

THE VALUE OF BROADBAND AND THE DEADWEIGHT LOSS OF TAXING NEW TECHNOLOGY

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Abstract

Recent work has emphasized the importance of new goods for consumers and the economy. When there are fixed costs associated with the development and diffusion of these new goods, taxes can generate large efficiency costs by slowing the rate of innovation. This paper develops an empirical methodology for quantifying this dynamic deadweight loss of taxation in the context of the value of Broadband and taxes on Internet access. Combining data on individual demand for broadband by market with data on supplier entry into broadband in those same markets, the paper yields estimates of the consumer and producer surplus and the size of the fixed costs of entry. Applying a tax to Internet access reduces the quantity of broadband as in a conventional calculation but in a few markets also pushes producer surplus below the level necessary to incur the fixed costs of entry. In these markets diffusion is delayed and the entire lost consumer surplus and part of the lost producer surplus become an additional deadweight loss from the tax. The results suggest that the pre-tax consumer surplus from Broadband access is almost \$700 million per year at the time of the sample and that the dynamic deadweight loss adjustment is more than double the conventional deadweight loss calculation. The standard calculation of incidence also significantly understates the share borne by consumers when it slows the introduction of new goods.

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1. Introduction

Recent work in industrial organization and macroeconomics has emphasized the importance of new goods in the economy and the potentially large consumer gains from such goods (see Trajtenberg, 1989; Bresnahan and Gordon, 1997; Hausman, 1997; Petrin, 1999; Nevo, 2000; Goolsbee and Petrin, 2000). The study of new goods has generally not affected the analysis of taxes or other public policies, however.¹ If the value of new goods is especially high and there are fixed costs associated with creating these new goods, taxes have major impacts on consumer welfare by slowing diffusion rates and this could be an important part of evaluating such policies.

This paper examines a specific case—the value of broadband and the impact of taxes on Internet access. It develops an empirical methodology for estimating the magnitude of the welfare cost of a tax that slows diffusion. Typically, the impact of taxes is based on the static demand curve for the product. Here, in addition to the conventional welfare effect, there will be some local markets where the after-tax profits from serving the market do not warrant the fixed cost of entry (but would if the tax did not exist). In those cases, the entire consumer surplus and part of the producer surplus in those bypassed markets becomes an additional deadweight loss from taxation.

Beyond the methodological point of incorporating the analysis of new goods into public economics, I examine the case of broadband in particular for several reasons. First, there is considerable interest in estimating the welfare gains from telecommunications products (see Wolak, 1996; Hausman 1997, 1998, 1999; Greenstein and Spiller, 1997) as well as with the extent and the spread of Internet Access and the rise of the digital divide (Downes and Greenstein, 1998; Hoffman and

¹ Exceptions include the work of Romer (1994), Feenstra (1995), and Klenow and Rodriguez-Claire (1997) that consider the impact that tariffs can have on the availability of new goods and Hausman (1998) on the welfare costs of regulatory delay in the telecommunications industry.

Novak, 1999; Compaine, 2001). In addition to analyzing the impact of taxes on welfare, I will be able directly estimate the value of broadband for consumers in the spirit of the industrial organization literature on new goods.

Second, the issue of fixed costs in the spread of broadband and the influence of government policy on the incentives to invest in the technology is one of the central issues in the open access controversy over whether cable companies should be required to allow other Internet Service Providers access to their cable lines into the home (see, for example, the arguments made by Owen and Rosston, 1998).

Third, the issue of whether to apply taxes on Internet access is currently a subject of political debate. Previous to the passage of the Internet Tax Freedom Act in 1998, ten states applied sales taxes to Internet access fees. The Tax Freedom Act placed a three year moratorium on Internet access taxes but this ends in 2001. The issue is likely to become highly charged since, as Goolsbee (forthcoming) shows, the potential revenue from taxing access is possibly even greater than the current revenue loss from not enforcing sales taxes online. This is the first paper to present empirical work on the economic impact of taxes on Internet access.²

The paper uses data on individual level demand for broadband to construct city specific demand curves that can be used to estimate the amount of consumer surplus as well as to make a traditional analysis of taxes. The results suggest that at the level of demand in late 1998/early 1999, the consumer surplus from Broadband was about \$667 million per year in markets where it was available and would

² There has been a rather substantial related literature on how people's use of the Internet responds to prices (see, for example, Varian, 1999, Beckett 1999, the discussions in Mackie-Mason and Varian, 1995 or the papers in McKnight and Bailey, 1997). This literature has become less relevant for analyzing taxes on access, however, since most Internet Service Providers (ISPs) currently charge a flat monthly fee for unlimited use.

be as high as \$1 Billion if it were available in all markets at that time. The results also show that at current market prices, the demand for broadband is highly elastic. A conventional analysis of the impact of a tax on broadband indicates that the deadweight loss in this market is large, as much as 200 percent of the revenue generated even before the dynamic adjustment.

Calculating the implied producer surplus before and after the tax and estimating the size of the fixed cost of entry suggests that there are several markets where profit would be sufficient to warrant entry before tax but not after tax. Adding the deadweight loss from the bypassed markets (medium sized areas like Milwaukee and Tampa) the dynamic adjustment arising from the lost consumer surplus in those markets is more than double the conventional deadweight loss. The incidence of the tax is also quite different than in the conventional calculation since it also includes the lost benefits in the bypassed markets. It will tend to imply the burden is borne much more heavily by consumers.

The paper proceeds in four sections. In section 2, I present an overview of the theory behind evaluating taxes on new technologies as well as the empirical approach for estimating such effects. Section 3 gives a description of the industry and the data sources I use in the study. Section 4 presents the estimates of the city level demand curves as well as the conventional tax analysis of the industry. Section 5 then uses those city level demand curves to estimate the size of the fixed costs of entry and provides the dynamic analysis of deadweight loss and incidence.

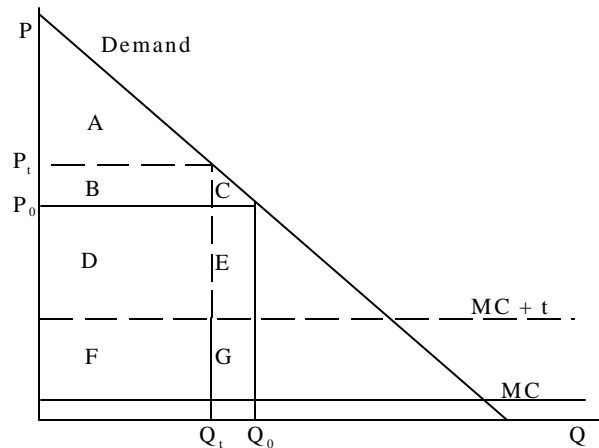
2. Theory and Methodology

The idea behind the approach is quite straight forward and begins with the notion that there are fixed costs associated with creating a new product. As described below, the spread of a new technology like broadband requires the supplier to incur some rather substantial fixed costs of entry into

the market. Following on the idea of Romer (1994) that the true welfare cost of tariffs may be much larger than static calculations suggest because they can reduce the variety of imports, the welfare costs of taxing Internet access may be much larger than in conventional calculations because it may reduce the spread of broadband coverage.

Consider the market for broadband where the suppliers (local cable monopolies) face downward sloping demand curves and charge a price in excess of marginal cost as in Figure 1.

FIGURE 1



In a conventional (static) analysis of taxes in such a market, imposing a tax of t will reduce the number of people interested in the new product and this will create a deadweight loss that depends on the elasticity of demand. Before taxes, the supplier will produce at the level where marginal revenue is equal to marginal cost according to the familiar rule. Before the tax, the price is P_0 , the quantity is Q_0 , the consumer surplus is the area ABC and the producer surplus is the area $DEFG$.

If the government imposes a per-unit tax on the seller, this raises the cost curve to $MC+t$. The after tax price rises to P_t and the quantity falls. The consumer surplus after the tax is A . The producer surplus is BD and the revenue raised is area F . The lost consumer and producer surplus in area CEG is

the deadweight loss of the tax. This is a conventional analysis of taxation under monopoly similar to Sumner (1981).

Let us assume there is a distribution of markets such as that in figure 1 which are of different sizes and in each of them the firm is considering whether to enter. To do so, the firm must pay some fixed cost F . So long as the producer surplus earned by the cable company after the tax (area BD) exceeds F , the firm will enter that market and the DWL from taxation will be exactly as calculated in the conventional approach. If, however, area BD does not exceed F the company will not enter the market. For these marginal markets, those where $DEFG > F > BD$, the entire producer and consumer surplus are lost (although the firm does not have to pay the fixed cost). The importance of this dynamic adjustment is a strictly empirical matter. It depends on the elasticities of demand and the cost structure and whether there are any markets where applying taxes would reduce profits sufficiently to slow or prevent the spread of broadband.

The incidence of the tax in figure 1 is also changed because of the dynamic element. In the typical incidence calculation, one computes the change in the after tax price to consumers as a share of the total tax and uses that as the share borne by consumers. In the case where markets are bypassed, however, there are costs that are borne that are not proportional to revenue. To the extent that new goods generate large consumer surplus but only modest producer surplus in excess of the fixed costs, the incidence will tend to be borne significantly more by consumers than in the typical estimate.

B. Empirical Methodology

In order to estimate the quantities involved empirically, one needs to have information about the demand curves, costs, and entry. I will follow a three step approach. In the first step, I estimate a

demand curve for broadband at the city level by aggregating data on reservation prices at the individual level. This yields a series of demand curves in every city (including those where entry has not occurred yet) that can be used for a conventional market and tax analysis—price and quantity before and after the tax.

In the second step, I compute the producer surplus arising from each market's demand curve (assuming constant marginal costs and Bertrand competition) and then use the observed entry patterns to estimate the size of the implied fixed cost of entry for a Broadband provider. This is done by estimating a Probit of the decision to enter on the total profits that could be earned in the market.

Then, the third step takes this estimate of the fixed cost and compares it to the before and after-tax profits for each market in the first step to determine if any cities are on the margin meaning producer surplus is high enough without taxes to enter but not high enough after taxes. In those cases, the entire consumer surplus and producer surplus in excess of the fixed costs becomes deadweight loss.

Finally, I consider the issue of tax incidence in this dynamic context and document that the true burden is much more heavily borne by the consumer than the conventional calculation indicates.

3. Background and Data

A. Broadband and Cable Modems

Broadband, and specifically cable modems allow Internet users to receive data from the Internet over their fiber-optic cable line rather than over conventional telephone wires. This allows the user to access the web at speeds up to 100 times faster than standard dial-up modems. As this technology becomes widespread, it will certainly lead to major changes in the information content of the Internet, potentially fostering the growth of online television, video-on-demand, distance learning, or many other

services that require large amounts of bandwidth. At the time of this sample broadband accounted for only 2-3 percent of online users (Mines, et al., 1998; Strategis Group, 1999). Its growth rates are extremely rapid, however. The subscriber bases have grown from less than 40,000 in 1996 to about 750,000 by mid-1999 and analysts forecast that by 2002 or 2003, the number of broadband users could range between 4 million and 27 million, as high as 35 percent of total online subscribers (Mines et al., 1998; Kinetic Strategies, 1999; Kasrel et al., 1999; CATC CyberLab, 2000; Gillett and Lehr, 2000).

The major current competitor to cable modems is DSL, a service provided over telephone lines. At the time of the data I use, however, DSL availability was almost non-existent for residential customers (see Freed and Derfler, 1999; Gillett and Lehr, 2000). Even now, cable modems have between 75 and 90 percent market share (Scafidi and Zohar, 2000; Strategis Group, 1999). This is probably because DSL is only available for a limited distance from a switching station (speed decreases very rapidly more than 20,000 feet from the station), has primarily been targeted to small businesses, and is, on average slower and more expensive than cable modem access. At the time of the same in this paper, cable modems were widely regarded as the superior consumer choice (PC Magazine, 1999) so I will treat each broadband provider as having a local monopoly over broadband in its area. The typical fee for broadband access through a cable modem is about \$40 per month. For people not currently subscribing to cable this is typically about \$20 higher.

When cable companies want to introduce cable modem service to a large community (as opposed to a pilot project), they typically must make major investments in upgrading the cable lines, electronics, and head-end equipment as well as extensive marketing efforts and the per-customer expenses of installation and the cost of the cable modems themselves (usually rented to the customer as

part of the monthly service, somewhat like a cable box). These potentially large fixed costs make up the critical issue in analyzing the impact of taxes in these markets. The cable firms must decide when to enter various markets and the way they do this depends on how profitable they think the markets will be compared to the fixed costs of entry (see Owen, 1999 or Carriere et al., 2000 for more detailed discussions of the the potential costs of entry).

C. Data sources

To make these estimates I will combine several sources of data. The first is individual level reservation price data on people's willingness to pay for broadband as given in the surveys of Forrester's *Technographics 1999* program. Forrester is a leading market research company who studies the information economy and each year they conduct a survey of close to 100,000 people about their usage of various products as well as demographic information. More detail on the Forrester survey can be found in Bernhoff et al. (1998) or Goolsbee (2000). The precise question involved is one that asks consumers how much they would be willing to pay (in dollars per month) for high-speed Internet access up to 100 times faster than on conventional modems. Their answers are of the form "Less than \$5", "\$5-\$15", "\$15-25", and so on up to "\$65+." I will sum these individual demand curves in each of the top 70 metro areas. These answers give demand curves even for markets where there is no broadband access yet.

These demand curves make up the heart of the analysis and since they are not based on transaction data, I will be very concerned with establishing whether they are reasonable estimates of the demand curve for broadband. To check the plausibility of these demand curves I will compare the results to independent sources of aggregate data as well as to results using the micro data in the

Forrester survey of whether people actually have cable modems in locations where they are available. The results are quite consistent. For the availability of cable modems at the time of the survey (late 1998), that are necessary for estimating the fixed costs of entry, I use the information in PC World (1999).

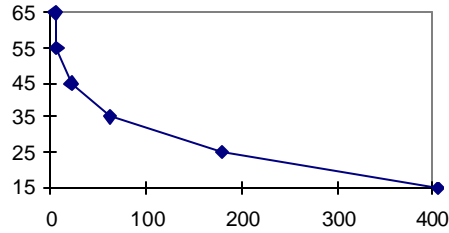
4. Demand curves & Static Tax Analysis

A. Demand for Broadband by Market

Analyzing the impact of taxes on broadband in either the conventional or the dynamic context must begin with a demand curve. Using the data on reservation prices, I sum the number of respondents in a market who say they would be willing to sign up for high speed access at a series of prices (\$65, \$55, \$45, and so on) and do this for each of the 70 most populous television markets in the U.S. (together accounting for about 75 percent of the total population). I make two restrictions of the sample. First, I use only people reporting reservation prices of at least \$15 per month to keep people far from the equilibrium prices from influencing the estimated shape of the estimated demand curve. Second, I use information only for those people that already report having internet access from home. I do this both because this prevents people that have never used a dial-up modem or perhaps have never been on the Internet from giving a valuation of faster Internet service.

As an example, I plot the demand curve for the San Francisco metropolitan area in Figure 2. There are 70 such demand curves, one for each market. Price per month is on the vertical axis and the number of respondents who would purchase broadband at that price is on the horizontal axis. As there are 1,680 respondents from the Bay area and 2.4 million households in that market, each respondent represents about 1410 households (Nielsen, 1999).

FIGURE 2: DEMAND CURVE FOR BROADBAND (SAN FRANCISCO AREA)



For each of the markets, I then fit a quadratic inverse demand curve to the data. For San Francisco, the full results are listed in Table 1.

TABLE 1: Estimated Demand Curve for San Francisco

	(1) Dependent Variable: P	(2) Dependent Variable: ln(Q)
Quantity	-.2814 (.0839)	
Quantity ²	.00044 (.00019)	
Ln (Price)		-3.1728 (.3330)
Constant Term	57.152 (5.631)	15.016 (1.203)
Number Obs.	6	6
R ²	.90	.96

Notes: The two columns give estimates of the demand curve for broadband in San Francisco as described in the text.

The coefficients for all the cities are listed in Table 2. The R² is high in every market. The first column lists the calculated elasticity for the market at a price of \$40. In San Francisco, this elasticity is -2.65 and they range from -2.15 to -3.76. The second to last column of Table 2 gives the coefficient from a log linear regression of log quantity on log price (the last column gives the R² from that regression). In most of these cases, the elasticity here is slightly higher than in the quadratic. The average in the

quadratic specification was around -2.75 and in the log linear was about -3.20 .

A typical problem with calculating consumer surplus (i.e., integrating under the demand curve) is the major influence exerted by the small numbers of people with very high estimated valuations (see Petrin, forthcoming). Obviously this is rather extreme in the case of the log demand curve since there is no price at which quantity falls to zero. For the results below, I will use either the quadratic specification because it is simple and because it has a zero quantity price (it is the constant term and is reported in the second column of table 2) or else the log linear curve but capping the maximum price at \$65 (the highest value actually given by the respondents). The capping has no impact on the equilibrium price or the estimated producer surplus.

B. Checking the Demand Curve

Obviously if demand for broadband is this price elastic, the efficiency cost of taxing Internet access is going to be quite high indeed. Since this demand curve is from reported willingness to pay data rather than actual transactions, it is important to check whether these results seem reasonable. There is a considerable literature in psychology and marketing about survey design and how to elicit measures of price sensitivity (see Nagle and Holden, 1995 for an overview) and similar issues arise in the discussions about contingent valuation in the environmental economics literature (see Diamond and Hausman, 1994; Hanemann, 1994). The literature suggests this problem is particularly pronounced for non-market goods or for goods where people have no direct experience or information. For this reason, these results are based on people who already have Internet access (and can, presumably, appreciate the benefits of access 100 times faster than a traditional modem).

I have three pieces of evidence that suggest these results are not overly price sensitive. First

these price elasticities of broadband are in the same range as the elasticities found in the Berkeley INDEX experiments where individuals were placed in randomized experiments and given different prices of Internet access and their online behavior was tracked. The own price elasticities of high bandwidth were generally between -2 and -3 (Varian, 1999). This is not the same margin as the one in this paper since it concerns an incremental hour of use versus the discrete choice of getting broadband but the elasticities are similarly high.

The second piece of evidence about the reservation price data comes from looking at the take-up rates in places where it is already available (at prices between \$40 and \$50 per month). The reservation price data suggest that among Internet users who live in places without cable modem access, about 4.7% report they would be willing to pay more than \$35 per month and about 2.0% report that they would be willing to pay more than \$45 per month for broadband access. Using data from PC World (1999) to identify major metropolitan areas in which cable modems were widely available (though often not universally within the region), I calculate that the actual take-up rates in those areas was about 2.2% in the Forrester data and the take-up rate among those actually having the ability to get access computed in other sources is somewhere between about 3 and 5% (see Kinetic Strategies, 1999 and Gillett and Lehr, 1999). This also suggests that the reservation price data is not overly price sensitive.

The final check uses the Forrester micro-data in locations where cable modems are available. The problem with directly estimating the elasticity of demand for broadband using the observed data is that there is not much price variation across markets to identify the effects. Instead, I exploit the fact that in most markets in the sample, cable companies offered different prices for cable subscribers than it did for non-subscribers. The average \$40 per month price is for cable subscribers. Non-subscribers

typically had to pay about \$60. Assuming that the decision to purchase cable is made independently of cable modem choice (i.e., people with cable already had it when they made the decision to get a cable modem), I can use a dummy variable for whether the household has a television hooked up to cable as an indicator of the price. I use the log of 40 or 60 dollars as an approximation, though this will tend to introduce measurement error and bias the price elasticities toward zero. Table 3 presents results from linear probability models for people who report having access to the Internet at home in markets where cable modems are available. This is measured in one of two ways. The first is in the question asking whether the computer has a modem and if so what type (dropping all observations that answer variants of “unknown”) and classifying those with cable modems as a one. The second measure uses responses to the question asking what services the individual receives from their cable company (one of them is Internet access from the cable company) and classifying anyone that says they pay a monthly amount for cable Internet service as a one.

These are individual level regressions that also include the price for the individual (determined by cable ownership), as well as dummies for individual income, education, age, gender, race, marital status, presence of children, years having been online, dummies for ownership of 24 other high-tech products such as a cordless phone, a personal stereo, etc., and dummies for every television market-state combination (e.g., NYC market in New York state, NYC market in New Jersey, and so on).

The results show that, controlling for individual characteristics, there is a significantly increased likelihood of having a cable modem for people with lower prices (i.e., for people that are cable television subscribers). The magnitudes in the first column suggest that the elasticity of broadband with respect to the price is about -2.8 . In the second the elasticity is -3.5 . These elasticities at market prices are large and are very close to the elasticities that come from the reservation price data.

Each of the three tests gives results that are consistent with the willingness-to-pay data so I will use the survey data demand curves as being accurate representations of demand in the separate markets.

C. Consumer Surplus and the Conventional Tax Calculation

With no fixed costs (i.e., when every market gets served), the aggregate demand in 1998 the entire United States would be about 922,000 households in the log linear demand curve and 1.6 million households in the quadratic. Integrating under the demand curves will give the consumer surplus arising from access to broadband. To get the market price in the markets, I assume that the local cable monopolies price in a Bertrand manner and that they have a constant marginal cost. To estimate this cost, I note that it will be related to the market price according to the familiar mark-up rule $P=MC*(-1/\eta)$. The average elasticity in markets that actually have cable modem access at the time of the sample is -2.75 and the average actual market price is approximately \$40. This implies a MC of about \$25 per month or \$300 on an annualized flow basis. This is in the same ballpark as the actual per-customer costs described in Owen (1999) and very close to the cost estimates in Carriere et al. (2000). I will assume it to be equal across markets.

Given this marginal cost and the quadratic inverse demand curves, I can solve for the marginal revenue function in each market and set it equal to marginal cost to get the quantity sold and the market price. In the calculations here, the projected market prices across areas form a relatively tight band around \$39.50 per month for the quadratic demand curve. This is comforting given that there is not much actual variation in prices of existing broadband services across markets.

The first thing to come from the demand curve estimates is a calculation of the potential welfare

gains to the new product. Using the estimated market prices, the producer surplus will be $(P-MC)*Q$ for each location and the consumer surplus will be the integral of the demand curve out to the market quantity. To get the numbers into understandable units, I will weight each city by the average number of households per survey respondent (i.e., about 1220). For San Francisco, the projected price is \$40.05 and the quantity is 95,000 with the quadratic demand curve, \$36.51 and 52,000 with the log linear. Integrating under the demand curve, the consumer surplus is about \$4.6 million per month in the quadratic, \$2.1 million per month in the truncated log linear (this is where the truncation matters). Summed across all markets the total consumer surplus adds up to about \$955 million per year in the quadratic or \$448 million in the quadratic (in only those markets that currently have service, the totals are \$667 million and \$313 million).

The second thing that comes from the demand curve analysis is the standard analysis of the projected tax on Internet access. Consider a \$2 per month tax on Internet access that is paid by the cable company, raising the marginal cost from \$25 to \$27 per month. Solving through the same process as before, this would raise the average equilibrium price to \$40.60 from \$39.50. The share of the tax born by consumers in different areas ranges from 50 to 60%. After the tax, the total quantity falls from 1.63 million to 1.51 million so the annual revenue raised by the tax (\$24 per customer per year) is about \$36 million. With the new prices, the total consumer surplus summed over all markets falls to \$875 million per year and total producer surplus falls to \$250 million. The after tax surplus is the sum of these three and amounts to \$1,161 million. The \$64 million drop in social surplus is the deadweight loss. Here, the DWL of the tax is 180% of the revenue raised by the tax. This large efficiency cost arises because of the large elasticity of demand at equilibrium prices.

The other thing to come out of the standard model is a calculation of the producer surplus

arising in the no-tax environment. This producer surplus will depend on both the size of the market as well as the elasticity of demand. The largest producer surplus is New York City with \$23.2 million per year in the quadratic case. The producer surplus in the median market is only about \$180 thousand. The producer surplus in each market is listed in Table 4. Matching these values with the decisions about entry will yield an estimate of how big the fixed costs must be.

5. Fixed Costs & Dynamic Analysis

A. Estimating the Size of the Fixed Cost

In the producer surplus rankings, there is a noticeable positive relationship between potential profit and entry (correlation of .5), consistent with a fixed cost of entry. Firms have thus far been reluctant to enter markets where profit is too small. To estimate this fixed cost, table 5 lists the results from a probit regression of whether the metro area had general access to cable modems at the time of the survey as a function of the producer surplus. Because these are assumed to be local monopoly providers, there are none of the key strategic adjustments to the estimation as in Bresnahan and Reiss (1990; 1994) and Berry (1994). Instead, a measure of the fixed cost of entering the market is simply the constant term divided by the coefficient on producer surplus. This measure gives the dollar value past which the probit index is greater than zero. This measure predicts about 75 percent of markets correctly (about 5 percent of the time a market did not have access when the model predicted it would and 20 percent of the time had access but were predicted not to). The value of the fixed cost is estimated to be about \$4.1 million per year for the quadratic demand case. This suggests that profit in all but 23 markets is not great enough at the time of the sample to warrant entry. Interestingly, the data in Kinetic Strategies (1999) suggest that there was entry into three of the four locations where the

predicted profit would seem to justify entry but there was no broadband available at the time of the survey.

B. Adjusting for Dynamic Deadweight Loss from Taxing New Goods

With a fixed cost of \$4.1 million per year, the standard tax analysis must be modified. First, the conventional analysis will apply only in the 23 markets (together accounting for about 46% of the U.S. population), where profit is high enough to justify entry. In addition, imposing the \$2 per month tax, however, reduces the amount of producer surplus in four of the areas (Miami, Cleveland, Tampa, and Milwaukee) such that it falls below the fixed cost. If this tax were in place before the investment decision (as opposed to applying the tax after the fixed cost has been incurred), the firms will bypass this market until demand grows sufficiently that profits will exceed the fixed cost *after* tax. In the mean time, all of the consumer surplus and producer surplus minus the fixed cost in these markets will become deadweight loss from the tax. This lost surplus is the dynamic adjustment from taxing a new technology that must be added to the conventional calculation.

To illustrate the magnitude such adjustments can have, note that in the 19 markets served both before and after the imposition of the tax (where the conventional DWL calculation is correct), the deadweight loss from the tax is \$43 million per year and the revenue is \$23 million per year. The lost consumer surplus from the four bypassed markets is \$56 million and the lost producer surplus (minus the fixed costs) is about \$14 million. Thus the dynamic deadweight loss adjustment of \$70 million exceeds the conventional deadweight loss by a factor of 2 (raising the total DWL from 187 percent of revenue to 491 percent of revenue). This was also true in the log linear case (raising it from 55 percent of revenue to 166 percent) although in that case the marginal cities are different than in the quadratic

case because the profit measures, demand elasticities and the size of fixed costs differ in that specification.

Obviously, the upward trend in demand for broadband is likely to mean that these markets will not be bypassed forever so the dynamic deadweight loss is unlikely to be permanent from these markets. To the extent that the tax also slows the potential spread of broadband into the smaller markets, though, it may be that a similar dynamic loss will exist for many years.

C. Dynamic Incidence Analysis

Given the projected dynamic deadweight losses from taxing Broadband, the traditional concept of incidence is also changed. Typically, the share of the tax borne by consumers is calculated by comparing the pre-tax to the post-tax consumer price. This gives the share of *the* burden borne by consumers *assuming that the division of the deadweight loss is the same as the division of the revenue*. Unfortunately, in the dynamic setting this will not be true. This is because the consumer surplus from the new goods is likely to exceed the producer surplus minus the fixed cost. The dynamic deadweight loss of losing new technologies arises, disproportionately, from lost consumer surplus in the bypassed markets so the consumer burden of the tax rises.

In the case of broadband, the overall burden of the tax calculated the conventional way shows that the average price before tax went from \$39.50 to \$40.60, suggesting that consumers pay about 55 percent of the \$23 million tax revenue. The correct burden of the tax exceeds \$23 million in revenue, however since it includes the deadweight loss, too. In the dynamic setting, the total burden of taxation on producers and consumers (equal to revenue paid plus lost consumer and producer surplus minus fixed costs) is \$136 million. Of that \$136 million, \$93 million or 70 percent is borne by the consumers.

In other words, the consumer incidence is seriously understated in the standard calculation.

This raises the possibility that subsidizing the expansion of broadband, say with an investment tax credit, could generate significant gains in consumer welfare.

Conclusion

This paper has developed an empirical approach to quantifying the deadweight loss from taxing new technologies and applied that method to thinking about the spread of broadband Internet access. The dynamic adjustment comes about from the lost consumer and producer surplus in markets where suppliers delay entry because of the presence of taxation. Such markets are those where profits before the imposition of a tax exceed the fixed cost of entering but after the tax do not. This simple point makes a major difference to the results from a tax on broadband. The deadweight loss of the tax triples with the dynamic adjustment and the conventional incidence calculation understates the burden borne by consumers by about 20 percent. Given the importance attached to new goods in the work in industrial organization and macro-economics, the findings in this paper suggest that taking into account the impact of taxes on innovation and technology may be fundamental for understanding the role of government policy in the new economy.

TABLE 2: DEMAND ESTIMATES BY MARKET

METRO	Elas(p=40)	Cons	Q	Q2	R2	Elas (log)	R2 (log)
1 nyc	-2.82	55.70	-0.16	0.000	0.87	-3.66	0.96
2 losangeles	-2.67	56.73	-0.22	0.000	0.89	-3.35	0.97
3 chicago	-2.59	57.39	-0.33	0.001	0.90	-3.15	0.97
4 philly	-2.75	56.22	-0.32	0.001	0.90	-4.18	0.91
5 sanfran	-2.65	57.15	-0.28	0.000	0.90	-3.17	0.96
6 boston	-2.81	55.85	-0.41	0.001	0.86	-3.37	0.98
7 dallas	-2.59	57.44	-0.42	0.001	0.89	-3.08	0.97
8 washdc	-2.61	57.25	-0.31	0.000	0.88	-3.02	0.98
9 detroit	-2.87	55.51	-0.55	0.002	0.89	-4.07	0.93
10 atlanta	-2.44	58.32	-0.61	0.002	0.89	-2.87	0.99
11 houston	-2.60	57.32	-0.66	0.002	0.90	-3.22	0.96
12 seattle	-3.07	54.42	-0.44	0.001	0.83	-3.63	0.96
13 cleveland	-2.96	54.94	-0.82	0.004	0.85	-3.59	0.98
14 tampa	-2.89	55.20	-0.85	0.004	0.87	-3.76	0.94
15 minneapo	-3.04	54.42	-0.58	0.002	0.83	-3.58	0.98
16 miami	-2.49	58.17	-1.01	0.005	0.88	-2.85	0.98
17 phoenix	-2.30	59.69	-0.70	0.002	0.91	-2.68	0.99
18 denver	-2.50	58.16	-0.80	0.003	0.92	-3.11	0.96
19 pittsburgh	-3.68	51.89	-0.79	0.004	0.79	-3.41	0.92
20 sacramen	-2.66	56.81	-0.64	0.002	0.85	-2.85	0.99
21 stlouis	-2.47	58.53	-0.89	0.004	0.89	-2.81	0.96
22 orlando	-2.90	55.06	-1.26	0.007	0.85	-3.57	0.98
23 portland	-2.74	55.97	-0.97	0.004	0.85	-3.26	0.99
24 baltimore	-2.82	55.64	-0.76	0.003	0.89	-3.78	0.93
25 indianapo	-3.45	52.64	-1.06	0.006	0.79	-3.76	0.96
26 sandiego	-2.90	55.35	-0.71	0.003	0.89	-3.91	0.92
27 hartford	-2.31	59.14	-1.79	0.013	0.94	-3.28	0.95
28 charlotte	-3.06	54.38	-1.65	0.014	0.86	-3.32	0.97
29 raleigh	-2.44	58.74	-1.21	0.008	0.93	-3.14	0.93
30 nashville	-2.64	57.00	-1.03	0.006	0.90	-3.50	0.93
31 milwaukee	-2.54	57.88	-1.03	0.006	0.82	-2.44	0.97
32 cincinnati	-2.63	56.79	-1.38	0.009	0.91	-3.41	0.94
33 kansascity	-2.15	60.30	-2.68	0.025	0.89	-2.69	0.98
34 columbus	-2.96	55.05	-1.13	0.007	0.88	-3.12	0.94
35 greenville	-3.30	52.97	-3.09	0.042	0.81	-3.81	0.99
36 saltlakecity	-2.99	54.72	-1.14	0.007	0.86	-3.60	0.97
37 sanantonio	-2.64	56.74	-2.01	0.019	0.88	-2.83	0.99
38 grandrapids	-3.24	53.55	-1.54	0.013	0.80	-3.40	0.94
39 birmingham	-2.53	57.57	-3.11	0.046	0.85	-2.80	0.98
40 norfolk	-3.01	54.50	-1.27	0.008	0.87	-3.33	0.98
41 neworlean	-3.31	53.37	-1.68	0.017	0.78	-3.26	0.94
42 buffalo	-3.08	54.24	-1.41	0.010	0.85	-3.24	0.98
43 memphis	-3.07	54.23	-2.33	0.028	0.85	-3.20	0.98
44 westpalm	-2.78	56.15	-1.70	0.016	0.86	-3.14	0.96
45 oklahocity	-3.76	51.48	-1.69	0.016	0.74	-3.78	0.88
46 lancaster	-3.50	52.33	-1.76	0.016	0.80	-4.10	0.97
47 greensbor	-3.50	52.51	-2.62	0.040	0.81	-3.11	0.95
48 louisville	-3.40	52.77	-2.13	0.024	0.81	-3.86	0.97
49 albuquer	-2.71	56.50	-2.20	0.025	0.87	-3.07	0.97
50 *provid	-3.05	54.43	-1.73	0.016	0.80	-3.17	0.97
51 wilkesbar	-3.74	51.42	-2.00	0.020	0.77	-4.20	0.95
52 jacksonvil	-2.79	55.57	-2.48	0.027	0.90	-3.17	0.99
53 albany	-3.60	52.17	-1.29	0.010	0.79	-4.09	0.94
54 dayton	-3.22	53.56	-1.64	0.014	0.83	-3.45	0.98
55 fresno	-2.38	58.77	-2.81	0.036	0.91	-2.93	0.98
56 lasvegas	-3.72	51.80	-1.76	0.019	0.79	-3.37	0.90
57 littlerock	-2.53	57.57	-2.86	0.038	0.88	-2.95	0.98
59 tulsa	-3.26	53.38	-2.70	0.039	0.83	-3.58	0.97
60 austin	-2.30	60.18	-1.50	0.012	0.95	-2.96	0.92
61 richmond	-3.02	54.84	-1.90	0.021	0.82	-3.06	0.97
62 mobile	-2.58	57.76	-2.72	0.042	0.95	-2.22	0.94
63 knoxville	-2.94	55.38	-2.46	0.036	0.80	-2.75	0.95
64 flint	-2.77	55.62	-4.09	0.070	0.90	-3.35	0.98
65 wichita	-2.75	55.68	-4.29	0.075	0.77	-2.79	0.93
66 toledo	-3.27	53.63	-1.82	0.020	0.79	-3.15	0.93
67 lexington	-3.31	53.05	-3.18	0.049	0.82	-3.67	0.98
68 roanoke	-2.41	58.83	-3.43	0.059	0.94	-2.71	0.96
69 greenbay	-3.28	53.08	-3.37	0.051	0.83	-3.32	1.00
70 desmoines	-2.92	55.22	-3.76	0.077	0.89	-3.07	0.95

**TABLE 3: LINEAR PROBABILITY REGRESSIONS OF
THE LIKELIHOOD OF HAVING BROADBAND**

	Cable Modem	Internet fr/Cable
ln (p)	-.0378 (.0064)	-.1097 (.0086)
Dummies	Own 24 goods Years online Income Education Race Gender Age Kids Metro Area-State	Own 24 goods Years online Income Education Race Gender Age Kids Metro-Area State
n	12,673	14,665
R2	.03	.05
Estimated Price Elasticity	-2.78	-3.50

Notes: Each regression is a linear probability model where the dependent variable is a {0,1} variable for whether the individual has Broadband Internet access at home. The price variable is \$40 per month for people without cable television at home and \$60 per month for people without. There are dummies for other control variables as listed in each column.

TABLE 4: PRODUCER SURPLUS BY MARKET

METRO	PROFIT	Cable Moder
1 nyc	23218	1
2 losangeles	18840	1
3 sanfran	14991	1
4 washdc	13804	0
5 chicago	12760	1
6 philly	12385	1
7 dallas	10240	1
8 boston	9384	1
9 seattle	7890	1
10 atlanta	7300	1
11 phoenix	6916	1
12 detroit	6873	1
13 houston	6395	1
14 sacramen	6395	0
15 minneapo	5914	1
16 denver	5589	1
17 sandiego	5268	1
18 stlouis	5148	1
19 baltimore	4905	1
20 miami	4392	1
21 cleveland	4390	0
22 milwaukee	4281	0
23 tampa	4270	1
24 nashville	4006	1
25 portland	3912	1
26 raleigh	3844	0
27 pittsburgh	3669	1
28 austin	3377	1
29 columbus	3227	1
30 saltlakeci	3104	0
31 cincinnati	2916	0
32 indianapo	2891	0
33 orlando	2843	0
34 norfolk	2735	0
35 hartford	2591	0
36 buffalo	2431	1
37 westpalm	2313	0
38 albany	2298	0
39 grandrapic	2132	0
40 charlotte	2098	1
41 providence	2013	0
42 sanantonio	2006	0
43 dayton	1994	0
44 neworlean	1940	0
45 richmond	1907	1
46 toledo	1831	0
47 albuquer	1822	0
48 kansascity	1822	0
49 lancaster	1687	0
50 lasvegas	1655	1
51 oklahocity	1653	1
52 fresno	1622	0
53 mobile	1618	1
54 knoxville	1537	0
55 jacksonvil	1491	1
56 littlerock	1482	0
57 memphis	1462	1
59 louisville	1438	0
60 wilkesbar	1376	0
61 birmingham	1365	1
62 roanoke	1353	0
63 tulsa	1193	0
64 greensbor	1162	0
65 greenvilll	995	0
66 desmoines	980	0
67 lexington	978	0
68 greenbay	920	0
69 flint	901	0
70 wichita	861	0

TABLE 5: PROBIT OF MARKET ENTRY AT THE METRO AREA LEVEL

Constant	-.8394 (.2623)
Producer Surplus	.0030 (.0009)
n	69
Implied Fixed Cost	\$4.1 Million per market

Note: The dependent variable is a 1 if the data in PC World (1999) indicates the metro area had cable modem access at the time of this sample.

TABLE 6: MARGINAL MARKETS AND DYNAMIC LOSSES

Metro Area	Pre-Tax PS	Post-Tax PS	Pre-Tax CS
Miami	4.4m	3.9m	13.8m
Cleveland	4.4m	3.8m	14.5m
Tampa	4.3m	3.7m	13.9m
Milwaukee	4.3m	3.7m	13.5m

Notes: Author's calculations using the quadratic demand curves. These are the markets where the producer surplus exceeds the fixed cost before the tax but does not after the tax.

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