Is the Price Right?

The CPI for Internet Access.

A Report for the Bureau of Economic Analysis.

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Executive Summary

The official price index for Internet access started in late 1997. This report explains the procedures for the official Internet access index in the CPI. It also catalogues and explains the most obvious criticisms of these procedures. It assesses criticism in light of practical considerations. It ends with several recommendations about how to improve the construction of the index.

This study concludes that the price index accomplishes what it sets out to do. It accurately reflects changes to the prices at which users transact for Internet access.

The study also concludes that the official index does not measure the change in cost of living from the Internet revolution, as commonly understood and experienced by millions of Americans. That is, it does not measure the change in the cost of living arising from the growth of the use of the web over the last decade, nor the economic change in user experience from the rapid infusion of email/browsing into everyday life. Not trivially, the price index does not try to do this, nor could it do so if it BLS wanted to.

The study also concludes that the official index presently does not, but could, reflect the increase in quality from changes in Internet access. This is a serious deficiency and important to remedy. Not accounting for qualitative change results in an index that over-estimates the rate of inflation. As done in other high tech market, several pro-active steps by the BLS could partially remedy this deficiency.

The study also concludes that many such steps are feasible. This report's recommendations focus on taking steps towards reaching this modest goal.

I. Introduction

The Internet commercialized in 1992, fueling a high tech boom from 1995 to 2001. The commercial model for providing Internet access combined approaches from two previous activities. Prior to commercialization there was a model for delivering free Internet access at research universities. There was also a model for charging access to servers in the bulletin board industry. [2] The firms who provided Internet access for a fee became known as Internet Service Providers, or ISPs for short.

Commercial ISPs began to enter in large numbers in 1995. The industry began to become noticeably large after that. At about the same time, the browser began to diffuse. Netscape had its IPO in August, 1995, an event commonly credited with fueling new venture formation in dot-coms and demand for ISP services. Over the next half decade many users adopted the Internet who had never used it.

The official price index for Internet access in the CPI started in late 1997. In 1998 the access market was a 10.8 billion dollar industry, with roughly half that revenue coming from access fees.[3] Table 1 contains a summary for Internet access in the United States.[4] This study focuses on assessing this table.

The price of Internet access attracts interest for two reasons. First, the industry is young, exciting and dynamic, but the value of the Internet is unknown. The access price is one place where most users give up money in exchange for free Internet services. The

[2] It is possible to find advertisements for commercial Internet access in Boardwatch magazine as early as 1993-94, with references to them starting even earlier than that. PSINet, a now bankrupt commercial provider, claims to have offered commercial service as early as 1991. See Stranger and Greenstein, 2002, or Greenstein, 2001, for summary of the developments in this industry.

[3] See revenue for NAICS 514191. See the 2001 statistical abstract, table no 1151, Census Bureau. This lists revenue of $10,882 million for 1998 and $18,025 for 1999, with access fees accounting for $5,499 and $8,979 respectively. These revenue estimates are based on the 1999 Service Annual Survey, Information Sector Services.

[4] This is "computer information processing services" at http://data.bls.gov, or see "On-line information services," NAICS 514191.

typical household spends more than three quarters of the time on line at free or advertising supported sites.[5] Other than through access fees, there is little data from which to infer user's valuation of these sites. This component of the web – that is, access fees – also produced the highest fraction of total market value in the first decade of the commercial Internet. Though subscription based services are growing, the revenues spent on access fees swamp subscription services in magnitude. Fees for access also exceed revenue for advertising on line.[6]

Table 1. US Internet access price index.[7]

YEAR	12/1997	12/1998	12/1999	12/2000	12/2001	11/2002
INDEX	100	103.3	96.0	95.7	100.3	99.9

Next, the price index elicits interest because it defies common sense, at least on the surface. It declines little in five years. This is not the price movement usually associated with the diffusion of a revolutionary technology. More to the point, this index seems almost unrelated to the improved experience of virtually every online surfer. So it opens US statistical agencies to criticisms that they are failing to measure the change in the cost of living arising from the development of the Internet.

This report assesses this index. First, it explains the logic behind the procedures that

[5] Goldfarb, 2002, contains click stream data verifying this trend in detail across many categories of uses. It is also commonly verified by observers web use, such as Media Matrix. Also see O'Donnell for an estimate of the relative magnitude of the value chain behind access and advertising on the Internet.
[6] According to NAICS revenue for 514191 and 514199, access fees exceed advertising by three or four times. For example, total advertising for 1999 was 1,355 + 1,477 = 2,832, as compared with 8,979 under NAICS 514191 alone. See the 2001 statistical abstract, table no 1151, Census Bureau.
[7] This is the monthly price quote, as indicated, under "computer information processing services." See http://data.bls.gov/.

produce the official index for the CPI.[8] It then catalogues and explains the most obvious criticisms of these procedures. Finally, it assesses criticism in light of practical considerations. It ends with several recommendations about how to improve this construction of the index.

This study concludes that the price index accomplishes what it sets out to do. It accurately reflects changes to the prices at which users transact for Internet access.

At the same time, the official CPI index does not measure what most economists and journalists want it to measure (or incorrectly believe it measures). That is, the official index does not measure the change in cost of living arising from the Internet revolution, as commonly understood and experienced by millions of Americans. That is, it does not measure the change in the cost of living arising from the growth of the use of the web over the last decade, nor the economic change in user experience from the rapid infusion of email/browsing into everyday life. There is good reason to think that the official price index does not even come close to accomplishing that goal. Not trivially, the study concludes that no price index could possibly accomplish that goal. This will be explained below.

The study does focus on a more modest, but feasible, direction for improvement. The official index could, but does not, reflect the increase in quality from changes in Internet access. Accounting for qualitative improvement would be a worthwhile improvement for the price index. Not accounting for qualitative change results in an index that over-estimates the rate of inflation.

Accordingly, this report's recommendations focus on taking steps towards reaching this

[8] The report does not address issues affiliated with assembling the PPI. The goals and procedures of the two indices are too distinct. Many of the same issues will arise in both indices, to be sure, but no attempt is made here to identify which will arise and which will not.

modest and feasible goal. Several pro-active steps by the BLS could partially remedy this issue. The report recommends that the official price index account for qualitative change, such as changes in the speed, reliability and availability of Internet access. This report also recommends that the BLS alter the name for the price index and post a proper explanation for it. It also identifies several ways in which historical indices have failed to account for quality and recommends modest changes to the historical price indices for Internet access.

The report first provides an overview of price index construction. It then catalogues and assess five different sources of concern about unmeasured quality. Each of these is discussed. Practical remedies are put forward when feasible.

II. Overview of price indices

As with other official statistics, the official Internet access index is based on a sample of price quotes, collected regularly from suppliers. The BLS staff then compiles the official price index from these quotes, weighing quotes based on a sample of household expenditure. These expenditure estimates come from lagged surveys of households.

As with many price indices in the official statistics, the price index for Internet access is a *transactional* index. It records the price at which users and vendors transact. To say it another way, the only data that enter the index are those that arose in actual transactions. By definition, the index is not shaped by hypothetical transactions that might have taken place, but did not. It is also not influenced by non-exclusionary goods for which there is no market (i.e., the quality of expression in use-net groups), nor any service that transacts at zero price (i.e., deliberate give-away schemes by some dot-coms trying to generate

publicity).

As with most price indices in the CPI, the official price index for Internet access is not a *utility-based* index. A transactional index is distinct from a *utility-based* index. A utility-based index attempts to compute the price change equivalent to the change in satisfaction over time to users. User satisfaction changes if there are changes in prices, but also if there are changes to quality of services, availability and other non-price dimensions of service. Note that such an index is necessarily shaped by hypothetical transactions that might have taken place, but did not. By definition, a utility-based index must make use of data and theory that does not influence a transaction index. It also may be shaped by the availability of free goods and non-exclusionary features of goods to the extent that their changing availability alters user satisfaction.

A transactional index and a utility-based index provide different insights about markets experiencing technical change. For example, these provide different insight in markets where nominal prices do not change much, but quality improves (i.e., caching and mirror sites lead to faster downloading, but users pay nothing for it). This type of developments certainly occurred in the market for Internet access since 1995. These two indices also provide different insights in markets in which publicly funded R&D leads to widely adopted technical inventions (i.e., the invention and refinement of html), which are, in turn, experienced by many users. These type of developments also occurred in the Internet. There is a well known and relatively mature academic literature developing these points.[9]

Consensus on this topic ends there. There are both disagreements about theory and

[9] For review of literature on price indices, see National Research Council, 2002, Hausman 2002. For a review in the context of IT, see Bresnahan and Greenstein, 2001.

about bringing theory into practice. To put it bluntly, there exists no routine agreement about the practical steps to go from a transactional index to a utility-based index.[10]

In the vacuum created by the absence of practical steps, a third approach emerged over the last two decades, inspired by hedonic price research. The BLS has begun adopting a program of calculating *quality-adjusted* indices in some select markets that experience rapid technical change, such as semi-conductors and personal computers. These indices usually employ a variant on hedonic methodology. That is, these price indices estimate price changes, controlling for the changing quality of product features. These quality-adjusted indices are thought to be better than transactional indices, because they adjust for qualitative change in a systematic way, not an *ad hoc* way. These indices are also thought to fall short of the ideal utility-based index.

To a student of this literature, the price index for Internet access appears ripe for either a quality adjusted index or a utility based index. There is plenty of casual evidence of qualitative change since 1995, not to mention the introduction of new goods. Moreover, there is plenty of evidence that this change was widespread. Non-price dimensions of Internet access have generally improved for most users after the commercialization of the Internet. Moreover, a substantial part of that improvement occurred during the latter part of the nineties, as the Internet diffused to households in the US. By 2001 over half the households purchased access to the Internet from commercial firms and few observers attributed this diffusion to declines in price after 1995 (since, in fact, nominal prices did not decline much). The potential for mismeasurement also became larger, as the Internet access industry became roughly a twenty billion dollar industry, with half of it going to

[10] See e.g., the Boskin et al, 1996, National Research Council, 2002, Fisher and Griliches, 1995, Hausman, 2002, Pakes, 2002, and many others.

access fees (see NAICS 514191 for 2001).[11]

In this study I will classify why quality adjustment could alter the official index. To be sure, utility based indices also would alter the official index. But for practical reasons, I will generally focus on quality adjustments. These are simpler to address. Also, they have the virtue of feasibility, which is not so for the utility-based index. Finally, it is possible to be reasonably prescient about the direction of qualitative change on the Internet in the next decade, so it is sensible to believe that there are high returns from a few pro-active actions by BLS.

III. The official index does what it sets out to do.

The official price index for Internet access accurately does what it sets out to do. It is constructed like many other prices for services and, as such, does not stand out as procedurally unique. So why might problems arise? Stated briefly, events in the commercial environment might fall outside the situations anticipated by standard procedures, giving rise to unintended errors. As will be developed below, this observation will grow into (the familiar) motivation for using quality-adjustment methods.

Here is a description of the official index. The index has two basic components: A component for new users (who may have to pay hook-up charges), and a component for continuing users. The latter is split into prices at either a monthly or yearly level. These components are then added together to generate an official index, using quotes from a multitude of firms. The quotes are not weighed evenly. Weights are determined by

[11] To be sure, this exaggerates the importance of the Internet to households. The revenue for GSDP includes fees from business users and household users. The CPI is only concerned with household users as consumers. That said, the prices for access to business and households is influenced by many of the same forces.

expenditure. The last expenditure survey was in 1999. For earlier years, the index used expenditures from 1995.

In recent years a huge weight goes to America Online's prices, which comprise a high fraction of continuing dial-up households in the US. In the past few years, when the service was growing rapidly, new users at AOL also comprised a high fraction of the first component.

As an aside, it is worth noting that AOL's prices have not declined much in a quite a few years. Thus, an official consumer price index cannot decline much, if at all. Their standard prices actually rose last year (i.e., from $21 to 23), which is why the index rises too.[12] In other words, the official price index in Table 1 follow a quite plausible path, as it reflects the stability of prices at a dominant vendor for many households.

As well broadband plays a small role in this index. These components also include prices for (cable & DSL) broad-band users. However, such prices have not have played much of a role in the official index up until, because broadband was quite young in the expenditure survey from 1999. Less than a few million households used broadband service then. Nobody expects this small role to continue in the future, as roll-out of broadband continues, and expenditure by households for broadband rises. Hence, the next expenditure survey is likely to reflect the increased diffusion of broadband to households. I will say more about this below.

IV. Accounting for qualitative change

How do unintended errors arise? It is incorrect to say that the official index does not

[12] The monthly index does dip considerably in the summer of 1999, after AOL offers price drops to CompuServe users (in an effort to get them to shift services after the two companies merged).

account for qualitative change. In fact, the official price index does account for *some* dimensions of quality. It is more accurate to say that the official index accounts for a couple dimensions of quality and does not account many others. As with any index in high technology markets, the extent of the error depends on changes in the commercial environment.

This study delineates different types of errors. It divides the discussion into six categories:

- Changes in speed.
- Changes in availability.
- Accounting for quality in contract features.
- Reliability and other non-price dimensions of use.
- Network effects.
- Other features of user experience.

Under each heading this paper will identify the source of problems. Then it will discuss the most practical step and low cost approach resolving problems. The ultimate goal is to introduce quality adjustment into price index construction.

V. Accounting for speed.

If we know one thing about user experience, we know that the quality of a users' experience improves as the speed of the connection increases.[13] Yet, the official index does not entirely account for speed. The key here is *entirely*. To be fair, the BLS does maintain separate accounts for the prices of cable and DSL (from such firms, as @home,

[13] This is also apparent from vendor behavior. Investment in equipment to increase the speed of delivery is a central concern for most ISPs. See Augereau and Greenstein, 2001, for one such study.

or Roadrunner[14]) and dial-up access, aggregating them by expenditure weights into the official index. The biggest issues will resolve around the *linking* of past prices for dial-up to new prices for broad-band in a way that adjusts for quality.

V.1 Problem identification

Four distinct issues arise in the linking of broadband with dial-up. These issues all arise from the same forecast. So let us start there. Virtually every observer in this market forecasts that the 60+ million households in the US who access the Internet today will consider adopting broadband technologies sometime over the next decade. Of those, the vast majority are still dial-up users today, so the use of broadband will *substitute* for dial-up service.[15] In other words, while the diffusion of broad will generate some modest increases in new users of the Internet at home, the vast majority of future broadband users will be former dial-up users. The majority of growth in this service will come from "switchers."

Said generally, there will competition between a lower-priced lower quality good and a higher-priced higher quality good. The latter is anywhere from two to three times as expensive for continuing use (i.e., not accounting for set-up expenses), and anywhere from five to thirty times better, depending on the engineering measurement used. Users will increasingly substitute into the latter as it becomes available, as it becomes more reliable, as it becomes easier to install, as its price declines, as users gain information about its availability and capabilities, and as users become more sophisticated, learning to take advantage of speed. Nobody doubts that such switching will take place over the next

[14] AT&T's ISP, @home, has declared bankruptcy. AT&T has announced the sale of its cable systems to Comcast. Roadrunner is the internet service of Time-Warner's division.
[15] FCC report on broadband, 2001.

decade and in large numbers. There is only a debate about how fast it will happen.

There is long experience with this type of situation in pharmaceuticals, semi-conductors and in personal computers. Transactional indices will show no decline in price, even as most households switch.

The typical switch illustrates the central issues. What happens when a household switches? It goes from paying $10 (e.g., a cheap Juno account) or $25 a month (E.g., a premium AOL account) to paying somewhere between $40 (for Cable) or $70 (DSL) a month, depending on what is available to them and how fast prices have come down (especially for DSL recently). The BLS will survey the cable service and DSL service providers to learn their transaction prices each month, so the BLS will immediately learn that prices have not declined much, if at all. The BLS does not immediately see the increase in expenditure because the expenditure surveys are performed with a lag, so expenditure weights do not change (at least not right away). Hence, if transaction prices do not decline, the official price index will not decline.

Why is this problematic? To continue with the example, at the end of the year, two vendors will make their reports for GDP purposes. The dial-up vendor will report a loss in revenue and the broadband vendor will report an increase. On net, this will lead to an increase in nominal revenue for access fees in NAICS 514191. Since the price index shows no increase in prices, it will appear as if real GDP increased by the amount of increase in revenue. But this is biased downward from the true experience of users, particularly when the broadband prices recently came down in price. There will be no increase in GDP reflecting the increase in quality of service experienced by the switcher. Said another way, there is no decrease in the price index for services, because it does not

reflect the increase in quality and for which the user paid.

There is a well-known general lesson that applies here: As long as the quality between two substitutes goes unmeasured, the price index underestimates the benefit to users from switching – in this case, from dial-up to broadband. This is a situation where either quality-adjusted index or utility-based index will give a much different insight about the rate of improvement arises from the diffusion of new technology.

There are four distinct issues in this situation.

First, the weighing is necessarily based on lagged expenditure surveys. Broadband is diffusing now and will be diffusing for a few years, so expenditure weights will almost certainly be too small for contemporary broadband. If prices begin to decline in broadband, then this movement will be given too little weight.

Second, and distinct, the price for broad band includes no quality adjustment. The linking of the broadband price and dial-up price does not reflect the qualitative improvement of broadband over dial-up. It is as if every dollar spend on broadband yields the same return as every dollar spent on dial-up, when, in fact, users got more for their dollar when their bought broadband. This leads to an underestimate of the price decline over time, when many households switch between the services.

There is a third and distinct issue related to speed, but worth bringing up in the context of this discussion. All Internet access has gotten faster over time. The most popular sites, such as web portals and e-retailing sites, have invested significantly to increase their own speed. For example, popular sites are much better at caching their material and using geographically dispersed mirror sites. In addition, hosting facilities have improved in performance. Related, backbone capacity across the country has also grown large, so that

a data packet is less likely to be slowed, cueing at a public exchange point. The feasibility of moving larger files has induced popular sites, such as Yahoo!, MSN, AOL, and many others, to use more complex images. In other words, Web pages appear and refresh faster for users – whether dial-up or broadband.

Fourth, and also related to speed, over the latter half of the nineties faster modems diffused to ISP and users. Today 56K modems are the default, having almost completely replaced 28K modems, which were the norm in 1997, when the index began. Again, in the latter part of the 1990s web pages appeared and refreshed faster for dial-up users.

V.2. Solutions and recommendations

What are practical solutions to these issues?

The first problem – weighing broadband -- has an obvious solution: more frequent update of expenditure to update the shifting composition of purchases into broadband and away from dial-up. This is also expensive, so a practical solution would involve very limited periodic resampling to establish these changes. Fortunately, it does not need to cost much. The regular sample in the CPS supplemental survey about computer use would be sufficient for providing guidance about how the relative market shares are shifting among different access modes. It already asks respondents about the type of hooks up used for the Internet (i.e., dial-up, cable, DSL).[16] While there is not a direct correspondence between type of mode and expenditure weights (since modes vary in their prices), it will be possible to check whether the BLS sample reflects the same modal choices made in the country. Periodic checking against these surveys should be sufficient

[16] See NTIA 2001, or for the precise questions and survey results see CPS supplemental web page at http://www.bls.census.gov/cps/computer/sdata.htm.

for updating expenditure weights in between survey years.

The second issue requires a pro-active stance by the BLS. BLS should attempt to completely survey all substitutes, bringing all forms or access into this price index, including fixed wireless. As for broadband in particular, BLS should bring broadband internet access (from AT&T/Comcast or AOL/Roadrunner) into its price tables at a discount from dial-up. That said, the hard question involves picking the level of discount. Cable modems and DSL are generally regarded as at least twenty times faster than dial-up modems at peak performance levels. Average performance level varies considerably, however, so there is no simple engineering number to use. Since there is more to user satisfaction than just the size of the pipe, there also is not an industry norm for how data-flow rates translates directly into user perception about performance (O'Donnell et al, 2001). I recommend a conservative approach. A conservative estimate would bring broadband into the price index at four to eight times the quality of dial-up.[17] The BLS also has sufficient price and engineering data about peak performance to do a simple hedonic estimate, if that method is preferred.[18]

The third issue – secular trends in speed across all uses -- simply goes unmeasured in present procedures. Unfortunately, engineering metrics for measuring performance are still in their infancy, and lack industry consensus. That is, there is no exact science for measuring the quality of service in Internet access, nor any generally accepted norm among vendors for grading quality, so this problem probably has no practical remedy in

[17] I figure this with the following back-of-the-envelope hedonic: Any non-AOL user can obtain dial-up Internet access for $10 from Juno, Cable for $40 and DSL for $70. The latter two are 4 to 7 times more expensive and (approximately) 15 to 25 times faster (if conservative) or 20 to 30 times faster (if optimistic). Hence, the quality improvement is somewhere between 4 to 8 times more valuable.

[18] The simplest hedonic would regress monthly price on a constant and speed from a cross section of data in one month. This would give a coefficient that could be interpreted as market price for speed. This would provide a yardstick for how to much to deflate the price of broadband services in comparison to dial-up.

the near term.[19]

The fourth issue – the adoption of 56K modems – is largely over, so it is only of historical significance. The Stranger and Greenstein, 2002, paper discusses an adjustment procedure for this adoption in the context of hedonic estimation for dial-up services. Adopting this index in historical statistics could provide one solution.

VI. Changes in availability.

Internet access is a geographically local and non-tradable service. As a dial-up service, it is cheaper if it is part of a local phone call. If it is broadband service, it is simply not available unless a local supplier has invested in the necessary infrastructure to bring delivery to a home. Either a cable internet provider or DSL provider has to make the necessary investment in infrastructure.

Ten years ago there was no commercial internet market. Then suppliers entered and offered service. By 1998 all but a small part of the US population had access to commercial firms (Downes and Greenstein, 2002).

Five years ago most urban dwellers had no broadband option. Today many have access to at least one high-speed possibility, cable or DSL. Seven to eight million take advantage of that now and more will in the future. Estimates about availability today differ. All observers agree that there always will be limits to supply for the on-going future, particularly in low density areas.[20]

[19] See the paper by O'Donnell et al, 2001, about quality of service. Or read subjective assessment of vendor quality in ISP-Planet.com.

[20] DSL is an urban technology today. With today's repeater technology it cannot provide service to users more than 1500 feet from the central switch. In rural areas *and* in many suburban areas this makes the technology infeasible to deploy. Hence, it is estimated that one quarter to one third of US consumers cannot

Changes in availability do not influence the official price index for internet access. However, it should shape quality adjusted indices and utility based indices.

VI.1 Problem identification

The problem is best illustrated, again, by a "typical switcher". In many areas of the country broadband access was neither available, nor reliable, until recently. In many places, it still is not available, nor reliable. What happens after it becomes available? Consider what happens when the household learns about the service and switches. As noted earlier, the typical switcher increases expenditure and the price index records no change in official prices.

In addition to the issues already noted with quality, this event is problematic because the observed transaction takes place against a backdrop of an unobserved transaction. In the past broadband service was not available for purchase by the household. In other words, the household could not even consider (and potentially refuse) to purchase broadband at a higher price than the one at which the household actually transacted.

This is a mature topic in economics of price indices for new goods. There is consensus about how to characterize the problem. Increasing availability ought to be thought of as the lowering of price from an extremely high level to a lower one (Fisher and Griliches, 1995). The price index should record a decline in price, but it does not. More precisely, a transactional index does not record anything. It only records the price for actual transactions, which are unchanged. Recorded transaction prices do not reflect the

receive this service. Of those it can reach, there are other factors that influence its costs, such as the quality of the lines. Cable modem deployment is limited by other constraints. It is only available where cable systems go. Only 90% of the US has access to cable systems. Most of these users are not rural. Of those reached, many of those systems require costly upgrade before Internet service is a viable business. See, e.g., FCC, 2001, or USDA, 2001.

increased supply of the local service at a lower price. Hence, the price index does not decline as much as the improvement users experience from increased availability.

This problem arises in the official Internet access index in two ways. First historically, there is no accounting for availability. The official index starts in 1997. The increasing availability prior to 1997 went entirely unrecorded. This is clearly a big omission, though probably not a remediable one.

Second, going forward, changes in availability shape the price recorded for broadband. In many areas, broadband is just now becoming available. This build-out is costly and will continue into the next decade.

VI.2. Solutions and recommendations

This problem is not solvable in the short run.

This problem requires estimation of a *virtual price*. That is, a utility-based price index should record that the price declined from a hypothetical reservation price to the transactional prices (actually observed). Most experts on price research would buy into this argument. There is not consensus, however, about how to implement this in either a utility-based price or a quality adjusted price index. The principal problem arises from consumer heterogeneity. Because different consumers have different virtual prices, it is unclear how to make a simple adjustment to price indices for changes in availability (Fisher and Griliches, 1995).

In addition, and not trivially, there is no consensus on how to precisely estimate the availability of broadband across the US. This is surprising, since there are good estimates

of adoption at both BLS and the FCC.[21]

This is clearly an important issue in this market. The potential mis-estimation from this factor could be quite large. It deserves further attention.

BLS could take a partial step towards addressing this issue during its next expenditure survey. It could add a question about the availability of broadband. The CPS supplemental survey about computer use is the appropriate vehicle for such a question. It already asks users about the mode of access and it asks non-users why they choose not to use the Internet. It would not be difficult to ask why non-broadband users why they do not use broadband, giving them the option to designate "no supplier in neighborhood." This would help suggest how severe the bias is. This is also interesting since there is also a large (somewhat independent) public policy interest in knowing whether consumers have none, one or two options available to them.

VII. Accounting for quality in contract features

The official price index for Internet access *does* account for differences between set-up expenses and continuing expenses. It also *does* account for the biggest differences between lengths of contract commitment by users, a month and a year.[22]

VII.1 Problem identification

What dimensions of quality does it not account for? To benchmark the discussion, let us begin with research on ISP prices. The official index is close to the research studies of

[21] See CPS Supplement at http://www.bls.census.gov/cps/computer/sdata.htm, and FCC, 2001.
[22] Third, it *does* implicitly assume that unlimited monthly or yearly contracts are the norm, eschewing collecting prices using a price-per-hour pricing norm.

Stranger and Greenstein, 2002, Greenstein, 2000a, and Prud'homme and Yu, 1999.[23] The official index differs from these research studies, however, because all research studies account for the effect of hourly limitations on prices. Such limitations are perceived by users as a reduction in quality and, accordingly, generate price discounts from unlimited prices. Such limitations play no role in the official index.

Could this omission give rise to a large bias in the official index? It will give rise to bias in two circumstances, one having to do with historical statistics and one having to do with contemporary statistics in urban/rural comparisons.

First, the absence of hourly limitations biases one's historical view. Hourly limitations were a common element of contracts early in the industry (1995-98) and only began to diminish in importance in the latter part of the nineties.

How big is this potential bias? I speculate that it is probably not too large. AOL did not give such discounts after it adopted unlimited service as its norm in late 1996. Accordingly, this feature cannot influence a large fraction of the prices in the official index. The smaller ISPs more frequently used these features, but they are a small fraction of total market share. Even at their smallest, the top ten ISPs in the US comprise more than 75% of market share after 1997.[24] For example, the largest firm prominently using restrictions today, Netzero, only provides service to several million households.[25]

Moreover, accounting for hourly limitations would probably not make much of a

[23] The latter constructs price indices using price per hour, while the former uses monthly unlimited contracts as the benchmark.
[24] This would include firms such as AOL, CompuServe (who merged with AOL), Earthlink, Mindspring (who merged with Earlthlink), AT&T Worldnet, IBM (whose on-line operations merged with AT&T's), Juno (who merged with Netzero), and so on.
[25] Netzero began initially as a "free" ISP, selling dial-up access in exchange for advertising. It found that a small fraction of its users were extremely expensive due to high monthly usage. To eliminate these costly users, Netzero adopted a policy of 40 hours maximum per month. After management later concluded that the advertising model was unprofitable, the firm decided to start charging $9.95 for this restricted service. It also charges more for a "premium" unlimited service.

difference. The Stranger and Greenstein [2001] research estimated only a modest decline in prices once the hourly limitations are controlled for (i.e., 12% decline between 1996 and 1999, after a huge drop in 1995 that is mostly attributed to explosive entry). So this feature of quality appears to be important for historical purposes, but not the source of any egregious bias today.

Looking forward, does the absence of controls for hourly limitations bias this indices beyond 2002? In general, probably not, since this contract provision is much less common today.[26] That said, there is one situation where an important exception arises.

The one exception arises in comparing urban and rural prices. Limited contracts play a larger role for ISPs in rural locations, even today, because capacity constraints continue to plague service in low-density areas. This is not a trivial public policy matter, since close to 15% of the US population lives in such areas.

What is the source of the problem? In short, rural provision is largely under-sampled in official statistics, since the index is constructed off surveys from users in cities. Over-sampling of cities is not a big problem for an index of time-series changes if urban and rural ISPs follow similar trends over time. This was probably true for the latter part of the nineties. The two types of regions probably followed similar trends since both types of areas were largely supplied by commercial dial-up firms (Downes and Greenstein, 2001).

As broadband access diffuses over the next decade, however, the price trends could diverge. Both DSL and cable modem will not diffuse to low-density areas at low cost, so these are unlikely to diffuse on a mass market level. Low density areas will not receive high-bandwidth provision in the next decade until the price of fix-wireless options

[26] Even a casual perusal of Boardwatch directory will show how rare these types of contracts have become. See Stranger and Greenstein, 2002, for a summary of the trends between 1995 and 1999.

declines. The trends in prices, contracting, and quality of the two areas will likely diverge as a result. In other words, it is possible that the sampling of cities will sharply misrepresent the trends in low-density locations throughout the US.

VII.2. Solutions and recommendations

What are practical solutions to these issues?

For historical statistics, the US could simply adopt the Stranger and Greenstein, 2002, estimates of commercial internet access. Hourly limitations play a role in those estimates. Adopting these estimates brings hourly limitations into official statistics prior to late 1998, when these contractual features were substantially more important.

For urban/rural differences, there is no simple answer short of sampling rural areas periodically. This is potentially costly, but worthy of study due to the public policy interest.[27] I am unsure how practical this would be.

VIII. Reliability and other non-price dimensions of use.

The official Internet access index also does not record many other improvements in quality. Some of these are complementary to increases in speed, but many of them are unrelated and independent.

For example, without a doubt, AOL over the last five years has gotten better. It has become easier to use, better at sorting mail, and more reliable**.** Users can do all sorts of things with Instant Messaging, streaming music, digital pictures, and so on. AOL has also reduced the probability of busy signals when using dial-up access.

[27] See NTIA, 2001.

Moreover, every other Internet service provider has also gotten better over time and in much the same dimensions. Many ISPs charge nothing extra for fewer busy signals, better links with new services, customer service after hours and other benefits, whether it is Joe Schmo's ISP or Earthlink. In other words, competitive forces have improved the quality of service across most suppliers.

Related, many ISPs provide their users with filters and tools to reduce undesirable features of the web. For many Web users, the drop in online advertising last year was an improvement in the quality of the Internet experience. Most people find advertising and spamming annoying. Most everyone cannot stand Web sites that induce another browser window to display the latest in digital cameras. Nor do most users like receiving large amounts of advertising in their mailboxes. Accordingly, many ISPs provide their users with filters against spam, unwanted advertising and other unwanted features.

VIII.1. Problem identification

As a young market, the Internet access business does not have a well-defined and constant set of features. ISPs alter their services when they believe it can yield competitive benefit from differentiation (Greenstein, 2000b). These changes might improve revenue and, as such, go into GDP. Often these changes are induced by the competitive process, as rivals match each other, and have no consequence for prices.

Changes in the scope of services do not shape the deflator for revenue for ISPs. The BLS does not alter its price index to measure changes in the boundary of services. The official price index is just about access. In other words, qualitative improvement or degradation goes unrecorded, though it is relevant to GDP.

More precisely, there are two issues underneath this issue. First, new capabilities go unrecorded for mundane reasons. For example, many users can make additional purchases from their ISP. It's now cheaper to get extra e-mail accounts, additional space for saving pictures, and other optional services, such as Intstant Messaging.

Related, some ISPs are now purchasing third party services to enhance their offerings. For example, the search engine, *Google,* sells modules for searching networks to any buyer. ISPs and their opening pages can rent these modules for their opening pages and improve their services. Again, this plays no role in the evaluation of quality at ISPs.

Second, new capabilities escape notice because nobody has responsibility for watching them. The official title for the official internet access price index illustrates the problem. The official title is "Computer information processing services." This gives the appearance that more than access falls into this category. In fact, the staff at BLS is quite clear that this index is only about "access " -- not services that are complementary in supply and demand, such as activities related to directory linking, email and web search. Hence, though the 1997 NAICS update was recent, this industry has evolved since then. It is possible for everyone to correctly do their jobs, and, yet, it is possible for nobody to have responsibility for tracking changes in the boundary of firms.

Of course, this latter problem is not unique to the price index for Internet access. It is shared by virtually any industry where the firms change the scope of their services frequently. As such, most of the industries related to the Internet are vulnerable to this problem. The good news is that the most recent NAICS update was recent, so misclassification issues are largely confined to events that arose since then.

VIII.2. Solutions and recommendations

The right question is: What sort of price decline is equivalent to the improvement in quality from, more default e-mail accounts, better directories of useful links, fewer ads or less spam? That is, how much should prices adjust for these improvements in the quality of experience for most users?

In principle, there is a way to answer this question. A hedonic estimation technique would estimate the value of these features by comparing the price of those who offer these services with those who do not. Then prices could be "adjusted" for the inclusion and exclusion of these features.

Unfortunately, so far no researcher has successfully figured out a way to do this.[28] Hence, for now, I do not have a recommendation for how to treat this issue broadly.

One modest recommendation is easy to make, however. The title for the official access index should change. "Computer information processing services" is not very descriptive. It should be relabeled as "Internet access." This should be part of a broad effort to direct attention to other areas in which NAICS classification is incomplete for Internet services.

IX. Network effects.

The official index does not account for the changing composition of the community of online surfers. This is a big issue for the construction of utility-based indices. It could be a big issue for the construction of quality-adjusted indices as well, since the composition of the community of users influences the quality of each user's online experience.

[28] Greenstein, 2000a, compared prices from thousands of ISPs in 1998. He found that prices were sensitive to contracting terms (i.e., length of contract or hourly restrictions), but did not find that they were sensitive to any other feature of the ISP.

Unfortunately, this problem can be defined on only the vaguest theoretical level, and has no practical solution. This section outlines why.

IX.1. Problem identification

In theory, network effects for Internet access could be either positive or negative. A positive network effect is one in which the addition of new users raises the quality of the experience for the entire community of users. A negative network effect is one in which the addition of new users lowers the quality of the experience for the entire community.

Positive network effects are clearly present in specific applications. They matter in popular on-line activities supported by some access providers, such as Instant Messaging, Gnutella, gaming and some use-net communities (e.g., Physicians on-line). Here is an example of a change in a positive network effect. Though I am a long-time online user, the growth of the mass market dramatically improved the quality of my experience. Specifically, my welfare improved three years ago when my parents, aunts, and uncles finally got online. Sending them online baby pictures is a real thrill for us all.

More generally, the diffusion of common standards and protocols for communications usually embed positive network effects since it aids communication. For example, the standardization of the URL, TCP/IP and Instant Messaging aids communication, and that, in turn, helps the number of participants grow. The diffusion of html and the world-wide-web had similar consequences. The standardization of XML and other e-commerce protocols holds the potential for similar gains.

Negative network effects are also present in specific applications. Here is an example of a negative network effect. Large scale use of network produces congestion, slowing

delivery of data, particularly on cable broadband systems. Related, cross-country e-mail travels more slowly at mid-day than at mid-night because the network server capacity goes underutilized at night. Again, congestion related to time-of-day use of bottleneck facilities (i.e., data exchange points) reduces the quality of experience for everyone.

In summary, network effects should play a large role in the understanding of the everyday experience of most email users and most web surfers. As such, these effects should have to play an important role in the measurement of changes to that experience. I conclude that a utility based index of on-line satisfaction over the last decade would need to account for such network effects.

IX.2. Solutions and recommendations

No researcher has begun to find an appropriate way to measure network effects. There are two fundamental barriers to progress. First, this effect is quite hard to identify in any standard statistical exercise. For example, in the standard hedonic framework, network effects would completely coincident with other time trends in quality and prices.

Second, it is hard to measure the *change* over time. Moreover, even if one could measure changes, since every user experiences a difference amount of positive and negative network benefit, it is not obvious how to aggregate across experience. Though most observers would bet that the positive outweigh the negatives for most users, this is speculation. It is completely unmeasured by any researcher.

I conclude that the measurement of these effects is in its infancy. There no consensus about the necessary theory, measurement technique and data for measuring network effects for purposes of constructing quality-adjusted or utility-based indices. It is

unrealistic to expect the BLS to estimate a price index for Inter access that …

X. Other features of user experience closely related to access.

The internet runs on top of a complex system of inter-connected web sites, mirror sites, hosted facilities and data exchange points, along with millions of web pages. This infrastructure supports an enormous economic web of activity (see O'Donnell, 2002). To most users, the mechanics of this system is invisible. Since 1995 this system has improved dramatically. To most users, that improvement is apparent in every day experience. Such improvement is expected in the future as well.

Most users surf, go on-line to seek information, conduct business or receive services.[29] The plain fact is this: all these activities are easier today than five years ago. There are many more Web pages. The portals are much easier. Email arrives sooner. All that improvement is not part of the price index, though it is a part of every user's experience when they use Internet access services. Moreover, many of these services come at no cost to the typical user. For users who pay no money for the Internet except at the point of Internet access, one could reasonably infer that users are getting more for their money.

The list of unrecorded improvement goes on and on. Most users pay nothing extra for any of these improvements. Many would pay for them if they had to.[30]

[29] Standard surveys on household on-line use reveal such facts as: the average dial-up household spends less than 30 hours on-line a month. Nearly a third of this time is spent at portals, such as Yahoo!, MSN, Google, and so on, with over half the time on-line spent on information intensive activities. The remainder is usually devoted to retailing, services, government or other transactions.

[30] This is not an observation that all such improvement goes unmeasured. Arguably, users *do pay* for some of these features at electronic commerce sites when the vendors internalize some private benefits to attracting greater sales. These sales do become a part of GDP.

X.1. Problem identification

There are two issues. One has to do with the estimate of utility-based indices, the other with classification of services.

A utility-based index would seek to estimate the value to users from the use of new technology, such as the Internet. The most natural place to estimate the value of the Internet is at the demand for access, because Internet access is the one expense that virtually all users incur. This is the one place where research might be able to estimate the value generated from the Internet's creation.

Yet, proper estimation would have to include changes in quality in the typical user experience, including changes in the quality of all the free services and advertising-supported services. It would also have to account for the technical improvements brought about through the diffusion of new inventions in use. Though the majority of web-surfing is relegated to only a few thousand destinations[31], many of these have changed dramatically in the last five years. The official price index certainly under-estimate these qualitative improvements, even though such improvements motivated purchases in this time period.

Second, there is a classification issue. Perhaps a price index for Internet access should not include changes to hosting, better contracting practices, and other free services. However, these changes should be a part of a price index for the Internet somewhere. But it is potentially not anywhere else either.

X.2. Solutions and recommendations

No researcher has figured out how to estimate demand for the Internet, accounting for

[31] See Goldfarb, 2002.

changes in quality. This is a large open question. At a minimum, I would make a modest recommendation. Official government agencies should encourage others to resist any temptation to interpret the official price index as a measure of value-creation. A discussion to this effect could be added to the FAQs sections of government web pages about electronic commerce, as maintained by the US Census (e.g., Mesenbourg, 2001) and the BEA (e.g., see Landefeld and Fraumeni, 2001, or Fraumeni, 2001).

In addition, there is another simple recommendation to make, to the extent that these issues are affiliated with completeness of the classification system for internet activities. At a minimum, the title for the official index should change. It should be relabeled as "Internet access." Then perhaps this will direct attention to other areas in which Internet classification is incomplete, as earlier noted.

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