.5 Mbps and 1.5 Mbps–3 Mbps

do not map precisely onto the old 200 kbps–2.5 Mbps tier. We take the simplistic, but probably unavoidable step of grouping all plans from the second half of 2008 and later with download speeds of 200kbps–3 Mbps into the older 200 kbps–2.5 Mbps tier. One implication of this approach is that the 200 kbps–2.5 Mbps tier will appear to have somewhat more subscribers than it does in reality, since it will also include any subscribers that have plans with 2.5–3 Mbps. By the same token, in those years the 2.5–10 Mbps tier will show fewer subscribers than is actually the case.

Residential Standalone Broadband

We first consider residential standalone broadband plans. Table 2 shows the results of estimating the regression when analyzing only standalone plans in the U.S. The first column shows the results when pooling all the plans together, and the next four columns group plans by speed. Few of the half-year coefficients are statistically significant, and the magnitude of most of them is close to zero, suggesting that quality-adjusted prices for standalone plans have not changed much from their levels in the first half of 2007.

Table 2
Residential Standalone Broadband Prices

		FCC Speed Tier			
	All Tiers Together	<2.5 Mbps	2.5–10 Mbps	10–25 Mbps	25–100 Mbps
Dependent variable	Log of net one-year price				
Mean of dependent variable	6.3	5.9	6.3	6.5	6.8
Log of downstream speed	0.253	0.234	0.348	0.355	1.033
	(33.14)**	(7.35)**	(8.61)**	(8.07)**	(9.93)**
Plan has a contract	0.179	0.876	0.036	-0.508	0
	(0.77)	(1.99)*	(0.10)	(1.62)	(.)
Log of contract months	-0.124	-0.341	-0.074	0.118	-0.061
	(1.49)	(2.32)*	(0.56)	(1.01)	(2.28)*
DSL	-0.256	-0.277	-0.219	-0.054	
	(6.49)**	(3.61)**	(3.81)**	(0.73)	
FTTX	0.22		-0.039	0.326	0.53
	(3.13)**		(0.31)	(2.46)*	(4.25)**
Other	0.112		-0.117		
	(1.61)		(1.06)		
2007 2nd half	-0.058	-0.05	-0.072	-0.028	0
	(2.28)*	(1.22)	(2.08)*	(0.54)	(0.00)
2008 1st half	-0.035	-0.018	-0.043	-0.021	0.134
	(1.33)	(0.41)	(1.25)	(0.40)	(1.56)
2008 2nd half	-0.016	-0.025	-0.053	0.013	0.044
	(0.61)	(0.57)	(1.40)	(0.27)	(0.52)
2009 1st half	0.043	0.066	-0.012	0.054	0.302

	(1.65)+	(1.50)	(0.31)	(1.09)	(3.56)**
2009 2nd half	0.032	0.023	-0.009	0.014	0.255
	(1.24)	(0.51)	(0.24)	(0.27)	(3.10)**
Constant	4.379	3.846	3.508	2.976	-4.266
	(34.92)**	(15.12)**	(9.74)**	(7.08)**	(3.72)**
Observations	822	237	327	229	26
R-squared	0.75	0.71	0.59	0.72	0.98

Absolute value of t-statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%.
Firm fixed effects included but not shown. Technology effects relative to cable; time effects relative to 2007 1st half.

Figure 6 graphs the coefficients to show the price changes over time. The only tier that shows significant price changes, both in terms of magnitude and statistical significance, is the tier that includes plans offering download speeds of 25–100 Mbps. Here, prices appear to have increased about 25 percent in this time period.

Figure 6
Residential Standalone Broadband Price Trend
U.S. Plans Classified by FCC Speed Tier

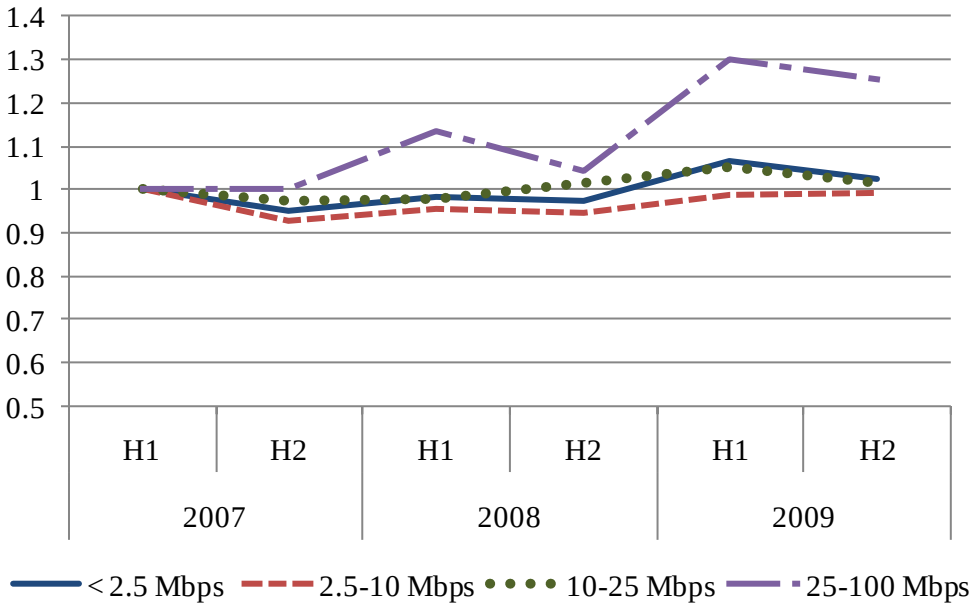


Table 3 shows the price indices based on these estimates and the distribution of subscribed speed tiers as reported by the FCC.

Table 3
Price Indices for U.S. Residential Standalone Plans

Time Period	Paasche	Laspeyres	Fisher
2007 1st half	1.00	1.00	1.00
2007 2nd half	0.88	0.94	0.91
2008 1st half	0.94	0.97	0.96
2008 2nd half	0.83	0.96	0.89
2009 1st half	0.88	1.02	0.95
2009 2nd half	0.77	1.00	0.89

Prices for plans offering download speeds exceeding 25 Mbps increased by about 25 percent, but this tier also contains the fewest subscribers. In December 2009 fewer than one percent of all subscribers purchased plans with speeds above 25 Mbps. As a result, this increase has little effect on the overall price index. In fact, because the most subscribed tier includes plans offering between 2.5–10 Mbps, the Paasche index shows an overall price decrease. Recall, however, that the coefficients were generally not statistically significant, suggesting that it is safer to interpret these numbers as meaning little, if any, change in overall prices.

Residential Triple Play

Table 4 shows the results of estimating the hedonic model for residential triple play plans in the U.S. As above, the first column shows the results when including all plans, while the following three columns estimate regressions separately for each speed tier for which we have data. The coefficients on the half-year dummy variables provide the basis for the price index.

Table 4
Residential Triple Play Prices

	All Tiers Together	By FCC Speed Tier		
		<2.5 Mbps	2.5-10 Mbps	10-25 Mbps
Dependent variable	Log of net one-year price			
Mean of dependent variable	7.04	7.03	7.05	7.04
Log of downstream speed	0.093	0.026	0.493	0.05
	(4.31)**	(0.62)	(3.90)**	(0.34)
Plan has a contract	-0.56		0.008	
	(3.37)**		(0.03)	
Log of contract months	0.28	0.04	0.133	0.223
	(3.78)**	(1.16)	(1.28)	(4.40)**
Log of number of video channels	-0.007	-0.03	-0.022	0.038
	(0.58)	(1.34)	(1.19)	(3.00)**

DSL	0.161	0.105	-0.049	
	(0.58)	(0.59)	(0.13)	
FTTX	-0.037	0	-0.146	
	(0.17)	(0.00)	(0.46)	
2007 2nd half	0.142	0.022	0.104	-0.215
	(2.35)*	(0.34)	(1.21)	(1.52)
2008 1st half	0.145	-0.055	0.16	-0.206
	(2.43)*	(0.77)	(1.86)+	(1.49)
2008 2nd half	0.147	-0.145	0.149	-0.191
	(2.49)*	(1.94)+	(1.62)	(1.46)
2009 1st half	0.167	-0.085	0.162	-0.152
	(2.71)**	(1.03)	(1.72)+	(1.14)
2009 2nd half	0.173	-0.099	0.17	-0.142
	(2.67)**	(1.09)	(1.63)	(1.11)
Constant	5.954	6.772	3.065	6.346
	(14.51)**	(19.40)**	(2.69)**	(4.62)**
Observations	303	83	176	44
R-squared	0.61	0.63	0.67	0.94

Absolute value of t-statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%.
Firm fixed effects included but not shown. Technology effects relative to cable; time effects relative to 2007 1st half.

The regression shows that the results differ substantially by speed tier. The pooled regression suggests that quality-adjusted prices for triple play plans increased by about 17 percent from 2007-2009, but this result appears to be driven by plans in the 2.5–10 Mbps tier, while the quality-adjusted price of plans in other tiers fell. Figure 7 graphs the price changes in residential triple play packages by speed tier.

Figure 7
Residential Triple Play Broadband Price Trend
U.S. Plans Classified by FCC Speed Tier

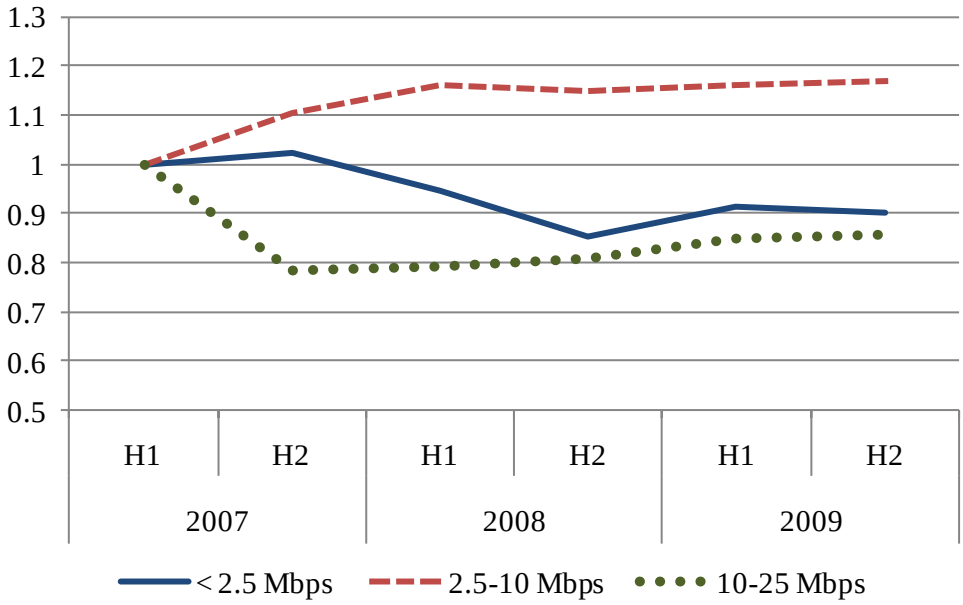


Table 5 shows the calculated price indices for residential triple play packages based on the distribution of subscribers according to the FCC.

Table 5
Price Indices for U.S. Residential Triple Play Plans

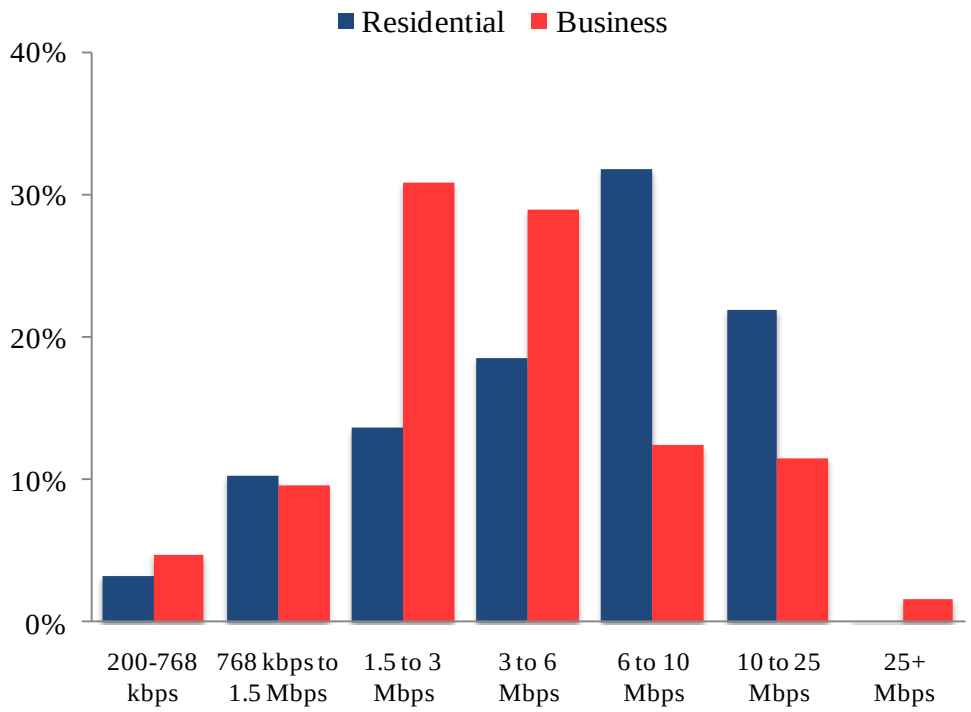
Time Period	Paasche	Laspeyres	Fisher
2007 1st half	1.00	1.00	1.00
2007 2nd half	1.06	1.06	1.06
2008 1st half	1.07	1.07	1.07
2008 2nd half	1.01	1.04	1.02
2009 1st half	1.03	1.07	1.05
2009 2nd half	1.04	1.07	1.05

The calculations suggest that, overall, quality-adjusted prices remained relatively constant from 2007–2009. The regression and the figure, however, show variation across speed tiers. Prices of plans offering download speeds of less than 2.5 Mbps and those offering speeds between 10 and 25 Mbps decreased by 10–15 percent. Prices of plans offering downloads speeds of 2.5–10 Mbps, however, increased by close to 20 percent. The overall indices show increases of several percentage points because the majority of wired connections fell in the 2.5–10 Mbps range during this time period.

Business Standalone Broadband

Businesses may choose their broadband services on different criteria from residential users. The limited data from the FCC suggests that is the case. Figure 8 shows the distribution of speeds by residential and business users, according to the FCC's December 2009 data.

Figure 8
Share of U.S. Business and Residential Broadband Connections by Speed Tier, December 2009



Source: FCC (2010c).

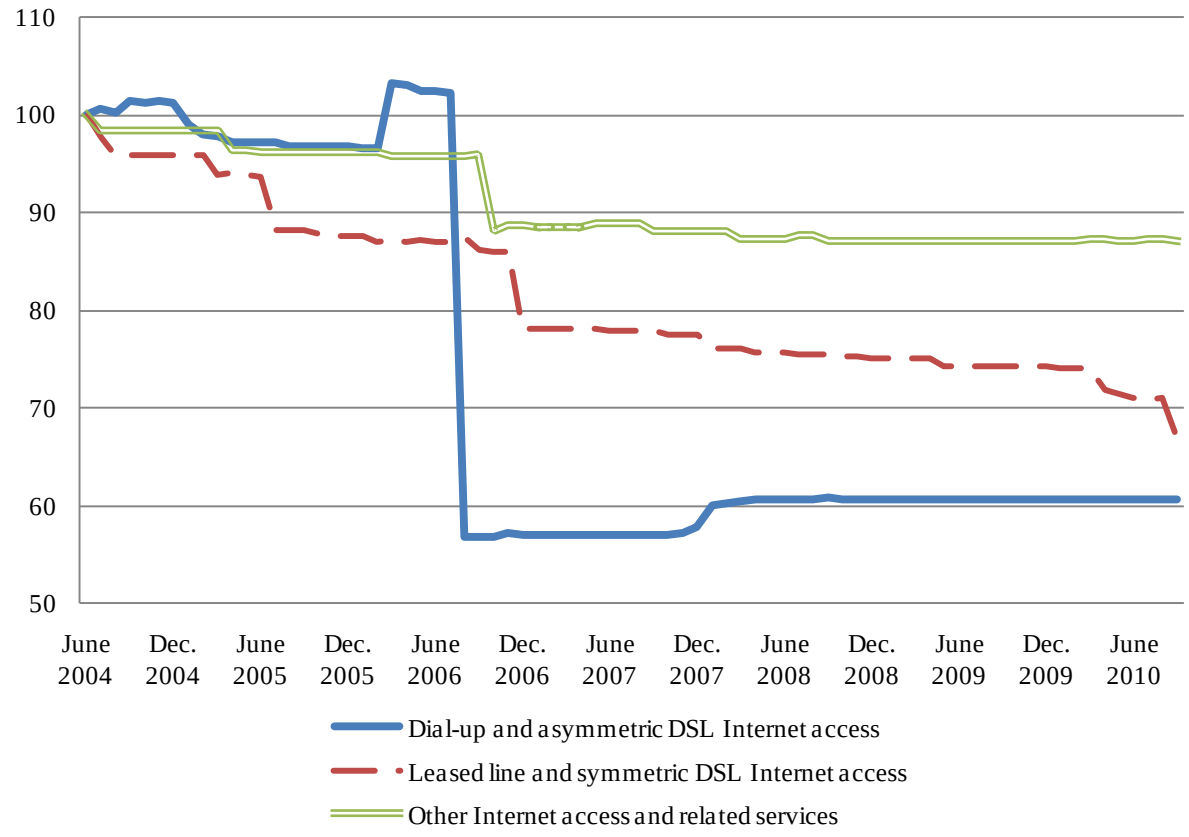
The figure shows that business connections tend to be slower than residential connections. This is perhaps not surprising, as businesses may have a stronger preference for reliability than for speed. For example, at about 1.5 Mbps, the maximum throughput of T-1 service is lower than advertised speeds for many home broadband connections. This simple comparison is inaccurate, however, because it ignores the fact that T-1 subscriber does not share capacity with other users. Performance is thus more consistent, and is usually purchased with an uptime guarantee (99.99% or better is common). Businesses may also be more dependent on upload speeds, which are symmetrical with T-1 and T-3 service but limited in (asymmetric) DSL and most cable systems.

Little research has examined business broadband prices, but data from the BLS are suggestive. BLS does not disaggregate its Internet access consumer price index (CPI) but does disaggregate the producer price index (PPI), which is a price index based on fees providers receive for service

(as opposed to prices consumers report paying to providers). This breakdown includes data on leased-line and symmetric DSL, which are almost exclusively business products.[7]

Figure 9 shows this information. The figure shows the illusion of a sharp decrease in dial-up and asymmetric service caused by AOL, as discussed earlier. Leased-line prices, however, show a steady decrease over time.

Figure 9
Producer Price Index, Internet Service



Source: U.S. Bureau of Labor Statistics[8]

[7] Specifically, BLS provides data on the following categories of Internet access services:

- Dial-up and asymmetric DSL Internet Access, which "…primarily covers transactions between Internet service providers and individual households."
- Leased-line and symmetric DSL Internet access, which "tracks prices of transactions between Internet service providers and institutional clients that require a large amount of Internet bandwidth capacity for their data processes. With leased-line Internet access, all or part of a private telecommunications line (a T-1 or T-3 line) is reserved for an individual client."
- Other internet access and related services, which "includes advertising services sold by Internet service providers and the provision of Internet access using any technologies other than dial-up, DSL, or leased lines."

See https://www.bls.gov/ppi/ppiisp.htm for details.

[8] Series ID PCU5181115181111, PCU5181115181112, and PCU5181115181113, base date June 2004.

For our own examination of price changes in the business market, we estimate the same analysis described for residential broadband, but with business standalone plans, and with one small difference. The FCC began showing speed tiers for residential and total connections—therefore implicitly relating business—in the December 2008 data. For this reason, here we must switch to using the new Form 477 speed tiers.

Table 6 shows the results. The first column shows the pooled results, which suggest a general downward trend in quality-adjusted business broadband prices from 2007–2009. The remaining seven columns show the analysis separately for each new FCC speed tier. The slower speeds, which contain most connections, show no significant price changes either in magnitude or in the statistical sense. Plans above 10 Mbps, however, show statistically significant large decreases in quality-adjusted prices during this time period. In this analysis, quality-adjusted prices for plans offering 10-25 Mbps have come down by about 60 percent, and plans offering 25 Mbps and more have come down by about 33 percent.

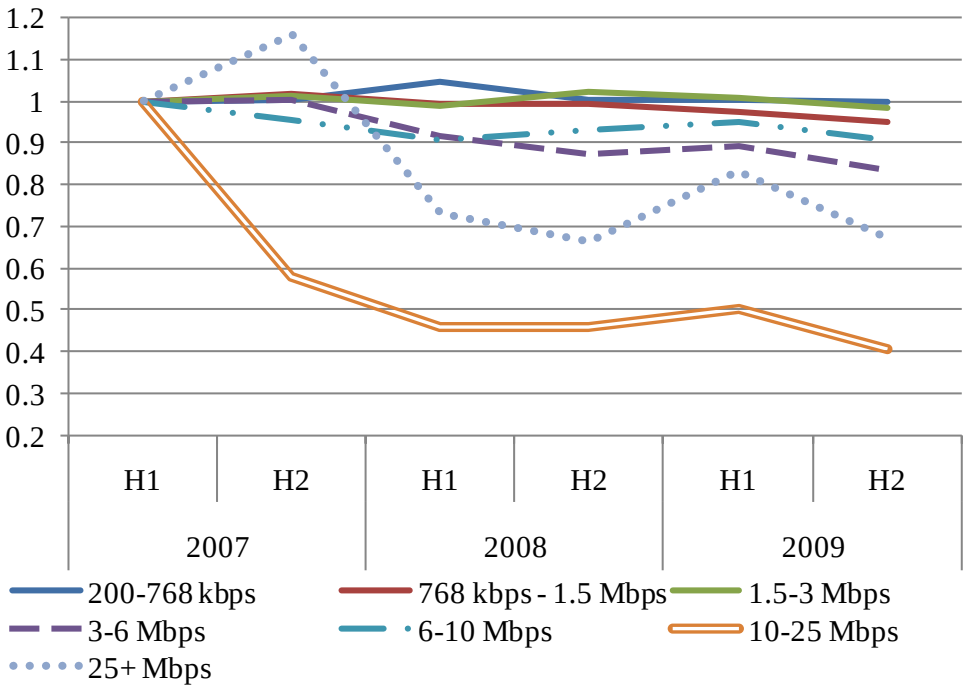
Table 6
Business Standalone Broadband Prices

	All Tiers Together	200-768 kbps	768 kbps - 1.5 Mbps	1.5-3 Mbps	3-6 Mbps	6-10 Mbps	10-25 Mbps	25+ Mbps
Dependent variable	Log of net one-year price							
Mean of dependent variable	7.2	7.2	7.4	7.2	7	7	7.5	7.1
Log of downstream speed	0.367	0.115	0.796	0.889	0.892	0.027	0.885	0.643
	(38.37)**	(4.27)**	(10.26)**	(6.63)**	(5.25)**	(0.08)	(7.58)**	(8.60)**
Plan has a contract?	-0.283	0.292	-0.232	-0.223	-0.444	-0.095	-0.083	-2.008
	(3.34)**	(2.86)**	(2.18)*	(1.93)+	(1.89)+	(0.77)	(0.40)	(4.34)**
Log of contract months	-0.013	-0.142	-0.123	0.004	-0.051	-0.059	-0.067	0.515
	(0.48)	(4.48)**	(3.88)**	(0.10)	(0.66)	(1.47)	(1.10)	(3.81)**
DSL	-1.257	-0.431	-0.158	-1.523	-2.037	-0.763	0.558	
	(37.99)**	(2.93)**	(2.55)*	(39.96)**	(12.06)**	(4.87)**	(2.53)*	
FTTX	-0.907				-1.209	-1.025	0.182	0.527
	(16.08)**				(6.19)**	(5.98)**	(0.93)	(3.91)**
20072	-0.027	0.003	0.018	0.011	0.002	-0.044	-0.422	0.161
	(0.92)	(0.10)	(0.48)	(0.40)	(0.02)	(0.84)	(3.31)**	(1.49)
20081	-0.106	0.045	-0.005	-0.01	-0.084	-0.094	-0.54	-0.27
	(3.57)**	(1.30)	(0.13)	(0.37)	(1.02)	(1.85)+	(4.32)**	(2.61)*
20082	-0.108	0.004	-0.006	0.023	-0.126	-0.069	-0.542	-0.335
	(3.74)**	(0.10)	(0.16)	(0.83)	(1.59)	(1.38)	(4.42)**	(3.31)**
20091	-0.085	0.002	-0.027	0.008	-0.106	-0.05	-0.498	-0.166
	(3.05)**	(0.06)	(0.72)	(0.27)	(1.33)	(1.00)	(4.11)**	(1.55)
20092	-0.12	-0.002	-0.052	-0.019	-0.168	-0.092	-0.596	-0.328
	(4.22)**	(0.08)	(1.34)	(0.66)	(2.10)*	(1.83)+	(4.82)**	(3.13)**
Constant	5.426	6.232	2.55	1.914	-1.421	8.31	-1.073	1.235
	(28.94)**	(24.31)**	(4.91)**	(1.93)+	(0.97)	(2.76)**	(0.95)	(1.60)
Observations	1983	280	335	407	359	295	269	38
R-squared	0.69	0.89	0.92	0.96	0.63	0.56	0.80	0.97

Absolute value of t-statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%. Firm fixed effects included but not shown. Technology effects relative to cable; time effects relative to 2007 1st half.

Figure 10 shows these quality-adjusted price changes graphically. The large decrease in quality-adjusted prices for the higher tiers is apparent. Slower tiers show smaller price decreases, but recall that those coefficients were not generally statistically significant in the regressions, meaning that we cannot reject the hypothesis that those price effects remained constant.

Figure 10
Business Standalone Broadband Price Trend
U.S. Plans Classified by FCC Speed Tier



Constructing the overall price indices for the business plans is more problematic than it was for the residential plans due to the lack of data on the number of business subscribers by speed tier over time. In particular, the Paasche index requires having data on the quantity supplied in each time period for which we estimate price. We do not have that. The Laspeyres requires quantity data for the base year, which we also do not have. Thus, we use a modified Laspeyres index, in which we take the midpoint quantities as the base. More specifically, we set $q_{c,t_0} = q_{c,t_{2008\text{secondhalf}}}$. The implication is that we show a price index for a constant basket of plans (i.e. distribution of speeds) not at the earliest point in time, but for the basket purchased in the December of 2008.

Table 7 shows the results of that calculation. The table suggests that, overall, prices for business broadband plans fell about 15 percent between 2007-2009.

Table 7
Price Index for U.S. Business Standalone Plans

Time Period	Modified Laspeyres
2007 1st half	1.00
2007 2nd half	0.94
2008 1st half	0.89
2008 2nd half	0.89
2009 1st half	0.90
2009 2nd half	0.85

As with residential prices, changes in business prices differ by speed tier. In general, price decreases were more pronounced for plans offering higher speeds. Prices for the slowest plans saw almost no change, while prices for plans offering more than 25 Mbps decreased by over 30 percent. Taking into account the actual distribution of subscriptions to these plans leads to an overall estimate of an approximately 15 percent price decrease.

Discussion

It is not surprising that business broadband tends to be more expensive than residential broadband. It is not immediately obvious, however, why business prices appear to have decreased when residential prices have not. One explanation for decreasing business broadband prices is that they simply reflect poor macroeconomic conditions. Economic downturns put pressure on firms to reduce costs, which, in turn, may cause them to approach suppliers of inputs—including broadband service—and request lower prices. Another possibility is that there may be more competition for business customers, especially when considering that large firms may be able to handle their own broadband connections without a traditional ISP. Testing these hypotheses is beyond the scope of this paper and is left for future research.

IV. OECD Price Comparisons

Several reports attempt to compare prices across countries. In its "broadband portal," for example, the OECD records prices for what it considers to be representative plans in each country, as well as average prices by tiers of speeds offered.[1] As we alluded to when introducing our own dataset, these data are informative, but offer only an incomplete picture. They do not present information on bundles or attempt to create price indices that allow more rigorous comparisons of prices and price changes over time.

A few research papers examine prices in more depth and generally agree that the U.S. has low prices for low-speed broadband plans and high prices for high-speed broadband plans. Benkler, et al. (2010, 68), in their study of broadband policies around the world conclude that "the U.S.

[1] Available at http://www.oecd.org/sti/ict/broadband

does reasonably well at the very lowest speeds, but that prices increase substantially, by comparison to prices in other countries, for mid-, high, and very-high or next generation speeds. U.S. prices for next generation speeds are the highest, or near highest, in the world today."

Paltridge and Masayuki (2004) note that they do not have enough observations to reach statistically significant conclusions, but that prices appeared to be heading down and speeds up. They report that Japan and South Korea appeared to offer the best combination of low price and high speeds, while the U.S. and Canada appeared to have the most competitive "entry-level" broadband plans.

Wallsten (2009) finds that by various measures the U.S. appears to be somewhat in the middle of the OECD pack in terms of normalized prices and revenues per subscriber. Additionally, like the other authors he finds relatively low prices in the U.S. for low-speed broadband but relatively high prices for high-end broadband.

We improve on these analyses in several ways. First, we separate business from residential plans. Second, within residential plans we can examine standalone and bundled plans separately. Third, we compare prices across countries in those different categories after controlling for the other factors that can influence the price of a subscription. Finally, by combining our dataset with information on the number of subscribers within speed tiers we can construct rough price indices to examine how prices have changed across OECD countries.

Comparing Price Levels Across Countries

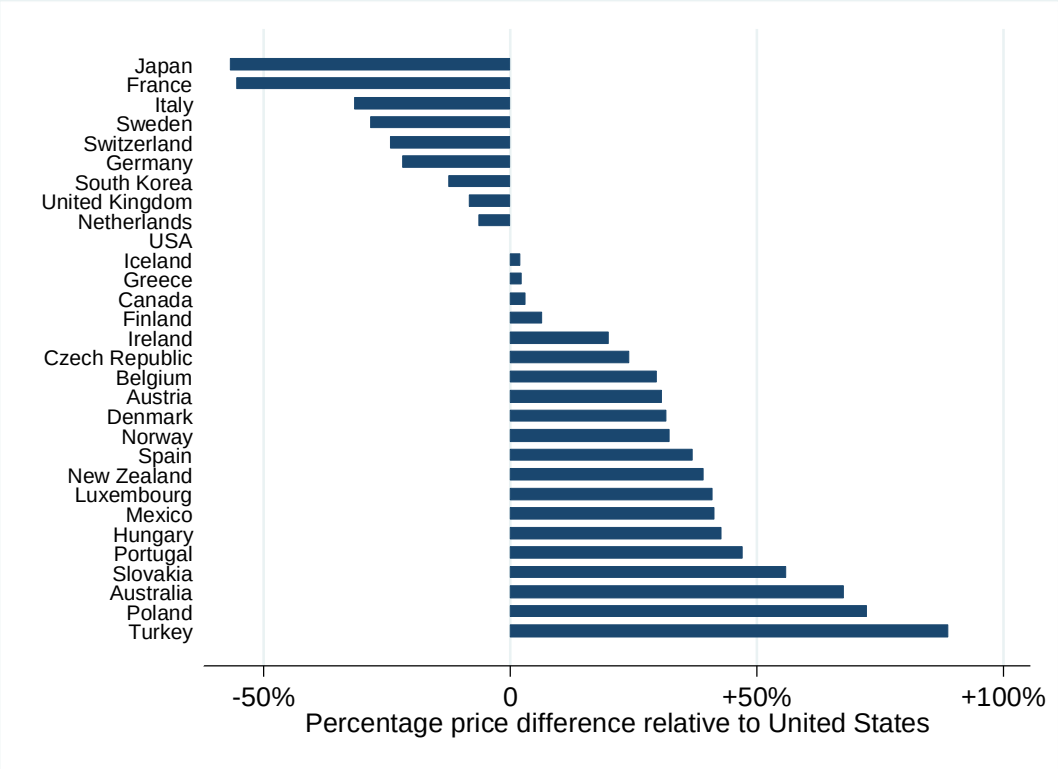
To construct meaningful price comparisons we estimate the same hedonic regression from Part III, with two exceptions, separately for residential standalone, residential triple play, and business standalone broadband plans in each of the 30 OECD countries.[2] We change the model in two ways for this section. First, we include another variable indicating whether tax is included in the recorded price of a given plan.[3] Second, instead of firm fixed effects we use country fixed effects. Unlike Part 1 of this project, where we were interested in the correlations between price and features like contracts, speed, and bitcaps, we now look to the coefficients on country fixed-effect dummy variables. We construct the model to estimate the average price difference (in percent) between plans in a given country and those in the United States. Recall that our regression also controls for advertised download speed, whether data usage is limited (and to what extent), whether a plan includes a contract (and of what length), the delivery technology used, and time effects. We run the calculation pooling together the three years for which we have data. To our knowledge, no previous study has attempted this type of comparison with such an extensive dataset.

Figure 11 below shows the overall prices (in 2007 through 2009) of standalone broadband plans in other OECD countries relative to the U.S.

[2] Our study does not include countries that joined the organization in 2010, namely Chile, Israel, and Slovenia, or Estonia, which is awaiting the completion of membership formalities.

[3] We did not include this variable when creating price indices for the U.S. because none of the prices for U.S. plans in the dataset include tax.

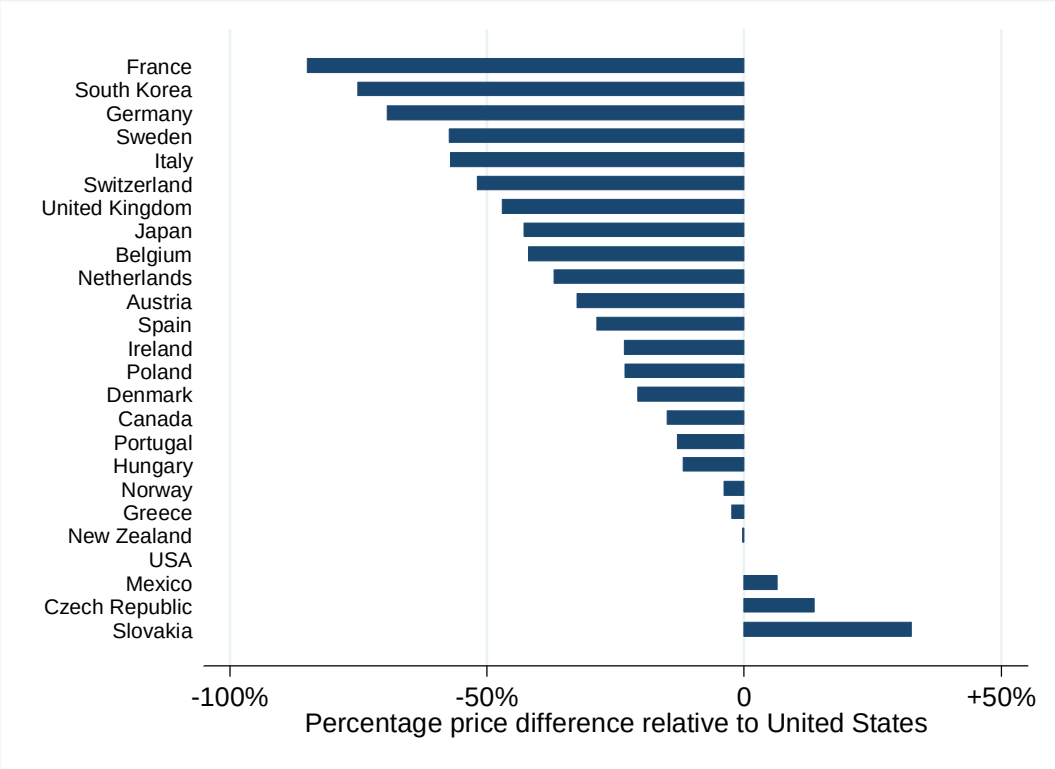
Figure 11
Quality- and Feature-Adjusted Price Relative to U.S.
Residential Standalone Broadband



The figure shows Japan and France with the least expensive standalone plans—each with quality- and feature-adjusted prices about one-half the U.S. level—and Turkey with the most expensive plans at nearly double the U.S. The analysis suggests that prices for standalone broadband plans in the U.S. are somewhere in the middle of prices in OECD countries, though closer to the leaders than to the laggards.

Figure 12 shows the relative overall prices for triple play packages. Most OECD countries with triple play plans in our dataset offer quality-adjusted plans at lower prices than are generally available in the U.S. Only Mexico, the Czech Republic, and Slovakia (excluding the handful of countries for which the data are not sufficient for our analysis) appear to have overall higher prices.

Figure 12
Quality- and Feature-Adjusted Price Relative to U.S.
Residential Triple Play Broadband



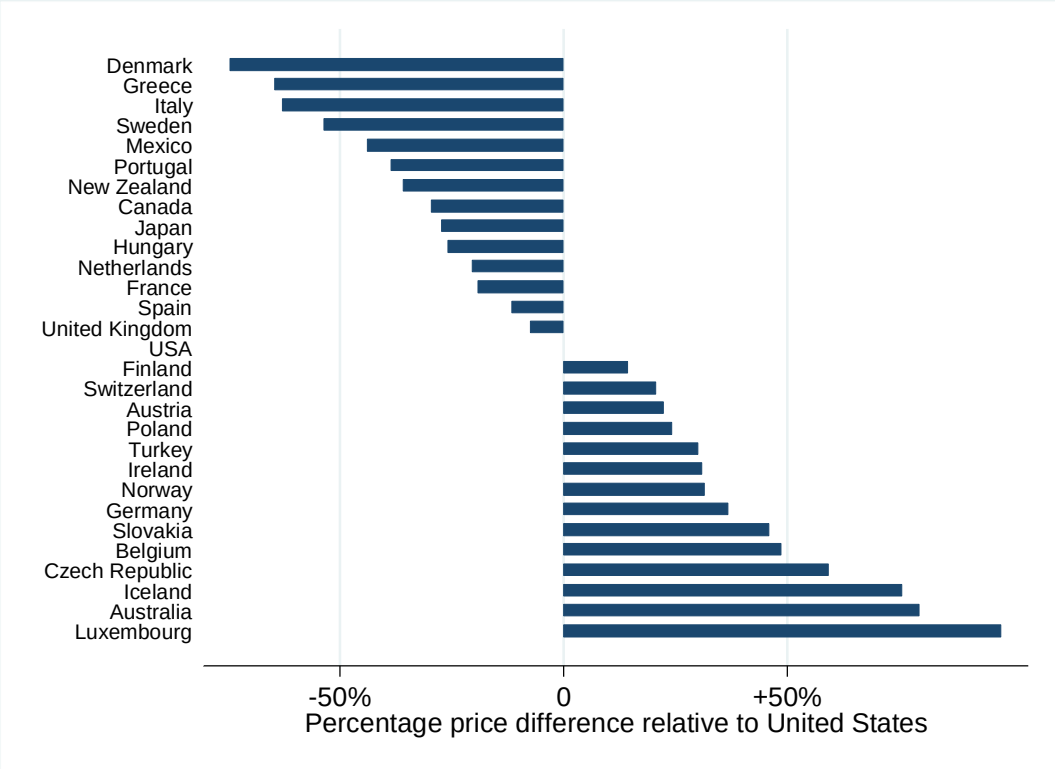
Note: Australia, Finland, Iceland, Luxembourg, and Turkey not depicted because we do not have sufficient data to compute country effects.

Some of the price differences across countries seem implausibly large—for example, plans in France are estimated to be about three-quarters cheaper than those in the U.S. At least two factors for which we do not control may help explain these magnitudes. First, while we control for the number of channels in a video package, we cannot control for the *type* of programming and the types of contracts distributors sign with programmers.[4] To the extent that programming expenses are large and differ across countries, they could have a significant effect on prices for which we cannot control. Second, we do not control for regulatory factors that can affect price, including those that affect wholesale access or program carriage.

Figure 13 shows relative prices for business broadband plans. The price of business broadband in U.S. has been almost dead-center in the set of OECD countries in recent years. The least expensive business plans appear to be in Denmark, Greece, Italy, and Sweden, where our coefficient estimates suggest similar business broadband service is about half as expensive as U.S. service. The most expensive business prices are in Iceland, Australia, and Luxembourg, which appear to exceed prices in the United States by about three-quarters.

[4] As we mention in Part 1, total number of channels is an imperfect quality measure of video packages, albeit the best possible given available data.

Figure 13
Quality- and Feature-Adjusted Price Relative to U.S.
Business Standalone Broadband



Note: South Korea not depicted because we do not have sufficient data to compute country effects.

Comparing Price Changes Across Countries

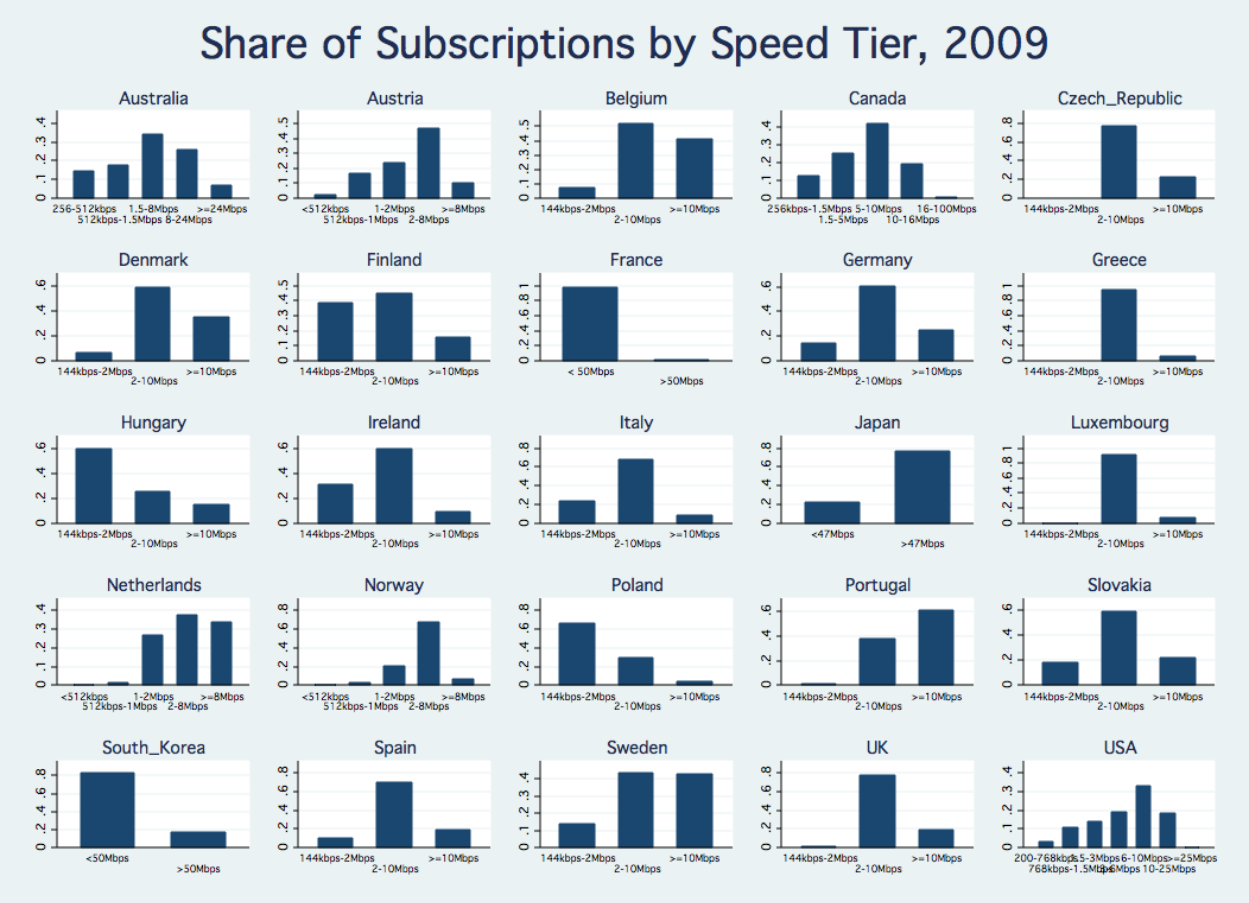
Having looked at price levels in general, we now turn to examining how prices have changed in each country in 2007, 2008, and 2009. We would like to examine price changes by doing for each country the analysis we performed when constructing price indices for the United States in Section III. Unfortunately, dividing the sample so many ways (by country, half-year, customer group, bundle type, and speed groups) leaves us with sample sizes in some categories too small for statistically meaningful regression analysis. One reason for those small sample sizes is not just because we divide the data into so many categories, but because some countries have a small number of ISPs. As a result, statistical insignificance itself is not especially meaningful if we have the entire universe of ISPs and plans represented in a given country.

Thus, rather than estimating the same type of regressions we did above, we use a median-weighted-mean, or what we call "representative middle," price for each group as the basis for the price indices. We calculate this representative middle by taking the median net one-year price for each ISP for plans in each specified consumer group/bundle type/half-year/speed group class. We then calculate a weighted mean of each of those medians in that consumer group/bundle type/half-year/speed group class, in which the weights are the ISP's share of the national broadband market. (See Appendix for additional data on representative middle prices.) With

perfect data we would weight by the share of subscribers to each plan, but that is not possible. Weighting by the ISP's share is the next-best solution.

With this price variable we still require a measure of the quantities sold in order to construct the price indices. Since we do not know the number of subscribers to each plan we assembled data on the number of subscriptions within particular speed groupings for as many countries as possible as a second-best approach. Just as the FCC counts the number of subscribers within certain speed categories, so, too, do many other regulators. That information does not tell us how many subscribers each plan has, but it gives us a reasonable idea of how to assign weights to different speed tiers. These were the "speed groups" used in calculating the representative-middle price above. They unfortunately vary between some countries, and for some we have as little as two tiers. (The Appendix details sources and methodology for each country.) Figure 14 shows the 2009 distribution of subscribers by speed grouping in the countries for which that information is available.

Figure 14



Source: National regulatory authorities and others (see Appendix).

Although we estimated price indices for the U.S. in a more rigorous way above, we apply the current method to the U.S. as well, in order to make for a more proper comparison and as a partial check on whether this method seems to yield reasonable results.

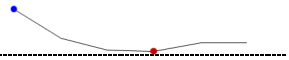
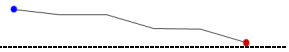
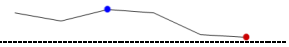
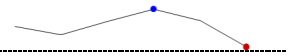
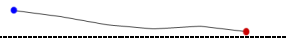
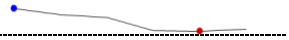
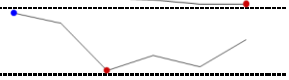
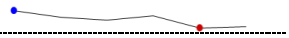
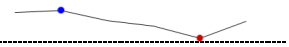
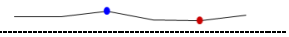
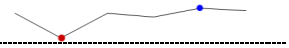
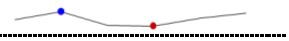
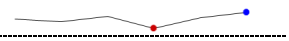
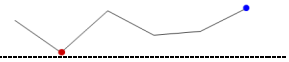
Table 8 shows price indices for residential standalone broadband plans.[5] The table lists the net change from the beginning of 2007 through the end of 2009 (except where noted), while the miniature line graph in each row depicts the price level at each half year. This method suggests that prices in the U.S. increased by about two percent over the time period, consistent with our statistically insignificant estimates above, suggesting no change in standalone prices. France and Belgium saw price decreases of about 40 percent while Norway's prices increased by about 20 percent.

Table 9 shows price indices for residential triple play plans. Portugal and the UK show the biggest price decreases. Again, the U.S. shows prices relatively unchanged at a two percent increase, consistent with our earlier estimates. Japan, Canada, and South Korea had slightly larger price increases of four, five, and seven percent

Lastly, Table 10 shows price indices for business broadband. This method shows business prices in the U.S. falling by 25 percent—a larger decrease than estimated above—and the sixth largest decrease in this group. Portugal shows the largest price decrease. Canada, Denmark, Norway, Japan, and the UK all showed increases in business prices. Australia showed the largest increase in price at 108 percent.

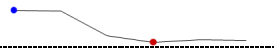
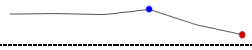
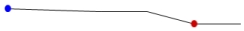
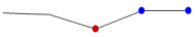
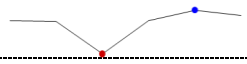
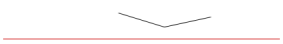
[5] Several countries are not indexed in the tables due to insufficient data, as noted in the Appendix. Also note that the paucity of standardized subscriber data also forces us to use tiers which vary between some countries, and that differ slightly in their reporting schedules, are repeated or averaged in some periods, and in the case of South Korea and Japan which are only proxies for the market as a whole.

Table 8
Price Indices for Residential Standalone Plans, 2007-2009

	Total Change	
France	-42%	
Belgium	-41%	
Hungary	-36%	
Netherlands	-30%	
Greece	-27%	
Germany	-26%	
Sweden	-26%	
Denmark	-25%	
South Korea	-21%	
Portugal	-21%	
Japan	-18%	
Spain	-11%	
Canada	-5%	
USA	2%	
Ireland	2%	
Austria	2%	
UK	3%	
Australia	7%	
Finland	8%	
Italy	16%	
Norway	20%	

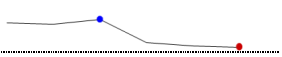
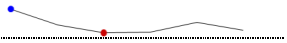
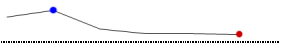
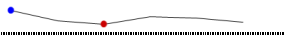
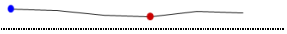
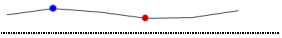
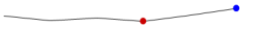
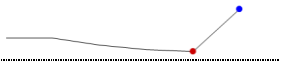
Note: Indexed by half years with 1H2007 = 1 for all but Norway, for which index begins 2H2007. Red dots represent series lows, blue dots are series highs.

Table 9
Price Indices for Residential Triple Play Plans, 2007-2009

	Total Change	
Portugal	-61%	
UK	-43%	
Norway	-28%	
Denmark	-27%	
Hungary	-22%	
Spain	-13%	
Germany	-8%	
Belgium	-3%	
Ireland	-1%	
France	0%	
Sweden	1%	
USA	1%	
Netherlands	1%	
Japan	4%	
Canada	5%	
South Korea	7%	
Austria	11%	
Italy	44%	

Note: Indexed by half years with 1H2007 = 1 , except for Hungary, Germany, Belgium, Ireland, Netherlands, Japan, and Canada, for which indices begin 2H2007, and Italy, which begins 1H2008. In addition, Italy and South Korea track prices only until 1H2009 (rather than standard year end). Red dots represents series lows, blue dots are highs. Horizontal line under Italy set at 1.

Table 10
Price Indices for Business Standalone Plans, 2007-2009

	Total Change	
Portugal	-52%	
Italy	-47%	
Spain	-46%	
Hungary	-37%	
Austria	-33%	
USA	-25%	
Belgium	-18%	
Netherlands	-8%	
France	-7%	
Germany	-6%	
Sweden	-5%	
Canada	9%	
Norway	9%	
Denmark	16%	
Japan	18%	
UK	42%	
Ireland	66%	
Australia	108%	

Note: Indexed by half years with 1H2007 = 1 for all but Germany, for which index begins 2H2007. Red dots represent series lows, blue dots are series highs. Dotted line for France interpolates missing period (2H2008).

Discussion of Price Change Comparisons

As we caution elsewhere in this paper, point estimates are estimated with some error and our analysis cannot control for all factors that affect price changes. For these reasons, the indices should be understood as indicative of general trends that can be compared across countries, but the magnitudes of the trends should be considered somewhat suspect.

This analysis attempts to construct price indices in order to meaningfully compare price levels and changes, but does not evaluate what accounts for those prices and changes and how they affect development of the broadband ecosystem. We leave those important questions to future research, but note that answering them empirically requires, ideally, a two-stage model. The first stage would incorporate factors that affect prices and price changes, such as competition and regulation.[6] The second stage would then examine the effects of prices on factors like broadband adoption, use, and investment.

These issues are not small. Consider, for example, the effects of regulation on prices and the effect of prices on adoption and investment. Few countries actively regulate retail broadband prices, but every country that mandates network unbundling necessarily regulates wholesale prices. Wholesale prices are part of an ISP's costs, meaning that wholesale price regulation can affect retail prices. Thus it may not be surprising that the biggest price decreases have occurred in the EU, where wholesale prices for full unbundled loop access fell by about 10 percent between 2007 and 2009.[7]

In the short run, consumers are better off when prices are low and falling. Some industries have been able to maintain consistent quality-adjusted price decreases for long periods of time.[8] Ultimately, though, it is difficult to determine if prices are "too high" or "too low," and both have implications for future investment and innovation. Prices that are "too high" allow firms to earn monopoly rents. Firms with market power are likely to invest and innovate less—or, at least, in different ways—than firms operating in competitive environments. Prices that are "too low" are unsustainable over time and will slow investment and innovation.

V. Conclusions and Caveats

This paper decomposes broadband prices and compares price levels and changes across OECD countries using a unique dataset of more than 25,000 residential and business broadband plans. We find that residential prices fell in many OECD countries between 2007 and 2009. In the United States, meanwhile, they have remained fairly constant. Business prices in the U.S., however, decreased by 15-25 percent during this time period. Prices for standalone broadband service in the U.S. lay at about the middle of OECD countries, while prices for triple play plans are among the most expensive.

[6] Note that this first stage should itself be composed of at least two stages in order to incorporate the effect of government policy on competition.

[7] See "Data in Excel file (3,25 MB)" for 15th Implementation Report at http://ec.europa.eu/information_society/eeurope/i2010/benchmarking/index_en.htm.

[8] Microprocessors and data storage, for example.

The dearth of good data on prices and the way we work around it with our dataset help make this paper unique. However, those factors also create problems. While we have tried to be clear about those problems and their implications, we feel it is important to reiterate them here. Perhaps the biggest problem, as discussed above, is that we do not know how many subscribers a given plan has, especially as we define a plan. Calculating representative prices and indices through time is not possible without some measure of quantity. We use the best tools and data we can to mitigate this problem, including ISP-level fixed effects in the U.S. regressions, the number of subscribers to each ISP in each time period, and the number of subscribers in each country to different speed tiers. Even so, it is almost certainly true that in some cases some broadband plans will have bigger effects on the analysis than are justified by their true subscriber numbers.

An important implication of the problem of not knowing the number of subscribers to a plan and the need to compensate for missing information is that the coefficient estimates give a false sense of precision. It may, therefore, be better to think of the results as showing the direction of change in prices and generally how those price levels and changes compare to other countries rather than as precise estimates. For example, it would be correct to interpret the analysis as finding that triple play prices in France are, in general, much cheaper than they are in the U.S.; it is less likely to be true that prices in France are exactly 84 percent cheaper than they are in the U.S.[9]

The next research steps include understanding how competition and regulation account for observed prices and price changes, and exploring the real effects of prices. What is the empirical relationship between price regulation and investment? What are the welfare implications of price discrimination in broadband? For example, triple play prices in the U.S. are, on average, among the most expensive in OECD countries, but also show the highest variance. A wide variation in prices is consistent with the price discrimination common in many industries with high fixed costs, and the impact on consumer welfare is ambiguous. We leave these and other important questions for future inquiry.

[9] Note that this is why we do not include the numerical estimates used to produce Figure 11 - Figure 13.

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