

Valuing ‘Free’ Media in GDP: An Experimental Approach
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Abstract

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‘Free’ consumer entertainment and information from the Internet, largely supported by advertising revenues, has had a major impact on consumer behavior. Some economists believe that gross domestic product (GDP) growth is badly underestimated because GDP excludes online entertainment (Brynjolfsson and Oh 2012; Ito 2013; Aeppel 2015). This paper introduces an experimental GDP methodology which includes advertising-supported media in both final expenditures and business inputs. For example, Google Maps would be final expenditures when it is used by a consumer to plan vacation driving routes. On the other hand, the same website would be a business input when it is used by a restaurant to plan delivery routes.

Contrary to BEA’s critics, including ‘free’ media in the input-output accounts has little impact on either GDP or total factor productivity (TFP). Between 1998 and 2012, measured nominal GDP growth falls 0.005% per year, real GDP growth rises 0.009% per year and TFP growth rises 0.016% per year. Between 1929 and 1998, measured nominal GDP growth rises 0.002% per year, real GDP growth falls 0.002% per year and TFP growth rises 0.004% per year. These changes are not nearly enough to reverse the recent slowdown in growth.

Our method for accounting for ‘free media’ is production oriented in the sense that it is a measure of the resource input into the entertainment (or other content) of the medium, rather than a measure of the consumer surplus arising from the content. BEA uses a similar production oriented approach when measured GDP. In contrast, other researchers used broader approaches to measure value. Brynjolfsson and Oh (2012) attempt to capture some of consumer surplus by measuring the time expended on the Internet. Varian (2009) argues that much of the value of the Internet is in time saving, an additional metric for capturing consumer surplus. The McKinsey Institute (Bughin et. al 2011) attempts to measure the productivity gain from search directly.

In particular, this production oriented accounting has no method to account for instances where the good or service precedes the revenue that it eventually generates. Over the past two decades, many Silicon Valley firms have followed the disruptive business model described as URL: Ubiquity now, Revenue Later. Some firms have been creating proprietary software or research, which is already captured in the national accounts as investment. Other firms have been creating intangible investments in open source software, customer networks and other organizational capital. Despite their long-run value, none of these intangible assets are currently captured in the national accounts as investment. If we treat these asset categories as capital, then the productivity boom from 1995 to 2000 becomes even stronger and the weak productivity growth of the past decade may be ameliorated somewhat.

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Introduction

Stiglitz, Sen, and Fitoussi (2009) argued that measured GDP is not a perfect proxy for welfare. One frequently discussed discrepancy between welfare and GDP is ‘free’ media. Facebook contributes directly to consumer welfare, but that contribution is not currently captured in the final expenditure part of GDP. We outline an experimental methodology to capture Facebook or Google’s contribution to consumer welfare while staying within the framework established by the official guideline for national accounting, the System of National Accounts 2008 (SNA 2008). As with owner-occupied housing, we impute production and consumption even though no money changes hands.

We impute a barter transaction between media users and media companies: media users watch ads in return for ‘free’ content. Our experimental methodology has at its heart two balancing components. On the expenditure side, we impute media purchases equal to the cost of providing media services. These costs are paid by advertisers, so ‘free’ apps are actually advertising-supported entertainment. Media could have been supplied through non advertising-supported media, and, indeed, they can be thought of as having been bid away from alternatives. For example, driving directions can be downloaded from an advertising-supported website like Google or a subscriber-supported website like PCmiler.

The identity of the user determines both the terminology used and also the impact on measured GDP. When consumers use ‘free’ media, we call the media ‘consumer entertainment’ and add the value of that entertainment to personal consumption expenditures (PCE) and GDP. Balancing that additional PCE, we impute income to viewers that are, in effect, paid to view advertising, with those payments being equal to the cost of providing entertainment programs. This additional income precisely equals the additional PCE, so there is no change in household savings. When businesses use ‘free’ media, we call the media ‘business information’ and add the value of that information to intermediate inputs. Balancing that additional intermediate input, we impute business output for ad viewership. This additional business output precisely cancels out the additional expenditures on intermediate inputs, so measured value-added and GDP do not change. However, measured productivity may change because the newly recognized outputs and inputs have different prices.

This paper recalculates productivity growth when ‘free’ media are included as both final expenditures and business inputs. We estimate the contribution of ‘free’ media from the supply side by measuring the advertising expenditures that support them. That is, we do not directly capture the value of Google Maps, but only measure the cost of providing it. This can be interpreted as a lower bound on the contribution of these ‘free’ media to output and productivity – but it is consistent with the standard methodologies for estimating an industry’s contribution to output and productivity. Therefore, our supply side numbers will be comparable to other productivity research.

This paper studies four separate categories of advertising-supported media: a) print newspapers or magazines; b) broadcast television or radio; c) cable and other non-broadcast television or radio and d) online media. Within each category, some media products receive all of their revenue from advertisers and others receive a portion from advertisers and a portion from subscribers. Our experimental methodology considers all advertising revenue to be the same, whether or not it is supplemented by subscription fees. Unwanted media like telemarketing, junk mail or spam e-mails are excluded from our research. In addition, we also exclude minor categories of advertising-supported media like athletic endorsement deals or movie promos because we could not find consistent data back to 1929. We believe that these minor categories display the same general patterns as the major categories tracked, and so excluding them does not change any empirical results significantly. Finally, we exclude ‘free’ media like PBS which are supported by governments and non-profits because those media outlets are already counted in GDP as part of government or non-profit output. Later in the paper, we will show that each media category displays very different growth rates over time – so researchers who focus on online media may overestimate the overall impact of ad-supported media. This paper focuses on measuring GDP in the United States from 1929 to 2013. In an earlier paper, we’ve studied the impact of ‘free’ media on cross-country GDP (Nakamura and Soloveichik 2015).

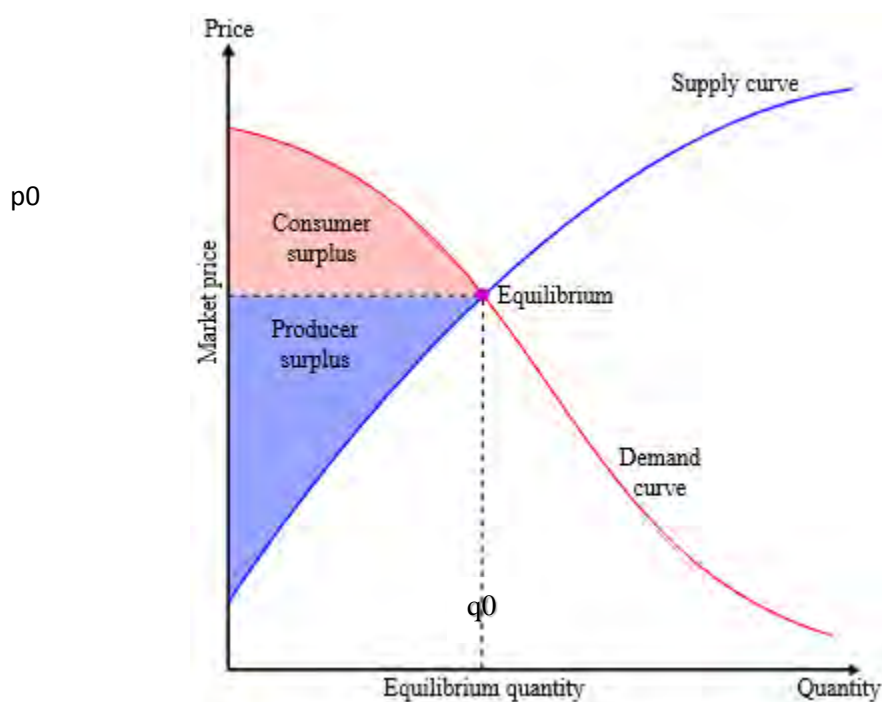
Our paper will be divided into five parts. Section 1 provides background information on the current methodology for handling advertising-supported media in GDP. We then describe our experimental methodology in more detail and review the previous literature on advertising-supported media and entertainment. Section 2 collects data on advertising-supported media revenue and advertising-supported media use in the United States. We then use that data to recalculate nominal output and nominal GDP from 1929 to 2013. Section 3 introduces our price

indexes for ‘free’ media and advertising viewership from 1929 to 2013. Section 4 calculates real output, real inputs and productivity by industry using the earlier data on nominal output and prices. In this section, our productivity numbers are calculated using the standard formulas – and so they may not reflect special features of the online media industry. Section 5 discusses how network effects impact the online media industry. We then calculate how measured TFP might change when network effects are included. This section is speculative. Finally, we include two Appendixes with more detailed information for interested readers. Appendix A shows how our methodology changes the input-output accounts and other industry statistics. Appendix B describes the data used.

Section 1. Conceptual Discussion of Advertising-Supported Media

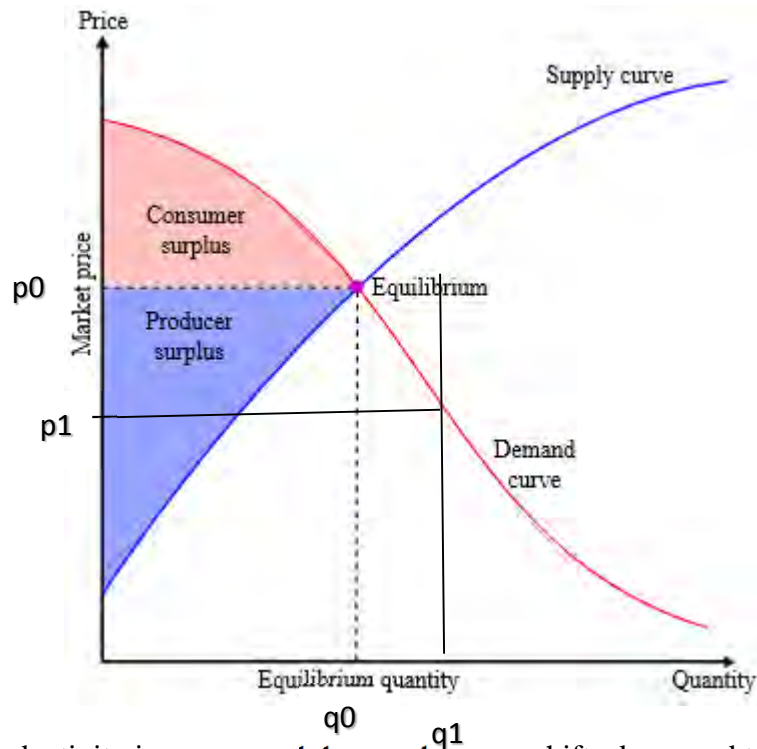
Measuring GDP and Consumer Surplus

We start with a general discussion of how BEA measures the economy. Below is a simple supply and demand graph from Econ 101:



The graph above has three areas potentially interesting to economists. The rectangle with dotted lines shows spending. In other words, how much are consumers **actually** spending on the good

studied. The red triangle above shows consumer surplus. In other words, how much would consumers be **willing** to spend on the good over and above the market price? Finally, the blue triangle below shows producer surplus. In other words, how much profit do producers make from the good in question. Here total output is p_0q_0 , the area of the rectangle shown with the dashed lines.



When productivity increases and the supply curve shifts down and to the right, price falls from p_0 to p_1 and quantity increases from q_0 to q_1 , the red triangle expands and the blue triangle shifts downward and to the right. The consumer now pays p_1q_1 . Consumer surplus is now much larger. An upper bound to the increase in consumer surplus is captured in a quantity index that values the added production ($q_1 - q_0$) at the old, higher price p_0 , so that the real output increases to the rectangle bounded by the dashed horizontal line and the solid vertical line. Thus the real increase in output, measured at prices in the base year (p_0), captures the increase in consumer surplus.

Advertising-supported media has zero out-of-pocket costs for consumers. Therefore, the dotted rectangle has no volume and BEA's current methodology assigns no value to it. Its impact on the consumer is thus inherently difficult to capture in measures of economic output. Brynjolfsson and Oh (2014), attempt to capture some of consumer surplus by measuring the time

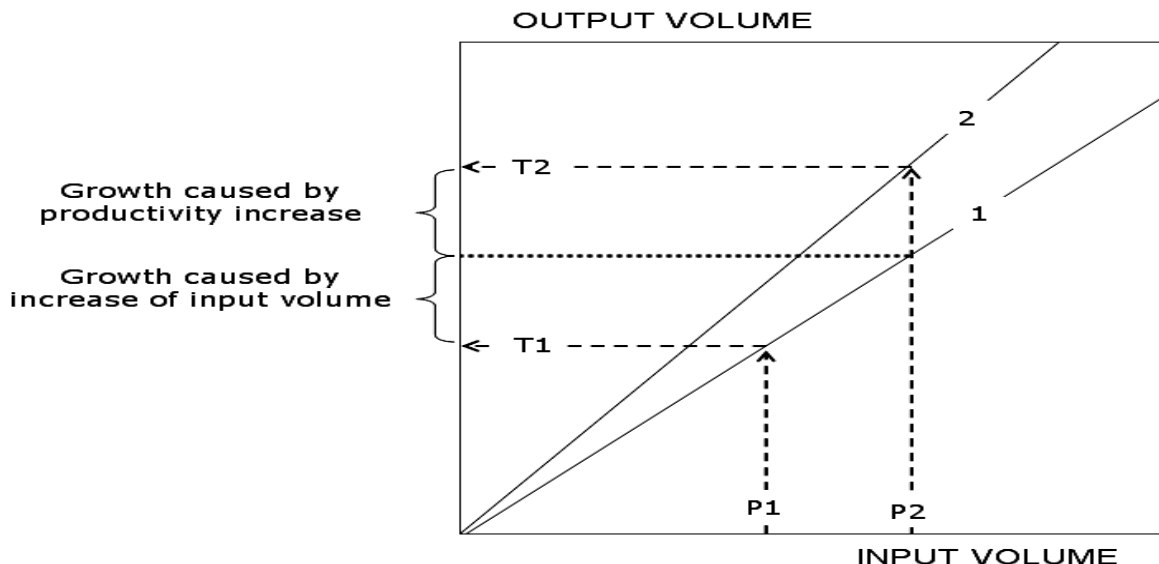
expended on the Internet. Varian (2009) argues that much of the value of the Internet is in time saving, an additional metric for capturing consumer surplus. He performs a back-of-the-envelope calculation of the savings of time from search, based on the search time savings estimate in Chen et al (2013), which is 15 minutes per search. Noting that on average Americans search once a day and calculating the average value of time as \$22, for employed workers, and multiplying by the number of employed workers, he concludes that Google save Americans \$65 billion a year.

However, those measures of consumer surplus are based on an implied opportunity cost of leisure time; with leisure time being based on surveys. This implied value of leisure time is estimated based on regression analysis, and has not been used in other contexts within GDP measures. In particular, we do not have any clear idea of how closely tied this measure of consumer surplus might be to economic activity. To make the argument differently, the weather may have a large impact on how much consumers enjoy certain recreational activities, but because this weather impact is not closely tied to economic activities, we do not include it in GDP; by comparison the improvement in consumer surplus captured in the demand-supply diagram is very closely tied to economic activity and direct economic measures.

This paper uses an experimental methodology to value advertising-supported media. Our estimated value is based on the **actual** costs of producing ‘free’ media. By design, our estimated value is calculated using very similar methodology to BEA’s published GDP statistics. Accordingly, we can compare our estimated value for ‘free’ media to overall GDP without conceptual problems. Furthermore, we can also use standard productivity formulas to calculate the productivity impact of ‘free’ media by industry. It should be noted that when we measure value from the cost side we may not track consumer surplus or consumer welfare as closely as we would in the presence of prices. A similar problem arises in the measure of the real output of government services such as public education or national defense. Nevertheless, our production oriented accounting is much less dependent on modeling assumptions than competing estimation techniques

Measuring Total Factor Productivity (TFP) and TFP Growth

Productivity researchers generally work with a stylized model of the firm: it uses inputs and produces output for sale in the market. The basic problem for TFP measurement is shown in the figure below.



If all inputs were held completely fixed, TFP growth would be easy to measure. The formula to calculate TFP growth would simply be:

$$\text{TFP growth from Years 0 to } t = (\text{Output}_t) / (\text{Output}_0)$$

However, the situation is much more complicated when inputs change over time. In that case, researchers need to break down the problem into two stages. First, they estimate the output that would be produced in year t if technology and other outside factors were held fixed from year 0 to t . After they've made this estimate, they calculate:

$$\text{TFP growth from Years 0 to } t = (\text{Output}_t) / (\text{Predicted Output}_t)$$

Unfortunately, predicting output is a hard problem. Most researchers studying TFP use a productivity formula that implicitly predicts output from input changes. That standard productivity formula is based on a simplified model that assumes constant returns to scale,

smooth production functions, and competitive industries with profit-maximizing firms. In addition, current output and prices are assumed to be unrelated with past output or prices.

Obviously, this simplified model is not a perfect match for Silicon Valley firms. For example, the URL business model assumes that lower prices now help companies become more efficient and eventually profitable. This contradicts the assumption that current output is unrelated with past prices. However, many other industries also violate some of the assumptions listed above. A researcher who tried to account for all the complexities of each industry would quickly find the calculations impossible. Most researchers use the standard productivity formula as a starting point when comparing TFP across industries, over time or across countries. We will follow the literature and use the standard TFP formula to estimate the impact of ‘free’ apps on aggregate productivity. For more discussion on TFP measurement, see ‘Education, Participation, and the Revival of U.S. Economic Growth’ (Jorgenson, Ho and Samuels 2015).

Current Treatment of Advertising-Supported Media¹ in SNA 2008 and the U.S. National Income Accounts

In the SNA 2008 and the U.S. Bureau of Economic Analysis (BEA) National Income and Production Accounts, advertising-supported media is treated simply as an intermediate input to the production of advertising slots. If we think of soap as being the advertised good, then a YouTube video produced to entertain households is an expense of the media company, which then sells the advertising slot to the soap manufacturer. In turn, the cost of the advertising slot is an expense of the soap manufacturer just like physical inputs such as lye or fat. In this treatment, there is no directly-measured consumption benefit to the consumer of the entertainment provided, except to the extent that the consumer pays for the hardware and services associated with receiving the entertainment, such as the computer or internet service.

The difficulty with that treatment is advertising-supported media provides a much greater value to consumers than the cost of a television set. Because advertising-supported media

¹ Our discussion assumes that media companies earn money by selling advertising services to outside companies, but the economics are the same if media companies collect and sell private information for non-advertising purposes like product design. We just use the word “advertising” because it would be too cumbersome to say “advertising or information collection.”

provides so much value to consumers, it seems wrong not to count it in the final expenditures. This difficulty is highlighted when television or the Internet bids entertainment or content providers, such as NFL teams away from the paid entertainment sector into advertising-supported media. Under the current treatment, these sports teams cease to be providing consumer recreation services and become advertising instead. A consequence is that in the 1950s, for example, real consumer recreation services declined in a period in which real personal consumption per capita rose substantially because households switched from movies to television as their prime source of entertainment. Another way to think about this is to consider how the value of a TV set to the consumer is affected by an increase in the number of ad-supported channels being broadcast. The increased variety increases consumer choice and therefore welfare. Should this improvement in welfare be reflected in the quality-adjusted price for television sets? Holding nominal output fixed, this decline in quality-adjusted prices for television sets would result in a real output increase for the TV equipment producing industry. In turn, this real output increase would result in an increase in measured TFP, even if there is no change in the direct product or process of the TV equipment producing industry.

It is useful to clarify the conundrum with the following highly stylized model. We consider a soap manufacturer, an entertainer, and households.² The soap manufacturer must advertise to sell the soap. Initially, the soap manufacturer spends \$550 to make the soap, spends \$250 on advertising with no entertainment value, and sells 800 bars of soap for \$1 each. The entertainer sells 100 tickets to her act for \$2 each. One hundred households each spend \$8 for soap and \$2 for entertainment. Now, suppose the soap manufacturer pays the entertainer \$200 to include an advertisement for soap in her program and cuts other costs by \$200. The entertainer now allows the same 100 households to attend her act without charging for tickets. The 100 households receive the soap and the entertainment but pay only the \$8 per household for soap (and listen to a soap announcement). For simplicity, we assume that the demand for entertainment is unaffected by this switch. In other words, households act as if they were paying \$2 for the entertainment, but instead, they are viewing the advertising and they appear to

² For simplicity, we assume that the entertainer produces and broadcasts the content by herself. In a more realistic model, the soap company might purchase advertising slots from a broadcasting company. In turn, that broadcasting company might purchase content from a production studio. The imputed barter transaction of advertising viewership in return for content is the same and measured GDP is the same.

perceive that viewing the advertising costs them \$2 each. Roughly speaking, the households consume the same amount but pay less out of pocket.

In the current national income accounts treatment, output drops. The entertainment is no longer measured as part of personal consumption, only the soap is. In the initial case, \$1,000 in economic resources was used to produce \$1,000 in consumption output. With advertising-supported entertainment, \$800 is used to produce \$800 in consumption output. Effectively, \$200 has disappeared from real output. However, this appears to be a misrepresentation in that the households are still consuming the same real amount of entertainment, but it has disappeared from measured output.

One possible treatment would be to view the entertainment with advertising as having the same real value but falling in price to zero. That is, nominal output is \$800, but real output is \$1,000. While we do not actually observe the market value to the consumer of the entertainment in most cases, we can impute the market value from the payment to the entertainer. But the some economic formulas do not work well when analyzing goods and services with zero prices. For example, it is difficult to explain why consumers sometimes pay to avoid advertising if the price for advertising-supported media is zero. Furthermore, if the situation should reverse and a price be paid, the rate of inflation for that item cannot be calculated.

A more satisfactory treatment, proposed by Cremeans (1980), and pursued in this paper, would be to consider the transaction as a barter trade of entertainment received by the consumer in exchange for which the consumer agrees to view the advertisement. We would record a dollar as paid by the consumer to the soap manufacturer for the entertainment, and the soap manufacturer would pay it back to the consumer for viewing the advertisement. In this treatment, advertising-supported media is reflected in the real income and consumption of the consumer. The amount mirrors the true value of entertainment to modern society and in a way which finds parallels with the treatment of similar products with no out-of-pocket price, such as residential services of owner occupied dwellings and financial services of checking accounts.

An alternative satisfactory treatment was recently proposed by Charles Hulten. Hulten argued that 'free' media can be viewed as a gift from media companies to consumers. In that case, we record the entertainment received by the consumer but do not record any service

received by the media company. Conceptually, this is parallel to the treatment of non-profit organizations serving households. This treatment has the same impact on measured GDP and gross industry output as Cremeans's 1980 treatment. But it is unclear how to attribute output gains when businesses receive inputs as gifts from other businesses. The gift raises the output of the gifting business without lowering the value-added of the gifted business. This violates the balancing of gross output with inputs that underlies productivity accounts.

Previous Research on Noncash Payments in GDP

Our experimental methodology does not require any major conceptual changes to SNA. In this paper, we treat advertising-supported media as a payment in-kind for services produced by households. SNA 2008 already counts other noncash payments as labor income (Section 7.51). SNA also imputes cash values for barter transactions (Section 3.75), owner-occupied housing (Section 6.34), and financial services indirectly measured (Section 6.163). Just as with those transactions, we impute a value for advertising-supported media based on estimated costs. However, since the household is not 'employed' by the media producer, we treat the household production of the service of providing access to advertising as a form of production by an unincorporated household enterprise. To minimize the deviation from BEA's official accounts, we do not consider the production process for this advertising viewership. We intentionally avoid this due to the plethora of issues involved in measuring household production.

Our paper is not the first to discuss treating advertising supported media as payment in-kind. Imputation for advertising-supported media was first raised in *The National Income – 1954 Edition* and was extensively discussed in the 1970's (Ruggles and Ruggles 1970, Okun 1971, Jaszi 1971, Juster 1973, Eisner 1978, and Kendrick 1979). The paper "Consumer Services Provided by Business Through Advertising-Supported Media in the United States" (Cremeans 1980) estimated that advertising-supported media was worth \$28 billion in 1976.³ Vanoli discusses this issue in *A History of National Accounting* (2005). More recently, *Businessweek*

³ For the same year, we estimate that advertising-supported entertainment added only \$8 billion to GDP. The main reason for the difference is the fact that we do not count non-media costs and advertising-supported business information in final expenditures. Neither our research nor the literature cited in this paragraph includes the value of amateur media production like personal blogs in GDP.

published an article in 2013 (Ito) and the Wall Street Journal published an article in 2015 (Aeppel) criticizing the BEA's GDP numbers for excluding 'free' online media. Recent work by the OECD focuses on many of the issues involved in measuring the digital economy, including 'free' consumer products (Ahmad and Schreyer 2016). Finally, we have previously written papers studying advertising-supported media and advocating that it be treated as a payment in kind (Nakamura 2005; Soloveichik 2014; Nakamura and Soloveichik 2015).

This paper extends the earlier research by considering how to account for the URL model within our methodology and by developing input-output and productivity accounts for advertising-supported media. Like other productivity statistics, this decomposition does not directly change aggregate GDP measurements. Instead, the decomposition allows researchers and policy makers to better understand the sources of GDP growth. In particular, our productivity statistics show faster TFP growth in the online media industry and slower TFP growth elsewhere.

Effects on Measured Consumer Welfare, Productivity and Other Summary Statistics

Our experimental methodology produces more intuitive welfare comparisons. In the United States, many sporting events are now moving from broadcast television to cable television. As cable television networks generally show the same amount of advertising as broadcast networks, consumers are unambiguously worse off from the switch. They are now required to pay subscription fees to get content they had previously viewed without any out-of-pocket costs and some refuse to pay the new fees and forego the entertainment. Yet, SNA's current methodology treats the new cable subscribers as a real GDP increase. Under the alternative method, real GDP falls. This drop in viewership is considered a decrease in final expenditures. Nominal GDP will likely rise with the switch from broadcast television to cable television. However, that nominal GDP growth would be more than canceled by higher prices for entertainment caused by the switch.⁴

⁴ This discussion focuses on the short-term effects of a switch. In the long-term, the higher earnings caused by the switch of sporting events from broadcast television to cable television may well result in more sporting events becoming available in more markets as well as in higher salaries to players, inducing higher-value workers to enter the competition and improving the quality of entertainment.

Similarly, our experimental methodology produces more intuitive productivity comparisons. In the early 2000's, many drivers purchased GPS software like Garmin or TomTom which provided driving directions. In recent years, advertising-supported services like Waze or Google Maps have taken over the industry. Even counting the implicit cost of viewing ads, the new advertising-supported services are cheaper to use. Accordingly, restaurants which require driving directions are unambiguously better off from the switch as the total cost of their meals has fallen and more customers go to them. SNA's current methodology treats these lower costs as a TFP increase in the restaurant industry. Under the experimental method, TFP in the restaurant industry is unchanged. Instead, the TFP growth is allocated to the Silicon Valley firms which are offering high quality driving directions cheaper.

By construction, the nominal income 'earned' by consumers watching advertising is equal to the nominal value of entertainment 'purchased'. As a result, our experimental methodology has no effect on consumer savings. Similarly, the nominal income 'earned' by business users watching advertising is equal to the nominal value of information 'purchased' and our experimental methodology has no effect on corporate profits. If the media provider is located in the same country as the viewer, imports and exports will be unaffected. If the media company is located in a different country, imports and exports will increase by the same amount with no effect on the net nominal balance of trade.

Consumers often need to buy expensive equipment before they can enjoy advertising-supported entertainment. SNA 2008 currently counts televisions, radios, smartphones, and computers as consumer durable goods. However, one could argue that those consumer durables should be reclassified as capital investment if advertising-supported media is considered an in-kind payment for advertising viewership. This change would have no impact on measured GDP, but it would increase capital stock and decrease the stock of consumer durables. In that case, the value of advertising-supported media would be considered mixed income and represents compensation for both the time spent watching advertising and the capital necessary to watch advertising. If SNA 2008 chose to implement our experimental methodology, the value of advertising-supported entertainment would be added to 'proprietor's income' (or 'mixed income' in SNA terminology) (NIPA Table 1.10, line 13). We do not pursue this approach here.

In practice, measuring cable prices is tricky and BLS's existing price indexes may not adjust for quality perfectly.

Other Research on Advertising, Brand Equity and Entertainment Originals

Our research on advertising-supported media is distinct from the rich literature on advertising. Previous researchers have studied why advertising exists and calculated how much firms should optimally spend on advertising (Dorfman and Steiner 1954; Nerlove and Arrow 1962). Other papers have argued that advertising increases sales over the long run, and therefore, they should be considered an investment in brand equity (Nakamura 2005; Corrado, Hulten, and Sichel 2009). All of this research is focused on the companies which purchase advertising viewership and then use it to sell products and build brand equity.⁵ In contrast, our research is focused on the media companies which produce content, barter the content for advertising viewership and then sell the advertising viewership to the rest of the economy. None of the results in this paper depend on how companies use their purchased viewership. The only thing that matters is that companies want advertising viewership and are willing to pay for it.

Advertising-supported media is also distinct from entertainment originals. Entertainment originals are long-lived intangible assets owned by media companies and artists. It is true that entertainment originals are sometimes used to produce advertising-supported media such as television. However, the categories are not identical. Advertising-supported media includes short-lived media such as newspapers, sporting events, and other entertainment that is not part of capital stock. Conversely, entertainment originals are used to produce consumer products such as DVDs or books that are sold to consumers and counted in personal consumption expenditures. This paper uses some of the data originally collected for a project on entertainment originals (Soloveichik 2013a, b, c, d, and e), but none of the results in this paper depend on the treatment of entertainment originals in GDP.

⁵ In addition, the marketing expenditures studied in those papers include more than ads shown on 'free' media. For example, companies can increase sales with telemarketing calls, junk mail and other products that aren't generally bundled with entertainment or useful information.

Section 2. Nominal Media Production and Consumer Entertainment

Nominal Output of Advertising-Supported Media

When measuring advertising-supported media, we study the four separate media categories discussed earlier: a) printed newspapers and magazines; b) broadcast radio and television; c) cable and other non-broadcast television and radio⁶ and d) online media.⁷ In some cases, the line between one category and the next is speculative. In particular, many websites contain articles originally produced for print publication. Our estimates of nominal media production are not sensitive to the split between the categories. However, each category has its own price index – so real growth rates may change if the split changes. Appendix B contains detailed information on the datasets used to track nominal advertising revenue and the benchmarking procedures.

Figure 1 shows advertising revenue by media category over time. Since 1998, online media has grown from almost nothing to 0.27% of nominal GDP. Over the same time period, print advertising shrunk from 0.56% to 0.13% of nominal GDP. The growth of Internet is almost certainly responsible for most of the print decline. Classified advertising has moved from newspaper sections to websites. Printed news articles are also being replaced by blogs and online newspapers. Print media advertising has also fallen in the past due to competition from radio and television. The same dynamic has been playing out more slowly in the television industry. Between 1980 and 2013, cable television grew from 0.08% to 0.41% of nominal GDP. Over the same time period, broadcast radio and television shrunk from 0.34% to 0.11% of nominal GDP. Consumers are clearly willing to substitute from one media to another.

Not all of the advertising revenue shown in Figure 1 is used to produce entertainment. Media companies need a sales staff to reach out to advertisers, plan the exact format of the ads, and bill the advertisers afterward. Reporters and editors may focus on topics useful for

⁶ This category includes all television viewed by households with cable, even if the channel is available over-the-air. We also include satellite cable, online videos and podcasts. We assume that all of these shows are produced and delivered with the same technology, so they have the same price index. In our sample period, cable television accounts for the majority of this category, so we will sometimes refer to the category as simply 'cable television'.

⁷ We subtract online audio-visual material from the online media category to avoid double-counting.

advertisers rather than for readers. In addition, printed media such as newspapers spend money printing ads and then stuffing them in news sections. In earlier research, we estimated that non-media costs account for 50% of newspaper advertising, 72% of magazine advertising (Nakamura 2005), and 25% of television, radio, and online advertising (Soloveichik 2014, Soloveichik and Wasshausen 2013 and Soloveichik 2013 a, b, c, d and e). When calculating non-media costs, we assume that these within-category ratios are fixed from 1929 until 2013.

Figure 2 shows estimated share of advertising revenue devoted to media content. From 1929 to 2013, the media content share of advertising grew from 45% to 69%. This steady increase is caused by a composition shift. Figure 1 shows that print media has been steadily declining relative to the other media categories. Relative to the other media categories, print media outlets spend a much larger share of revenue on physical production costs, so they have less advertising revenue available to subsidize media services. As a result, advertising-supported media has grown faster than overall advertising.

It is important to note that Figure 2 only measures the estimated cost of providing advertising-supported media, not the value that media users derive from the media. Just like much consumer surplus, this value is not counted in either GDP or TFP.⁸ Furthermore, the estimated cost is an imperfect proxy for the market price that might have been charged. This problem has been studied previously for government output, non-profit output and other items where GDP methodology uses costs as a proxy for value. Finally, a fixed ratio for non-media costs misses variation that may occur over time. As a robustness check, we collected IRS data tracking (Total Expenditures) relative to (Total Revenue) by industry and year. We found that adjusting for this variation increases the value of online media during the dot.com bubble and reduces volatility over the business cycle slightly – but it has little impact on long-term results.

⁸ A particular problem with media valuation is that media production costs are a lower bound on the market price that would be charged if advertising support did not exist. Media companies selling to individual users typically spend significant resources billing customers and dealing with payment issues. These costs are especially important for broadcasters and Internet publishers, which do not currently require out-of-pocket payments at all.

Media Usage by Consumers vs. Businesses

As we discussed earlier, our primary data on advertising revenue is taken from the 2007 Economic Census. The Economic Census splits advertising by format and product category – but it has no data on whether consumers or businesses are viewing the ads. In a few cases, the products advertised provide some clue about the likely industry of the user. For example, hospitals are the main purchasers of MRI machines – so magazines with ads boasting low prices for MRI machines are probably targeting hospital executives. But most websites target a general audience and have advertising unrelated to the precise media services provided.⁹ We talked to Hal Varian, who is the chief economist at Google, and he said that Google does not have much information on whether consumers or businesses are viewing their ads. To the best of our knowledge, no company or researcher has published any estimates of the consumer share for ‘free’ websites, advertising-supported newspapers and other sources.

This paper uses a variety of data sources to split media usage between consumers and businesses. For online media, we use survey data from Forrester Research. Since 2007, Forrester Research has asked survey respondents to report both ‘work Internet’ time and ‘personal Internet’ time. We use this data to estimate the consumer entertainment share of online media. For print media, we use genre data reported in the Economic Census and other sources to split consumers and businesses. For example, we assume that scientific journals are used for work rather than leisure. We were not able to find any data on the consumer share for radio or television. For now, we use our best judgment to pick a reasonable split. More information on the procedures used is given in Appendix B.

Figure 3 shows the estimated GDP share of advertising-supported media devoted to consumer entertainment. From 1929 to 2013, the entertainment share has hovered around 80%. Radio and television programs consistently have a higher entertainment share than average and Internet media has a lower entertainment share. However, neither the introduction of television in the 1950’s nor the introduction of Internet in 1990’s significantly changes the overall consumer entertainment share. This suggests that the overall demand for entertainment relative to business information is fixed and does not depend on the precise delivery technology.

⁹Even when a business is using a website for work, the advertisements may still push consumer products. Conversely, consumer entertainment products might push business inputs. In both cases, the advertisers are hoping that the website users carry the message between work and home.

Figure 4 shows the increase in nominal GDP from including advertising-supported entertainment. Consistent with Brynjolfsson's research, online consumer entertainment has grown enormously in the past decade and now accounts for 0.11% of nominal GDP. However, this growth is more than canceled out by a decrease in print advertising-supported entertainment. Total advertising-supported entertainment shrunk from 0.54% of GDP in 1998 to 0.50% of GDP in 2013. As a result, nominal GDP growth decreases slightly when 'free' media is included in final expenditures. Between 1929 and 2013, advertising-supported entertainment has hovered around 0.5% of nominal GDP. Therefore, long-term GDP growth is almost unchanged by our experimental methodology.

Figure 5 shows the value of advertising-supported business information relative to nominal GDP. The most striking difference between Figures 4 and 5 is that advertising-supported business information is much smaller than advertising-supported consumer entertainment.¹⁰ Despite the size differences, recent patterns are very similar. Just like consumer entertainment, we find that online business information has grown dramatically and print business information has shrunk. It is important to note that the advertising-supported business information shown in Figure 5 has no direct effect on measured GDP or aggregate value added.¹¹ Like all intermediate inputs, their cost is already captured in the purchase of the final expenditures and the value added of the industries that produced the intermediate inputs. Nevertheless, these numbers are potentially useful for researchers studying gross output, productivity by industry and other related parts of the national income and product accounts.

Comparing Our Results to the Industry Literature

In 2013, we estimate that online entertainment added \$19 billion to the United States GDP. This is not a trivial amount, but it is far lower than alternative estimates. For 2011,

¹⁰ Advertising-supported media is only one way for companies to market to businesses. In addition, many companies also supply 'free' training, free product samples and other marketing-supported learning opportunities to potential business customers. We hope to study this marketing-supported education in a future paper.

¹¹By construction, GDP depends only on final expenditures – so the intermediate outputs should be irrelevant. In practice, BEA uses expenditures as a proxy for government and non-profit output. As a result, changing intermediate input prices has the potential to affect measured output prices. For simplicity, we will ignore this aspect of GDP measurement in our paper.

Brynjolfsson and Oh (2012) estimated a value of \$376 billion based on time use data.¹² The Boston Consulting Group (Dean, Digrande, Field, Lundmark, O’Day, Pineda, and Zwillenberg 2012) estimated a value of \$500 billion in 2011, based on consumer surveys and an economic model. The much higher numbers are a consequence of different methodologies. Both studies use indirect methods to estimate the consumer utility gained from leisure time spent online. However, this paper is trying to estimate only the cost of producing online media. There are many areas of the economy in which consumer spending on an activity is much lower than total utility for that same activity. For example, sleeping occupies about one-third of total time and provides enormous utility. Yet, beds represent a very small fraction of consumer spending.

On the other hand, our estimates are consistent with pre-existing estimates of the consumer value for high-speed Internet. In 2006, Greenstein and McDevitt (2010) estimated that U.S. households received \$20 billion to \$22 billion of value from broadband Internet. In comparison, we estimated that U.S. households enjoyed \$7 billion worth of advertising-supported online entertainment in 2006.¹³ This \$7 billion excludes consumer utility from non-advertising online activities such as Wikipedia or Skype. It also excludes the value received by self-employed individuals who use residential Internet for business purposes or home-owners who use their Internet to research do-it-yourself home repair. We do not know the value of those activities, but it seems plausible that adding them would raise our numbers enough to be in the same ballpark as Greenstein and McDevitt (2010).

Section 3: Price Indexes for Media and Advertising Viewership

Media is a very difficult service to deflate properly. One issue is that media users constantly demand original content – so we cannot track the cost of producing the exact same website over time. In addition, media is a non-rival good with poorly defined units of output.

¹² Brynjolfsson and Oh’s paper (2012) values free websites, which is not exactly equivalent to advertising-supported websites. But that only explains a small portion of the difference.

¹³ Consumer utility from viewing websites = (Cost of Advertising-Supported Entertainment) + (Consumer Surplus from Websites) – (Disutility from Viewing Ads). Our methodology measures neither the consumer surplus from websites nor the disutility from viewing ads. For simplicity, we assume they cancel out.

For example, a blogger might switch from writing a few long posts to writing many short tweets. Is this change an increase or decrease in total output? Finally, media quality depends on the quality of the durable goods used in the production of the entertainment services, and that quality has risen dramatically. This applies to both the production of entertainment services by media publishers and the production of entertainment services in the home. For example, the quality of Google searches is enhanced by improvements in the cloud hardware and software employed by Google in conducting the searches as well as by the growing availability of websites to be searched. Similarly, high-definition televisions (HDTVs) and monitors enhance the quality of videos and television programs being watched and, indeed, the videos have higher production values to take advantage of the improved receiver quality.

The price indexes that will be presented in Figures 6-9 do not account for network effects, positive externalities from media consumption or other media-specific factors. We believe that those factors probably raise online media quality over time and therefore lower quality-adjusted prices. As a result, the inflation rates shown for online media should be seen as being on the upper end of the true inflation rate. On the other hand, size and direction of the bias for other media categories is harder to measure. In addition, the experimental methodology developed in this paper may have secondary implications for price measures for media which are partially advertising-supported and partially paid by users. These implications are a topic for future research. For now, we hold all other price indexes in the industry-level production account fixed.

Prices for Online Media

We start by constructing a price index for online media. The three main inputs to online media are software, computers to run the software, and everything else. For example, search engines start out with complex algorithms to optimize the search process. They then run those algorithms on server farms every time someone enters a query. In addition to those direct costs, online media companies also have overhead costs such as salespeople, utilities, and rent. We were unable to find price indexes specific to the software used by online media companies, the computers used to process requests, or their overhead costs. Instead, we use the BEA's price indexes for prepackaged software (Table 5.6.4, line 3) as a proxy for software costs; and a price

index for cloud computing services reported in ‘ICT Prices and ICT Services: What Do They Tell Us About Productivity and Technology’ (Byrne and Corrado 2016) as a proxy for computer costs; and BEA’s price index for personal consumption services (Table 1.1.4, line 6) as a proxy for overhead costs.

Figure 6 shows the combined price index for online media together with the individual component prices.¹⁴ We find that online media prices have fallen approximately 12% per year. Most of this decline is due to plummeting cloud computing prices; the small price declines for software mostly cancel out the small price increases for services overhead. At first glance, our price index appears to assume zero productivity growth in the online media industry. In fact, we assume that modern computer programmers are much more productive at writing software than they were in 1995. This rising productivity has allowed prepackaged software prices to fall 4% annually even as programmer wages rose. Similarly, data processing companies have become much more productive at using their servers to provide computing services. This productivity increase has allowed cloud computing prices to fall faster than prices for business computer investment. We assume that programmers producing own-account software for online media companies and servers producing own-account cloud computing services for online media companies have enjoyed similar productivity gains. Therefore, output prices for online media fall faster than average input costs.

Prices for Print Newspaper and Television

We construct a price index that covers both newspapers and magazines. Book publishers produce a very similar product to newspapers and therefore wholesale book prices are a good proxy for the costs of writing, editing, printing, and delivering newspapers. We use the BEA’s price index for book originals (Table 5.6.4, line 25) as a proxy for all those costs. As with consumer software, this is an output price and therefore includes some productivity growth over time. However, newspapers and magazines generally require more outside research than books do. We were not able to find any data specific to journalist research costs, but we believe that

¹⁴ Our combined price index is a simple geometric mean with equal weights for each component. The combined price index is very sensitive to the weights assigned to each component and the averaging technique.

those costs are related to communication technology. Before 1995, journalists did most of their research over the phone, so phone costs are a good proxy for non-labor research costs. Over the past few decades, journalists have been gradually shifting to online research, and therefore, the online media price index developed in Figure 6 is a good proxy for non-labor research costs.

Figure 7 shows the combined price index for print media together with the individual component prices.¹⁵ Unlike online media, newspaper prices have been rising steadily over time. It is true that cell phones and search engines make reporting much easier and more efficient. However, the basic job of writing and then editing a story has not changed much, so there is little increase in labor productivity. Furthermore, wages for white collar professionals like authors or journalists have risen substantially over time. The net impact is steady price growth for print media production.

Prices for Cable and Other Non-Broadcast Television and Radio

We construct a price index for cable television. Unlike the earlier price indexes, we could not find proxy indexes for advertising-supported television. It is true that BEA tracks prices for CD's, DVD's, cable television, movie tickets and other products that seem closely related to advertising-supported television. However, those four price indexes display very different growth rates in the published data. Because of this discrepancy, we are reluctant to use any of those four price indexes in this paper. As an alternative, we will use input prices as a proxy for output prices. The input-based price index implicitly assumes that television networks have not become more productive at delivering their media content over time. Despite that assumption, measured productivity for television networks could rise if they become more productive at producing television programs over time.

The technology for cable television programs is relatively simple. They start out by buying or creating media content. Next, they deliver that content to subscribers using cables, satellites or other transmission technology. We identify three separate input prices to track: a) non-sports programming costs; b) sports programming costs; and c) program transmission

¹⁵ Our combined price index is a weighted geometric mean, with an 85% weight on books. The weight for online media starts at 0.5% in 1995 and gradually rises to 10% in 2014. Phone prices are weighted with the residual.

equipment. It is relatively easy to find proxy price indexes for the first two inputs. We use the BEA's pre-existing price index for long-lived television programs (BEA Table 5.6.4, line 24) as a price index for non-sports shows and the BEA's price index for sports tickets as a price index for sports programming (BEA Table 2.4.4U, line 209). Tracking prices from transmission equipment is slightly harder. In recent years, BLS has published a PPI for radio and television equipment manufacturing. However, that price index only covers a few years. In addition, the paper 'Prices for Communications Equipment: Rewriting the Record' (Byrne and Corrado 2015) strongly challenges BLS's price indexes for communications equipment. In this paper, we will use their price index (Table B.7, column 'Total Transmission Equipment') from 1974 until 2009. Byrne and Corrado's price index for transmission equipment tracks reasonably well with BEA's existing price index for television sets (BEA Table 2.4.4U, line 39). We will use that price index to extrapolate prices for transmission equipment back to 1959.¹⁶

Figure 8 shows the combined price index for cable television together with the individual component prices.¹⁷ We find that prices have been almost flat since 1990. This price growth is midway between the price declines in Figure 6 and the price increases in Figure 7. Intuitively, cable networks use more computers than print media companies and fewer computers than online media companies.

Prices for Broadcast Radio and Television

Like cable networks, broadcast networks use media content and transmission equipment.¹⁸ However, they have another capital requirement as well. Broadcasters need spectrum to transmit their content from the station to users. If they don't have sufficient spectrum, then the television signal may interfere with other users of the airwaves. We have not

¹⁶ Conceptually, the television set is a large part of the viewing experience and we should include television set prices in our input measure. However, that would add complexity without changing any long term results.

¹⁷ Our combined price index is a weighted geometric mean, with a 20% weight for sporting events, 70% weight for non-sports television programs, and 10% weight for transmission equipment.

¹⁸ When calculating our price index for broadcast television, we use Byrne and Corrado's price index for broadcast equipment (Table B.3, 'Radio Station Equip. ex. Satellite') instead of the price index for cable. According to their paper, the price for broadcast equipment has dropped dramatically since the 1960's – but not quite as fast as the price index for cable transmission. The rising relative price may explain why consumers have mostly switched from broadcast television to cable television. In this paper, we use a weight of 15% for sports programming, 52.5% for other television programs, 7.5% for broadcasting equipment and 25% for spectrum costs.

yet been able to find any data on programming costs for radio programs. For now, we assume that radio programming costs track television programming costs.

Unfortunately, it is very difficult to track prices for radio or television spectrum. The first paper discussing spectrum sales was published in 1959 (Coase). But the Federal Communications Commission (FCC) did not start auctioning spectrum until the 1990's and even now does not allocate spectrum entirely based on market demand. We have explored using the spectrum price index developed in Wallsten (2013). However, that index does not start until the 1990's, contains very few auctions of radio or television spectrum and is very noisy. So, there is no pre-existing price index that is perfect for our needs.

We construct a new price index for radio spectrum based on reported sale prices for radio stations in 'An American Radio Trilogy: 1975 until 2004' (Duncan 2004). After 2004, we use BEA's pre-existing price index for cell phone service (Table 2.4.4U, line 279) as a proxy for both airwave costs and transmission equipment costs. We were not able to find reliable data on spectrum prices before 1975.¹⁹ Before 1975, we use average revenue per licensed commercial radio station as a proxy for airwave costs. We were also unable to find data on television spectrum prices. For now, we assume that they track radio spectrum prices.²⁰ We welcome suggestions to improve our price indexes for spectrum.

Figure 9 shows the combined price index for broadcast media together with the five component prices. We find that prices for spectrum rights grew very rapidly after 1975. As a result, the calculated price index for broadcast television grew much faster than the price index for cable television.

As a robustness test, we also considered using quantity data to derive prices. The paper 'The Random Long Tail and the Golden Age of Television' (Waldfogel 2016) demonstrates a simple methodology to count television show production. We followed his methodology and

¹⁹ Duncan's book contains some data on radio station sales between 1970 and 1975 – but it does not have ratings data. As a result, we cannot adjust sales for quality. After 1975, the unadjusted and adjusted price indexes display very different growth rates. As a result, we do not believe that the unadjusted price index before 1975 is reliable.

²⁰ As a robustness test, we explored using the share of households with cable as a proxy for television spectrum value. The basic intuition is that broadcasting equipment is cheaper than wired cable but the airwaves have limited capacity. So, the networks started out with broadcast and then switched to cable when the airwaves filled up. This proxy produces a very similar price history to the radio auction prices: spectrum values were low before 1975 and then jumped dramatically over the next ten years.

created a quantity index based on a simple count of all television shows running in the United States from 1949 onwards. Based on that quantity index, we calculate an indirect price index. We find that this indirect price index matches the input-based price index reasonably well.

Aggregate Changes to Real GDP

Even in our experimental methodology, watching television or surfing the Internet is not a highly paid activity. In 2013, we calculate that viewers received only 35¢ of content per hour of watching television ads. Other categories of ad viewership receive even less content per hour. In contrast, employees earned approximately \$31 per hour in 2013 (BLS series CMU10100000000D). Clearly ad viewership is closer to a leisure activity than it is to a work activity. Nevertheless, Americans spend huge amounts of time consuming media. As a result, the total value of advertising viewership contributed by the viewership sector is not trivial. In this section, we test the impact of advertising-supported entertainment on measured GDP.

Figure 10 recalculates our GDP quantity indexes when ‘free’ entertainment is included in final expenditures. We find that our experimental methodology raises GDP growth from 1998 to 2012 by 0.009% per year. This faster growth occurs despite the drop in the nominal GDP share for consumer entertainment shown in Figure 4. Intuitively, prices for advertising-supported media have been rising much slower than overall GDP prices. These falling relative prices more than compensate for the drop in relative nominals, producing faster real growth for advertising-supported media than overall GDP. As a result, measured GDP growth increases when advertising-supported media is included in final expenditures. The combined change of 0.007% per year can be decomposed into a -0.009% decrease associated with print media, a 0.002% decrease associated with broadcast media, a 0.010% increase associated with cable television and a 0.009% increase associated with online media. Before 1998, our experimental methodology has even less impact on long-term GDP growth rates. Advertising-supported media may be important to consumer welfare. But it is not a new source of economic activity that only arose in 1998. As a result, including advertising-supported in final demand does not change the overall trajectory of GDP growth much.

It is important to note that the real GDP numbers calculated above do not include the consumer surplus from advertising-supported media. An interesting measure of consumer

surplus was conducted by Noll et al (1973). They examine how much viewers were willing to pay for access to the three major TV networks in areas of the U.S. outside the broadcast range of one to three of these networks in 1969 (these are payments for no-frills community cable TV.) This permits them to estimate that the willingness to pay of U.S. TV viewers was close to \$20 billion, or some 10 times as much as the entertainment payments of TV advertisers. This suggests that consumers would be willing to pay up to \$0.07 an hour to watch advertising-supported television networks. This is substantially higher than the \$0.007 per hour that media companies spent on content in 1969. This large difference is one way of interpreting the discrepancy between our estimate of advertising-supported media values with the estimate of Brynjolfsson and Oh (2012).

Quantity Indexes for Advertising Viewership

If there was only interest in real GDP, Figure 10 would be enough to fully measure the impact of ‘free’ media on the economy. However, most policy-makers and researchers are interested in decomposing real GDP growth into the component parts of TFP growth for individual industries, quantity growth of capital, quantity growth of labor and quantity growth of other inputs. Holding real media output fixed, our experimental methodology treats more Internet surfing as an increase in inputs and therefore a reduction in TFP for the media industry. For other industries, more Internet surfing is considered an increase in gross output and therefore an increase in TFP. The intuition is that non-media companies use advertising-supported business information as an input. Ad viewership is the implicit payment for that ‘free’ business information, so it is counted as an output.

We will calculate advertising viewership quantities based on time use. First we estimate time spent by media category from 1929 to 2013. We then combine that time use data with the nominal advertising data shown in Figure 1 and calculate nominal prices per unit of time. This indirect calculation requires the strong assumption that the quality of advertising viewership has been constant over time.²¹ Appendix B contains much more detail on how we measure time use

²¹ This does not mean that advertising technology has been fixed over time. Rather, improvements in the technology for ad blocking may be canceled out by improvements in the technology for ad deliver. For example, DVR’s can be thwarted by ads at the bottom of a football game. The net effect of the arms race is assumed to be zero.

for each media category. We welcome suggestions for more data on time use or better proxies for the quantity and quality of advertising viewership between 1929 and 2013.

Figure 11 shows quantity indexes for advertising viewership from 1929 to 2013. Since 1950, we find that advertising viewership has grown much faster than overall population. That increase is partially due to increased media time per capita. But individuals are also consuming more advertising per unit of media consumption. The change was most dramatic for television viewers. Between 1950 and 2000, advertising slots increased from 15% to 30% of network time. The combined result is a huge increase in advertising exposure per person. If advertising viewership had remained constant over time, then measured prices for advertising viewership would rise much slower.

Section 4. Real Output, Real Input and Productivity by Industry

Recalculating TFP Using Our Experimental Treatment for ‘Free’ Online Media

This section calculates industry-level statistics for each of the 63 business sector industry categories tracked by BEA and BLS in their joint production accounts. We split the 63 industries between media companies and all other industries in the business sector. We then show how our experimental methodology impacts each category.²²

Figure 12 shows how our experimental methodology changes measured TFP. We find that measured TFP for media companies rises, raising business sector TFP growth by 0.011% per year. Internet publishing companies (NAICS 518 and 519) contribute the lion’s share of the TFP increase, but newspaper publishers also produce significant quantities of online media and contribute to the business sector TFP increase. Measured TFP for the rest of the business sector

²² In order to make our TFP numbers more comparable to the existing literature, we treat the household viewership sector as an entirely new industry. That new industry is not included in the 63 industry categories tracked in our calculation. We also exclude the government sector. Because of this focus, our TFP numbers only track private sector business and are not representative of the entire economy.

Our TFP calculations are based on the data set assembled in Jorgenson, Ho, Samuels (2015). These numbers do not always match perfectly with the joint BLS-BEA production accounts. However, the differences are typically very small and do not impact the revisions to TFP shown in this paper.

falls, lowering aggregate TFP growth by 0.005% per year.²³ The net effect is a combined TFP increase of only 0.007% per year. This change is not nearly enough to reverse the recent productivity slowdown.

At first glance, the numbers in Figure 12 appear implausibly small. Figure 10 showed that real GDP growth increases by 0.009% per year when online entertainment is included in final expenditures. Yet business sector TFP growth increases by only half that amount. These seemingly contradictory results can be explained by advertising viewership. Between 2007 and 2014, time spent online increased 80%. This increased time partially cancels out the increase in real media output. Conceptually, the real quantity of media received per hour online is roughly comparable to real wages. When labor hours increase, real GDP increases faster than real wages. Similarly, real online media output can increase faster than TFP in the online media industry

The revisions to measured TFP shown in Figure 12 are much smaller than predicted by the popular literature (Ito 2013, Aeppel 2015). The main cause of this difference is how we weight ‘free’ apps in our TFP numbers. The standard productivity formula assigns weights in proportion to gross output. Even in 2013, online media accounts for a very small share of the overall economy. Accordingly, higher TFP growth for Internet publishers has little effect on aggregate TFP growth. In contrast, the popular literature assigns weights in proportion to time use. By 2013, Americans spent more than 20% of their time online. If we used that weight to value ‘free’ apps, aggregate TFP growth would increase dramatically.

Recalculating TFP Using Our Experimental Treatment for ‘Free’ Online Media with Quality Growth

The business sector TFP numbers in Figure 12 are based the price index for online media developed in Figure 6. As we’ve discussed earlier, the price index in Figure 6 does not include any quality adjustment for network effects, user generated content or factors unique to Silicon

²³ At first glance it seems surprising that new technology like Waze is associated with lower TFP. However, Figure 12 is not showing actual TFP – but rather the revision to measured TFP caused by our experimental methodology. For example a restaurant might use Waze to get delivery directions. BEA’s current TFP statistics treat an improvement in the Waze directions as an increase in TFP for the restaurant industry. Our experimental methodology shifts the better directions from the restaurant industry to Silicon Valley, lowering measured TFP for restaurants and raising measured TFP for Silicon Valley.

Valley. In this section, we explore using bytes of data to proxy for these quality issues. Between 1998 and 2012, Cisco reports that IP traffic grew 79% per year. This growth rate continued throughout the dot.com bubble and bust, the Great Recession and the recent recovery. Based on that quantity growth, we calculated that quality-adjusted prices might have fallen as fast as 31% per year. As a robustness test, we will recalculate business sector TFP using that price index.

Figure 13 shows how the quality adjusted prices change measured TFP growth. Between 1998 and 2012, measured TFP growth now increases by 0.024% per year. This is five times the effect calculated in Figure 12, suggesting that quality growth may be very important when measuring advertising-supported online media. However, even a TFP increase of 0.024% per year is not enough to reverse the recent productivity slowdown (Syverson 2016).

Recalculating TFP Using Our Experimental Treatment for Print, Broadcast Media, and Cable Television

Even though the Internet receives the most popular attention, it is not the largest category of advertising-supported media. Figure 1 shows that online advertising is still much lower than television advertising and it has only recently surpassed print advertising. Just like online media, our experimental methodology includes ‘free’ print, radio and television media in consumer entertainment and business information. We can use the same TFP formulas developed earlier for online media to calculate how these media categories might change measured TFP.

Figure 14 shows the impact of print media. We find that measured TFP growth rises by 0.004% per year before 1998 and falls by 0.004% per year after 1998. These changes are not trivial, but they are smaller than the reductions in real GDP growth shown in Figure 10. Most of the reduction in real GDP growth shown in Figure 10 is caused by a reduction in the quantity of advertising readership. Like any other input, changes in advertising readership have no direct effect on measured TFP. These small effects may be explainable by the maturity of the print industry. Newspaper production technology has not changed much between 1948 and 2012.

Figure 15 shows the impact of broadcast radio and television media. Between 1948 and 1965, we find that measured TFP growth falls by 0.006% per year. After 1965, measured TFP

growth rises slightly. Most of the early TFP decline is probably associated with changing radio genres. Since 1965, approximately 80% of radio shows have been music oriented. Most radio music listeners are focused on activities like driving or exercising and are generally paying very little attention to the radio program. Prior to 1965, most radio programs were soap operas, quiz shows or other genres that require more attention. Holding everything else fixed, advertisers probably prefer listeners who are paying more attention. Therefore, the shift from soap operas to music programs can be seen as a quality decrease in radio listenership. It is possible that measured TFP growth would fall less or even rise if we adjusted our quantity index for listenership quality. This period also coincided with a government crackdown on radio payola, which might also impact measured TFP. This is a topic for future research.

Figure 16 shows the impact of cable television. Between 1975 and 2012, we find that aggregate measured TFP growth rises by 0.006% per year. This is almost as large as the 0.007% increase in TFP growth from online media shown in Figure 12. In recent decades, the dramatic growth in online media has received the lion's share of academic and policy-maker attention – but the growth in cable television also has large benefits to consumers. Recent research shows that the number of television shows produced each year has exploded without any apparent decline in their average quality (Waldfogel 2016). This increased variety is particularly beneficial for consumers with tastes different from the norm.

Other Effects of the Media Industry on Measured Productivity

In theory, the joint BLS-BEA production accounts already capture everything except advertising-supported media. For example, cable subscriptions are already in personal consumption expenditures (PCE) when purchased by consumers and already intermediate inputs when purchased by businesses. As a result, measured TFP should include the dramatic increase in the quality of media over time. In practice, quality improvement is sometimes hard to measure and BEA's existing productivity statistics may underestimate real output growth for some IT products and services.

Researchers disagree on how completely BEA's current price indexes capture quality change in the goods and services used to access media. In recent years, most research has

focused on Internet access. In the period from 2004 to 2009, Greenstein and McDevitt (2011a,b) take two different routes to measure the price of broadband services. Both studies find very modest declines in quality-adjusted prices, on the order of 2 % annually. These studies imply that the implied willingness-to-pay for broadband speeds and rapid increases in data downloads is not very high. However, these studies do not take into consideration the heterogeneity of broadband customers, which appears to be very high. This heterogeneity can be seen in the work of Nevo et al (2015), which uses hour-by-hour Internet data usage to estimate some 50 types of users, taking advantage of usage based plan differences across different plans. These usage based plans have different download speeds, covered by a fixed fee with a monthly download allowance and a linear price for downloads beyond the allowance. They calculate that consumer surplus for existing broadband customers is \$85 a month, while they pay \$70 a month. They further estimate that the adoption of Google Fiber (which has 14 times the download speed of the 2011 broadband average in the study) at \$70 a month (the current price offered in Kansas City) would increase consumer surplus to over \$200 a month, while tripling downloads.

Exactly how far quality-adjusted prices should fall is a difficult question to answer. An important issue is that the willingness-to-pay at a point in time is affected by the rapid change in the uses and usefulness of applications. For example, HD-televisions provide very little value for television shows filmed in low resolution but enormous value for television shows filmed in high resolution. Similarly, smartphones equipped with GPS technology have become much more useful with the introduction of location-based apps like Waze or Uber.

Broadband Internet, televisions and other media access spending account for a much larger share of GDP than advertising-supported media. According to BEA's published statistics, consumer out-of-pocket payments accounted for approximately 2% of GDP in 2012. In comparison, we estimate that advertising-supported consumer entertainment accounted for only 0.5% of GDP. Results are less detailed, but qualitatively similar for media usage by businesses. It is possible that the revision to measured TFP from new price indexes for broadband Internet services, television sets, or other media access technologies could dwarf the revisions to TFP shown in Figures 9-11. However, new price indexes for telecommunications, televisions and other media services are not directly related to the conceptual question of how to track advertising-supported media in GDP. After all, research on hedonic computer prices started long

before the Internet (Triplett 1989). This paper will focus on the advertising-supported media industry will not attempt to track every related good or service.

Section 5. Network Effects and Organizational Capital

URL: Ubiquity Now, Revenues Later

The previous sections have focused on media companies that rely on advertisers to subsidize the media content. In this section, we explore non-media Internet start-ups like Uber or Amazon who offer their goods and services below cost temporarily. A key feature of these firms is that they have positive user network externalities, that is, when more consumers use these sites each individual consumers benefit more from their own use. These network externalities are especially important for platform services like Uber or Airbnb which intermediate between users and providers. But they also apply to Internet companies like Amazon which offer goods and services directly. Sullivan (2016) provides a recent discussion of the importance of fast growth for Internet companies. In Silicon Valley, this is known as the URL (Ubiquity now, Revenues Later) business model. Early on, many Internet companies rely on venture capital funding to subsidize their products so that they can grow fast and achieve network externalities more quickly. In this section, we will explore accounting for venture-capital supported Internet companies which do not earn advertising money.

This poses an immediate challenge for output measurement.²⁴ BEA's current GDP statistics already include investment in research and design, software and entertainment originals. If these categories of intangible capital were the only components to creating a user network, then the current GDP statistics would measure network capital already. In fact, companies also invest in marketing, customer contact, business know how and other organization

²⁴ Another concern is the problem of price measurement, to the extent that the utility of the service may not be constant from period to period. Rather, quality increases over time: demand shifts outward over time, referring back to the figures in section 1, generating increases in consumer surplus that will not be well captured in standard price measures (see Nakamura 2014 for a discussion). Unfortunately, we are not aware of any method that would permit us to capture this type of utility gain.

capital. In this section, we explore how those categories of intangible capital might change the published GDP statistics. While firms are rapidly growing, building out their brands and market reach, they are expending more resources than they will need to once they have reached optimal size. One obvious example is Uber, which has been growing rapidly and in the process of growing rapidly has had a lot of expenditures in building intangible assets. It has invested in much more than its physical plant and equipment and as a consequence, since expenditures in intangible assets are generally expensed rather than capitalized, it has had relatively low profitability (and, despite that, a very high equity market value).

We will argue that customer reviews and other user generated content account for a large share of the network effects associated with the URL business model, and therefore even non-media companies are partially media companies. The barter transaction associated with customer reviews is conceptually similar to the barter transaction associated with advertising viewership: users pay less out-of-pocket in return for providing something useful. For example, Amazon has accumulated 35 million product reviews over 18 years.²⁵ These reviews would have cost billions for Amazon to write in-house. Even when customers do not actively review products, their decisions on what to buy, where to click and whether to seek a refund create implicit reviews for products and services. Accordingly, we can use the same experimental methodology developed earlier for advertising-supported media to recalculate GDP and TFP for non-media Internet start-ups.²⁶

Measuring The Value of User-Generated Content

The expenses of a firm that has pursued the URL model represent the expenditures the firm has made that might be considered to have been supported by the expectation of future revenues. The equity value of the firm might represent the expected value of those future

²⁵ Data up until March 2013 is available at <https://snap.stanford.edu/data/web-Amazon.html>

²⁶ The Internet allows consumers to participate in expressive activities such as as posting photographs, videotapes, political statements, product critiques, and artwork. These contributions blur the line between what is production and what is consumption. As production, they can be viewed as gifts to other individuals or as; Norman Mailer put it, "Advertisements for Myself." Prior to the Internet, individuals often participated in expressive activities with friends and family, but were not able to share their output worldwide and national accounts have generally excluded these household activities from GDP.

revenues, that is, the discounted present value of the flow of producer surplus that future sales are expected to generate. As such, the equity value should have some relationship to the past value received by consumers during the period of growth of the firm's network. Under free entry, the ex ante expenses and the ex ante equity value should be equal, across the set of firms competing to enter the market. In turn, overall ex ante and ex post equity value also should be equal. This would include the expenses of the firms that fail in their efforts to establish a network.

However, it is possible that some entrant may be able to exploit a uniquely valuable entry point that results in quick establishment of a monopoly, as Facebook did in its base in Harvard College, with its unique prestige. Such an early monopoly may break the equality between ex ante expenses and ex ante equity value. And the equity value will include the expected producer surplus of investments yet to be made, as the market value of a strong user base may well enable investments that have positive NPV.

Another difficulty, for the US national income and product accounts, is that the advertising base for an Internet firm may be the entire world, while we seek to measure the consumer gains to US domestic households.

With these caveats, two measures of the economic value to consuming households of these 'free' media websites might be (1) the expenditures for setting them up, one measure of which is the money raised from investors plus the expected future value of equity shares that reward the site's employees and (2) the equity value of the firm. Customer reviews represent a significant portion of the network effects which create firm equity. Therefore, we can use firm equity as an upper bound on the total output of customer reviews.

Leading examples of US social networks include Google, Facebook, Yahoo!, LinkedIn and Twitter. Together these five firms had an equity value of over \$650 billion in the middle of 2015, almost all of it generated in the past decade; only Google (\$50 billion in mid-2005) had a significant market value ten years ago. Thus these firms alone added \$600 billion in expected future value over the past decade, \$60 billion a year. This equity value is much larger than the advertising revenue earned by the firms over the same time period.

On top of that, worldwide the private valuation of the 131 start up private companies that had an individual valuation of \$1 billion or more, based on their financing round valuations, was some \$485 billion, according to KPMG CB Insights (2015). Out of that total, the US based firms amount to roughly \$300 billion. Assuming this investment was created over the past decade, this would add another \$30 billion a year to this investment. The case can be made based on these equity values that URL investments subsidize as much expenditures on behalf of consumers as are currently directly funded by Internet advertising, if we sum up the roughly \$1 trillion in equity value created. However, national accounting procedures depend on measuring flows of economic activity, rather than accumulations of equity value. We therefore turn to measures of the funding of Internet startups to measure the potential size of URL contributions to GDP.

Data from CB Insights on venture capital funding of US startups from 2011 to the third quarter of 2015 totaled \$218.5 billion (covering some 21 thousand deals), or \$46 billion a year for 4.75 years. This data does not include the additional funding raised through IPOs, but again, this will include many firms that do not expect to pursue an advertising model.

In order to be able to obtain a longer time series, we go to Standard and Poors Global Market Intelligence data service. We further limit the data to private equity funding of Internet firms, where we included all records for private placements in the US in six industries: Application Software, Data Processing and Outsourced Services, Internet Retail, Internet Software and Services, Online Gaming Operations, and Online Ticketing Agencies, going back to 1990. Notably, we see that in the Internet bubble era of 1999-2001, there was a sudden burst of private placement investments, amounting in total in the three years to \$84.5 billion. By comparison, in the period 2013-2015, we have recorded a total of \$75.4 billion. Thus the current episode does not imply an acceleration with respect to the earlier one in 1999-2001. On the other hand, it is possible that the current episode may prove to have more solid foundations.

Table 1 shows our annual numbers for private equity funding of Internet firms. The streams of private placement investment flows underlying the expenditures made by these Internet firms appear to be considerably less than this, more like \$10 to \$40 billion at most. Moreover, while there has been acceleration in this spending over the past few years, investments made were larger during the Internet bubble of 2000.

Figure 17 shows how measured TFP would change if venture capital-supported customer reviews were valued using the same methodology we used earlier for advertising-supported media.²⁷ Between 1998 and 2012, the experimental methodology increases average TFP growth by 0.003% per year. This average masks enormous variation over time. Between 1998 and 2000, measured TFP growth increases 0.03% per year. Measured TFP growth then falls with the dot.com bust and slowly recovers. As a result, accounting for Internet network effects actually makes the slowdown in TFP growth during the 2000's worse. Our TFP numbers end in 2012, so they do not include the recent acceleration in equity investment.

Concluding Remarks

The media sector poses a number of difficult questions for the national income accounts and the measurement of productivity. In this paper we have addressed one narrow question: how to account for advertising-supported media. We show that the Internet is not the first media category to be subsidized by advertising and many of the measurement issues can be addressed by a simple tweak to the current GDP measurement methodology. We then used our experimental methodology to recalculate GDP and GDP growth

We found that experimental method has a minimal impact on measured GDP growth and TFP growth. Between 1929 and 2013, nominal GDP growth rises 0.001%, real GDP growth falls 0.004%. Between 1948 and 2012, aggregate measured TFP increases by 0.006% per year when we include advertising-supported media in the input-output accounts. The main cause of the stability is that advertising-supported media has hovered around 0.5% of nominal GDP from 1929 to 2013. As a result, this category is simply too small to impact aggregate economic statistics much.

²⁷ For this graph, we use our pre-existing price index for online media to value non-media Internet products and services and our pre-existing price index for advertising viewership to value customer reviews. Just like advertising viewership, we focus on the short-term barter transaction and do not consider capital services.

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Figure 1: Advertising Revenues over Time

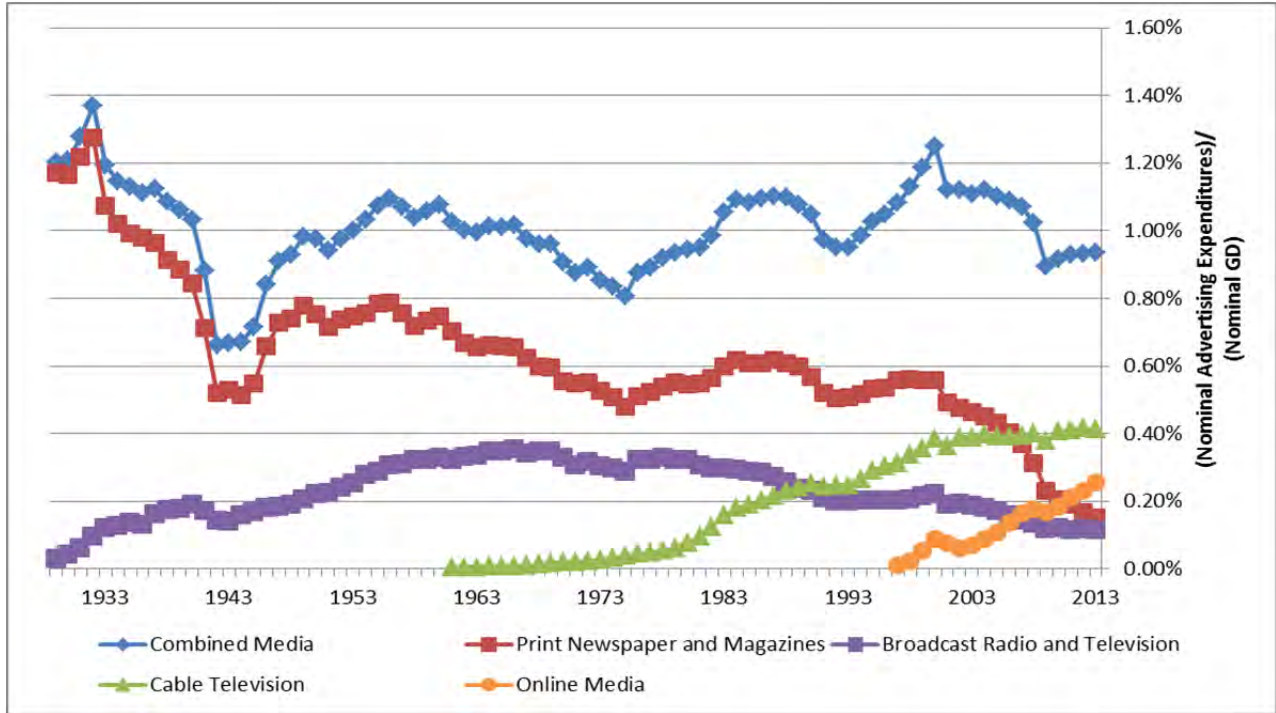


Figure 2: Share of Advertising Revenue Spent on Media Costs

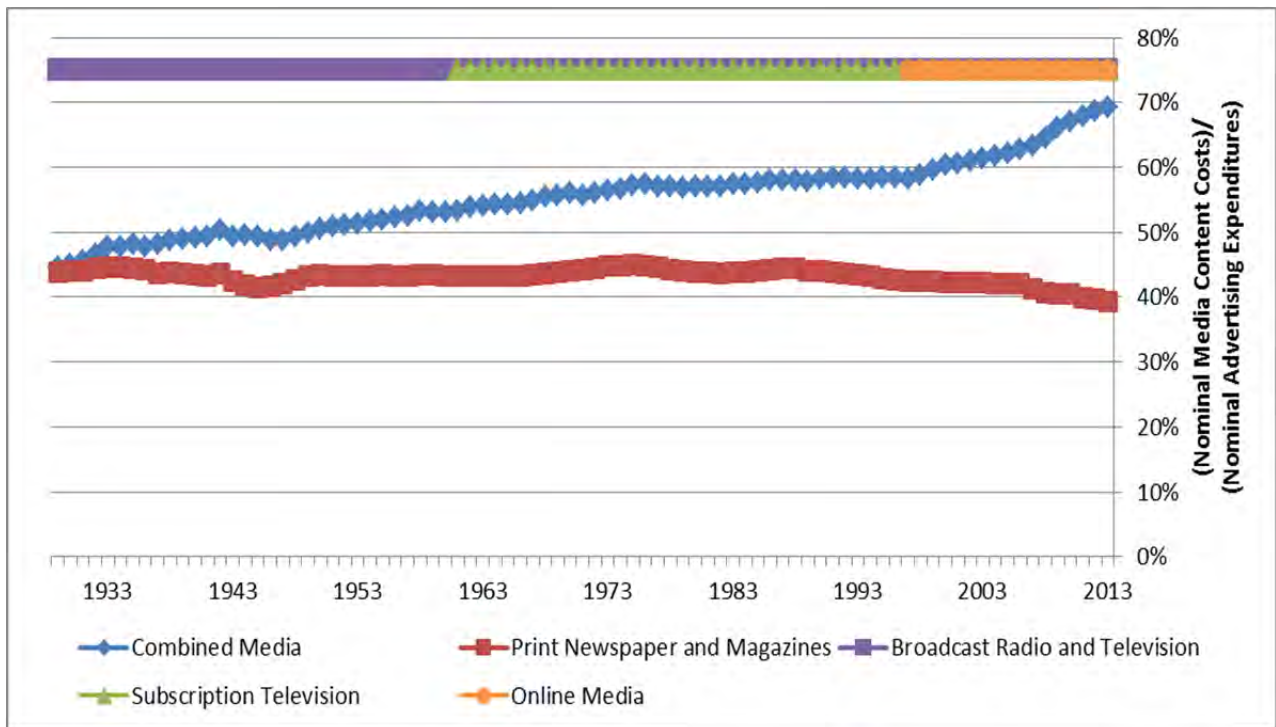


Figure 3: Consumer Entertainment Share of Media

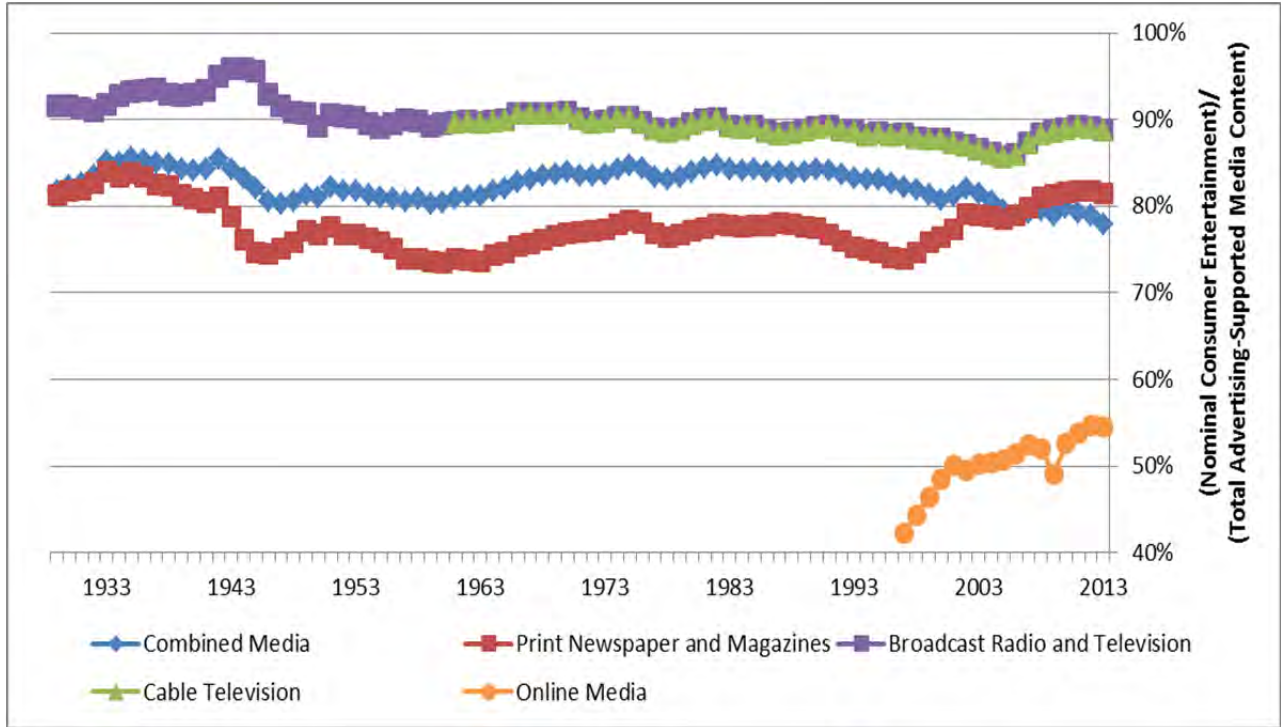


Figure 4: 'Free' Consumer Entertainment over Time

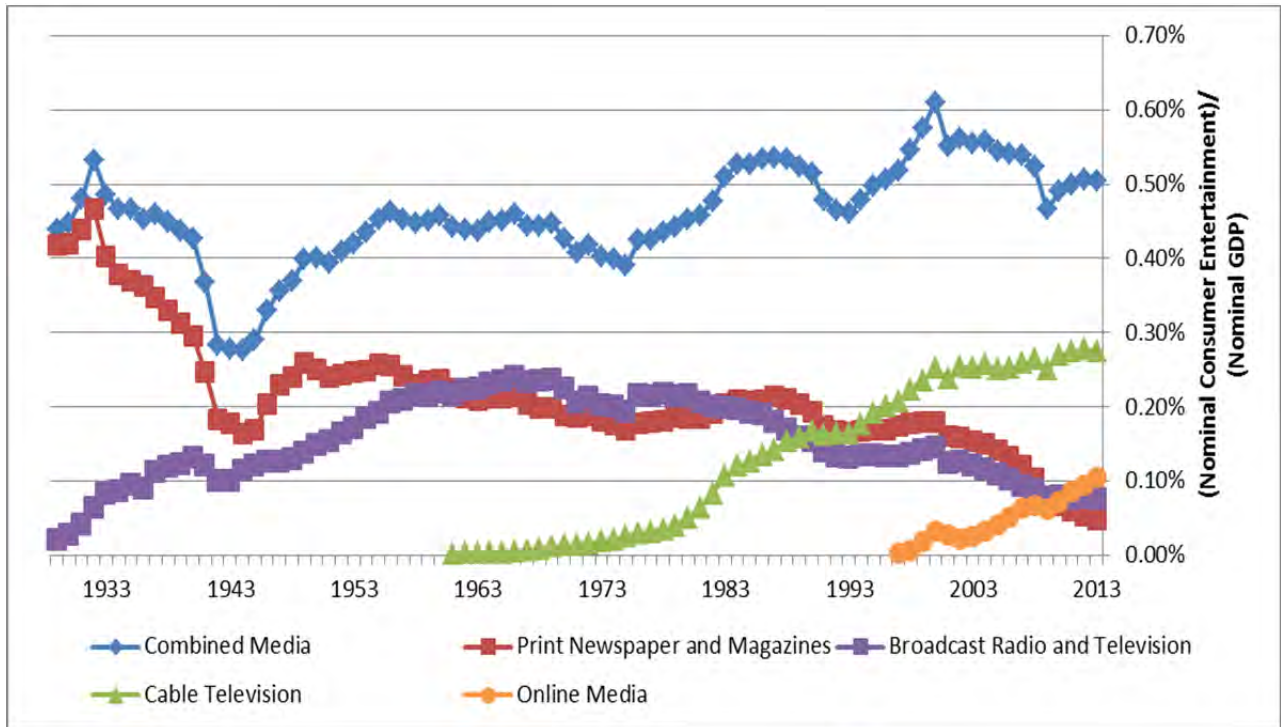


Figure 5: 'Free' Business Information over Time

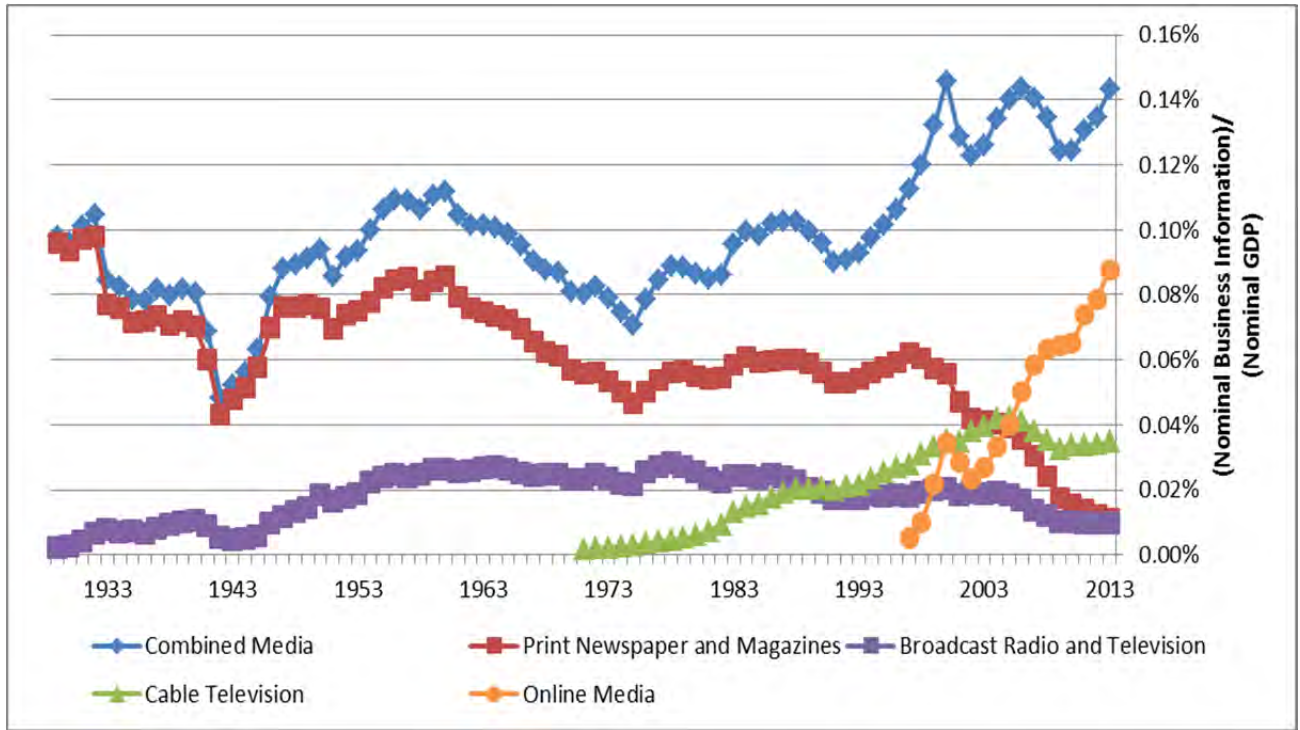


Figure 6: Prices for Online Media

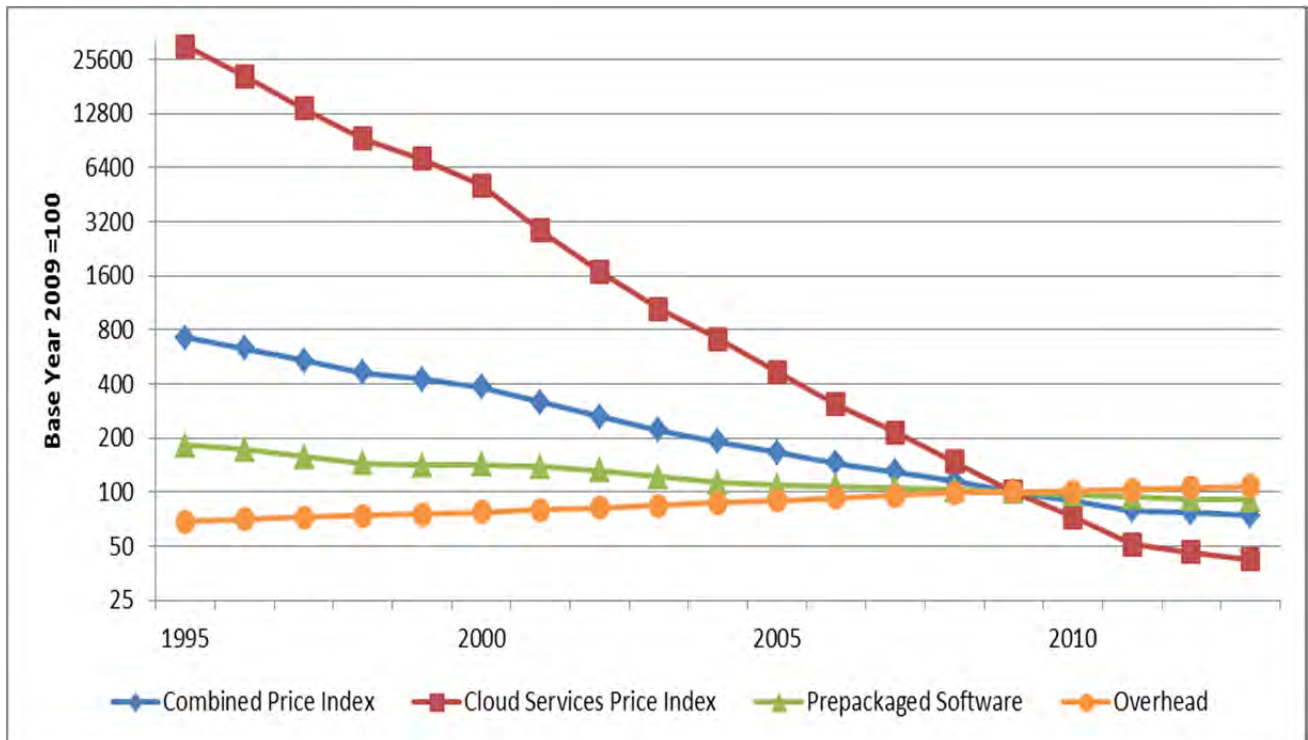


Figure 7: Prices for Print Media

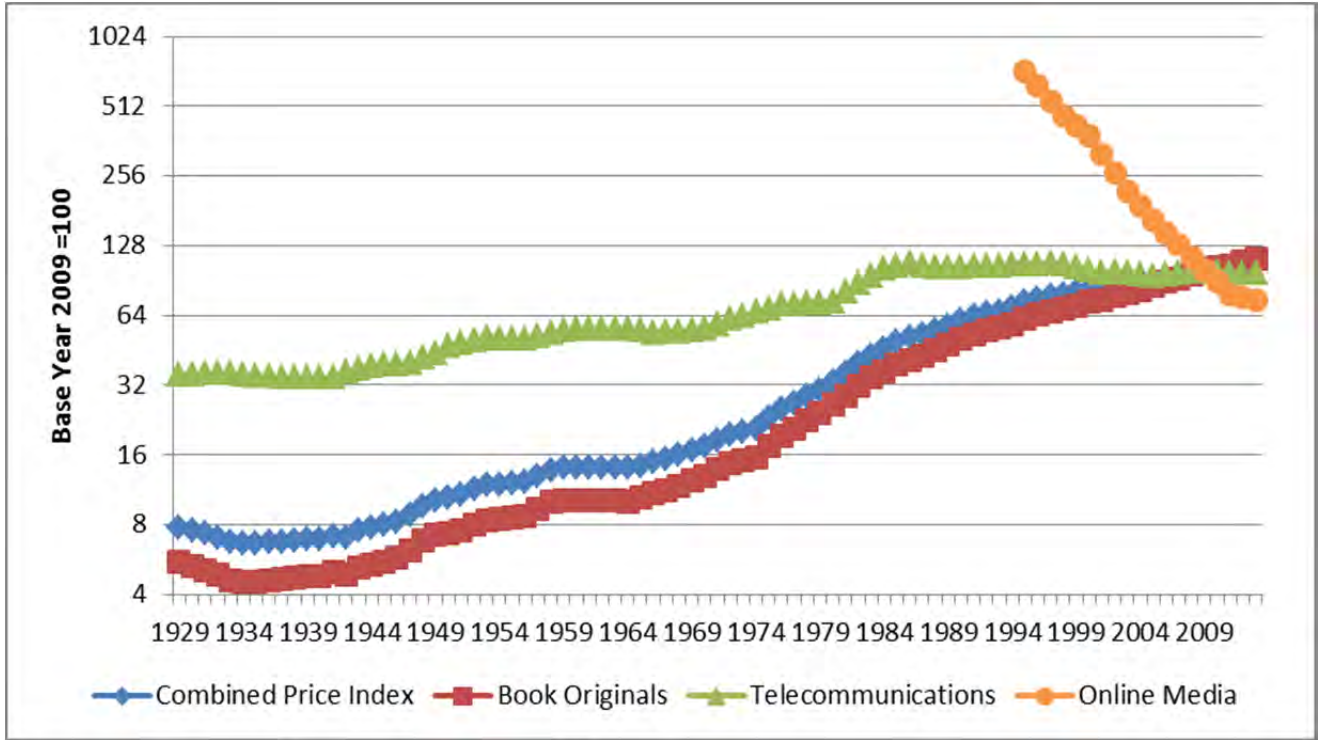


Figure 8: Prices for Cable Television

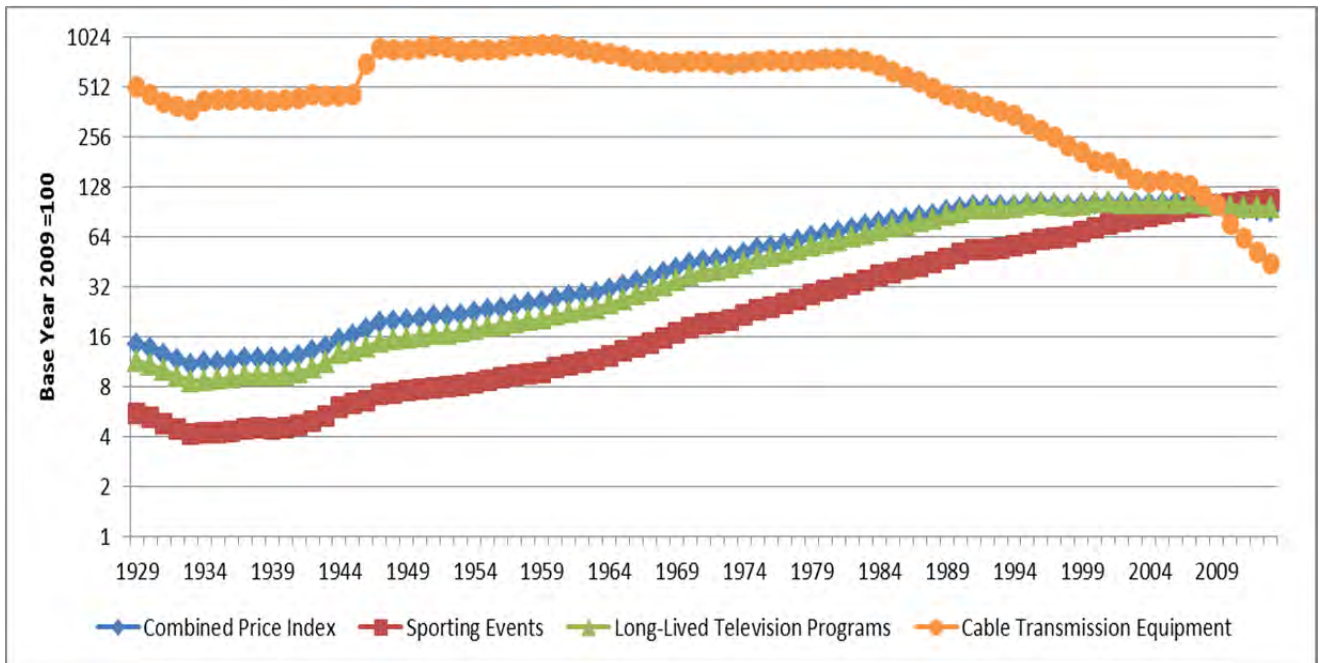


Figure 9: Prices for Broadcast Television and Radio

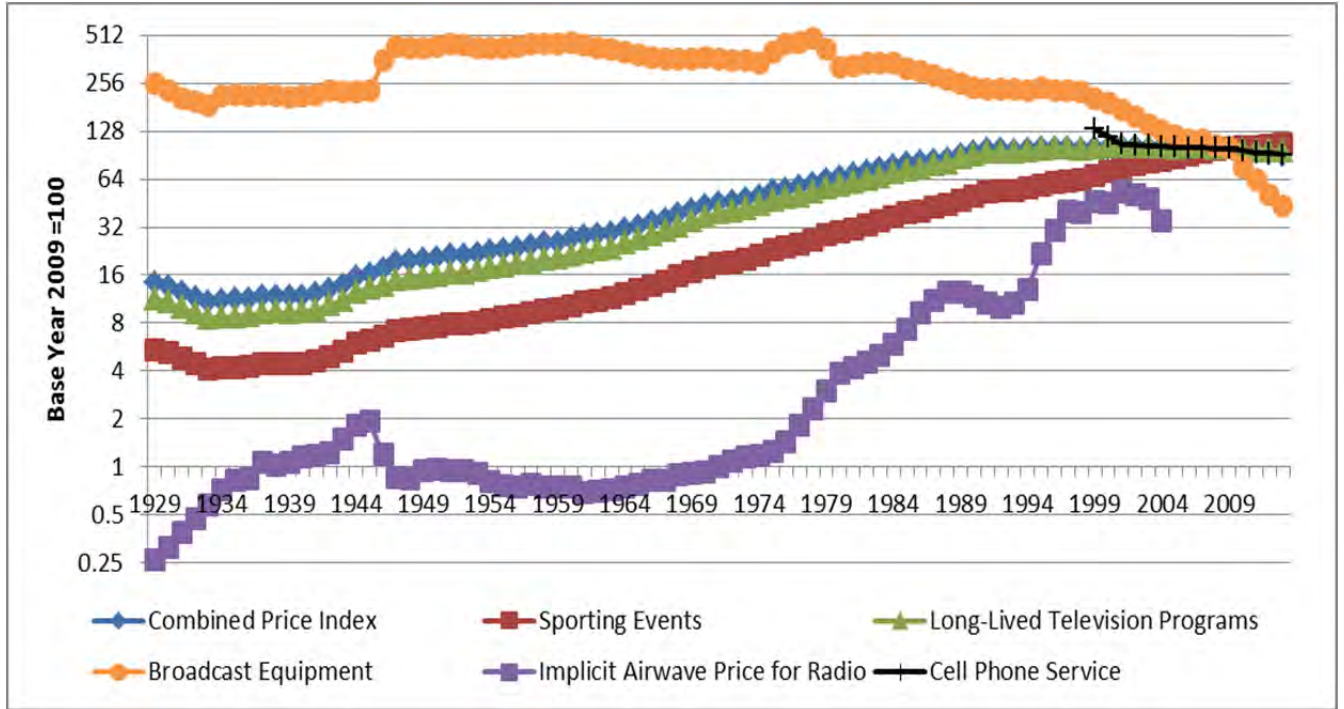


Figure 10: Change in GDP Quantities from 'Free' Media

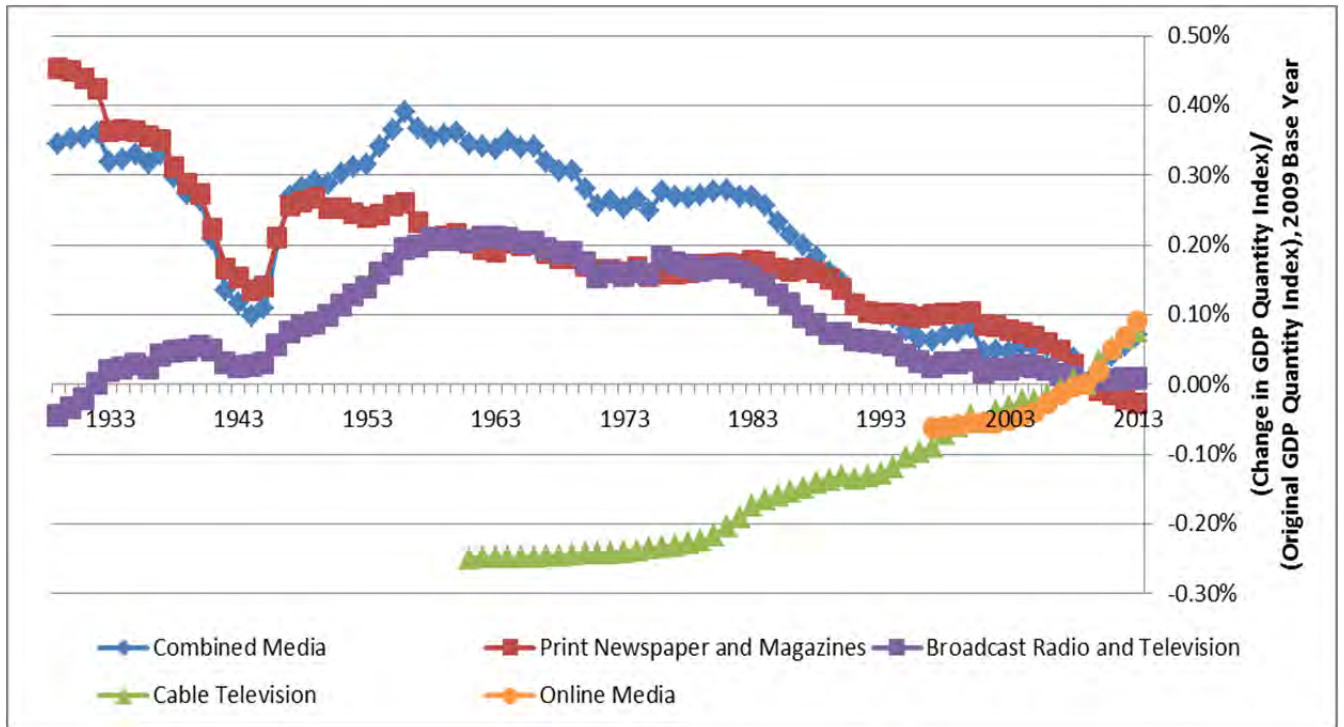


Figure 11: Quantity Indexes for Advertising Viewership

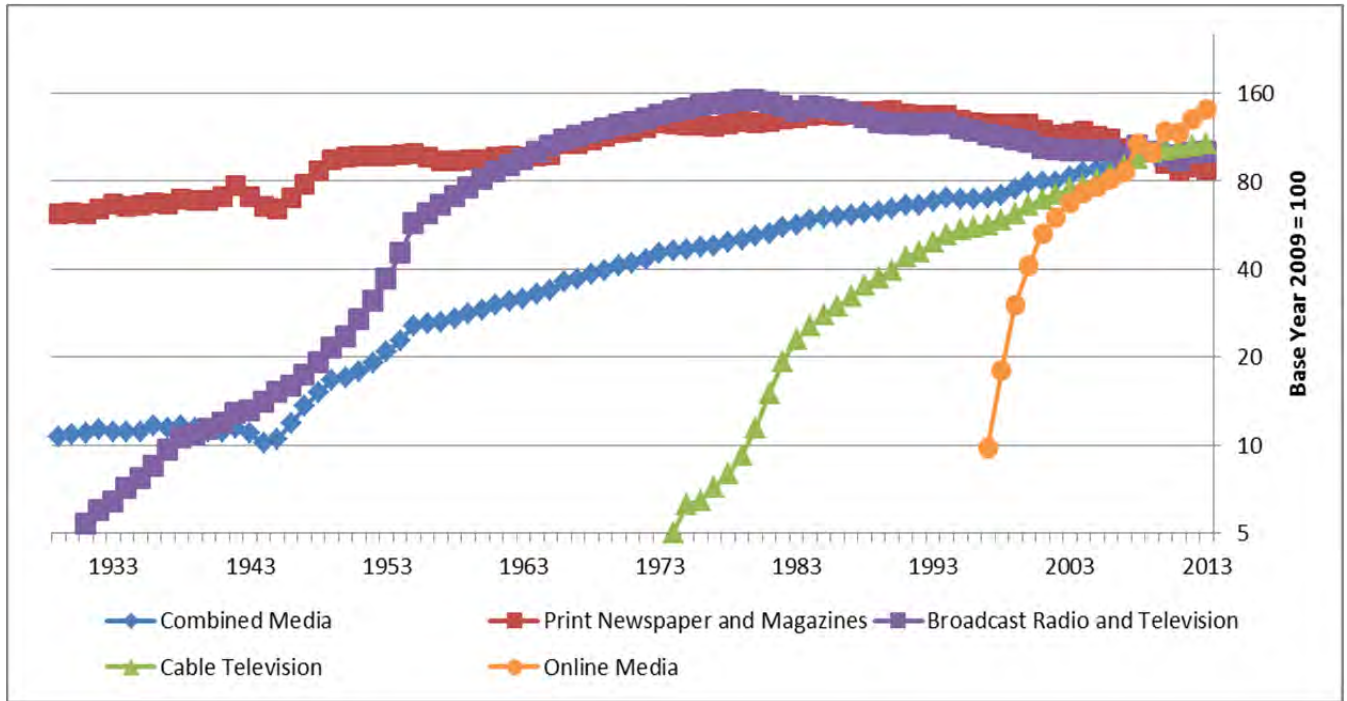


Figure 12: Change in Business Sector TFP from Online Media

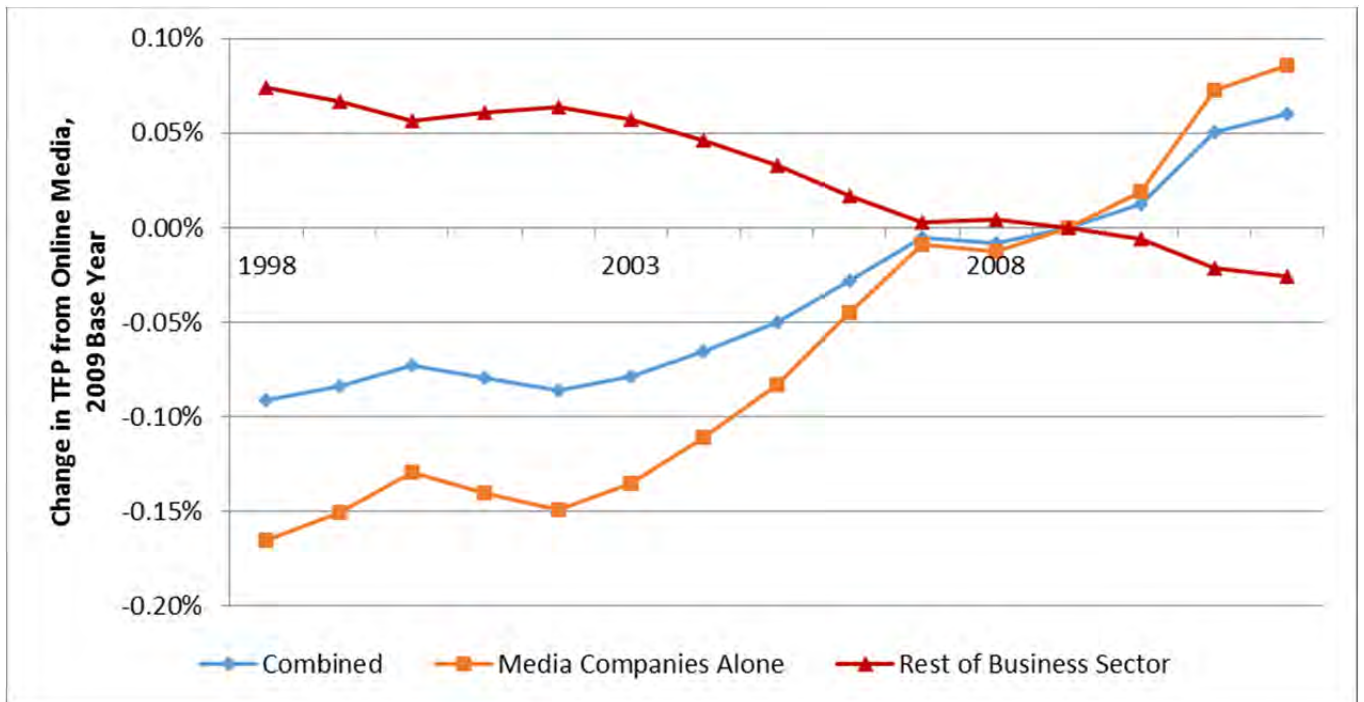


Figure 13: Change in Business Sector TFP from Quality-Adjusted Online Media, an Upper Bound Based on Bytes of Data

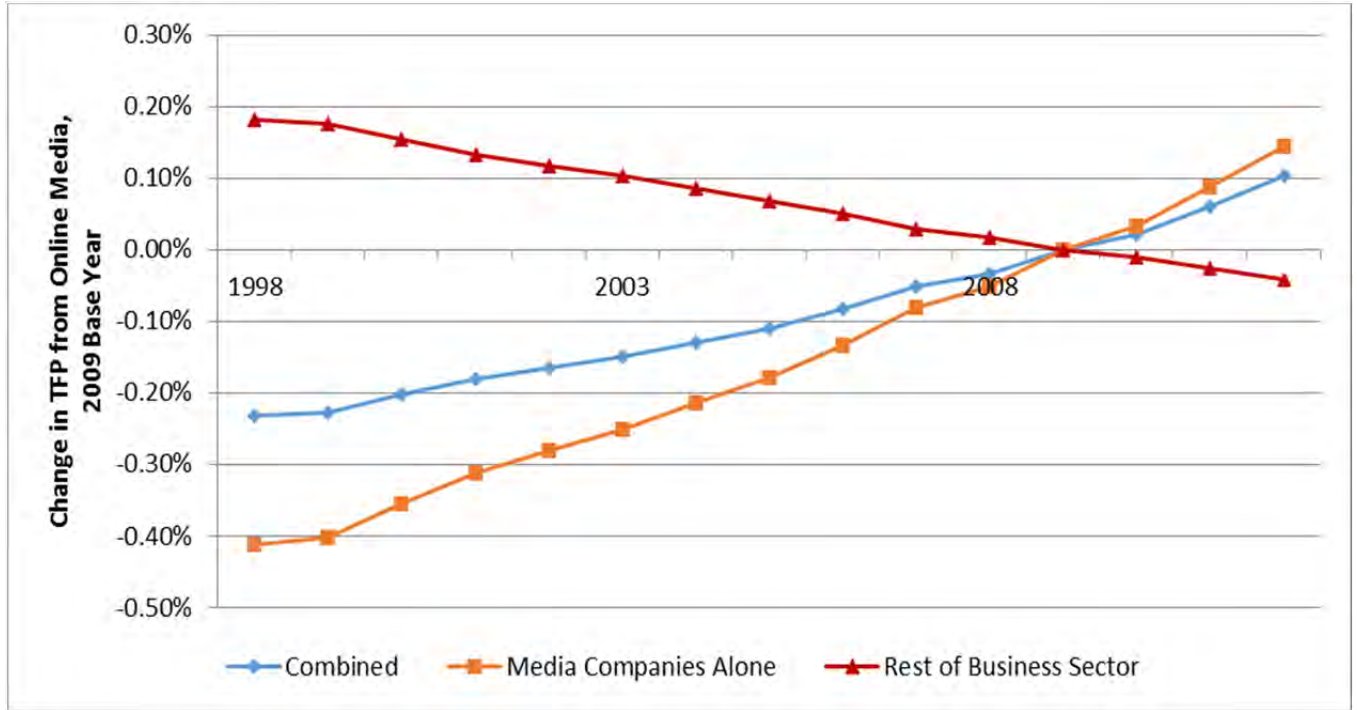


Figure 14: Change in Business Sector TFP from Print Media

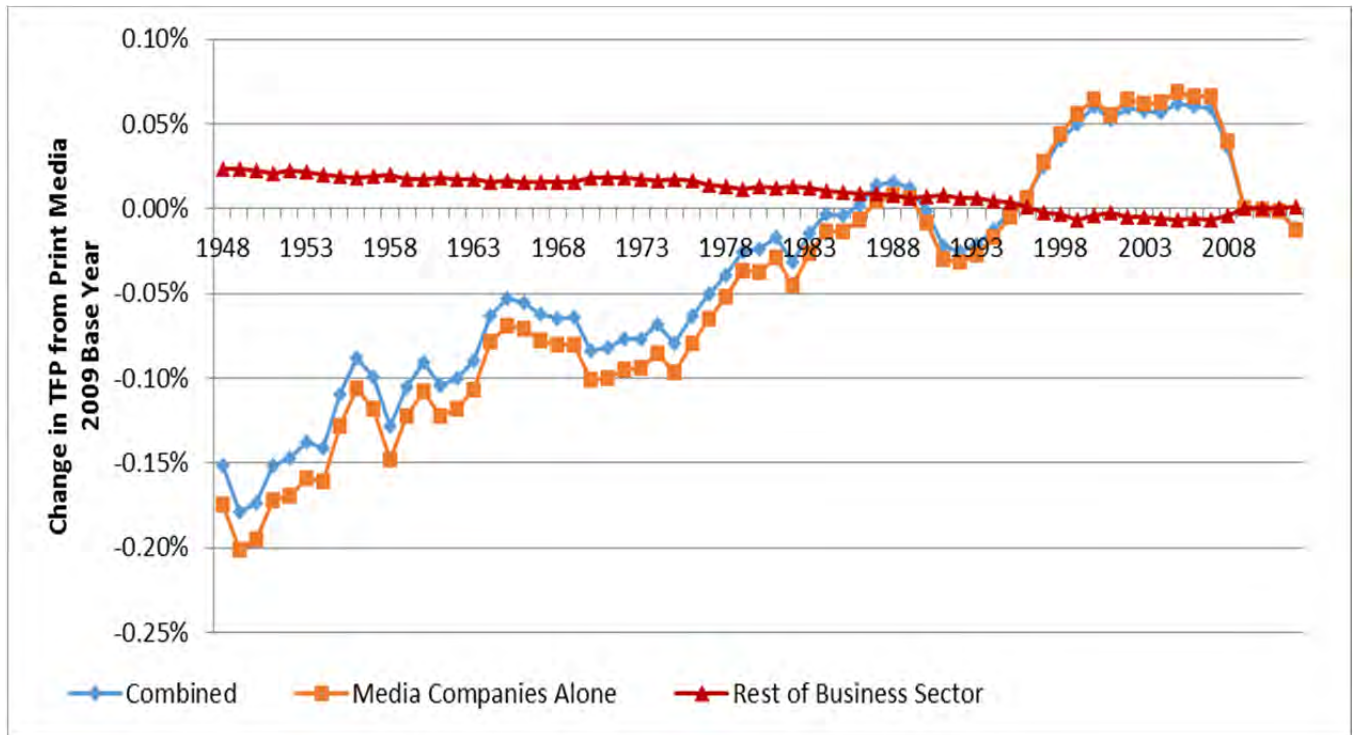


Figure 15: Change in Business Sector TFP from Broadcast Television

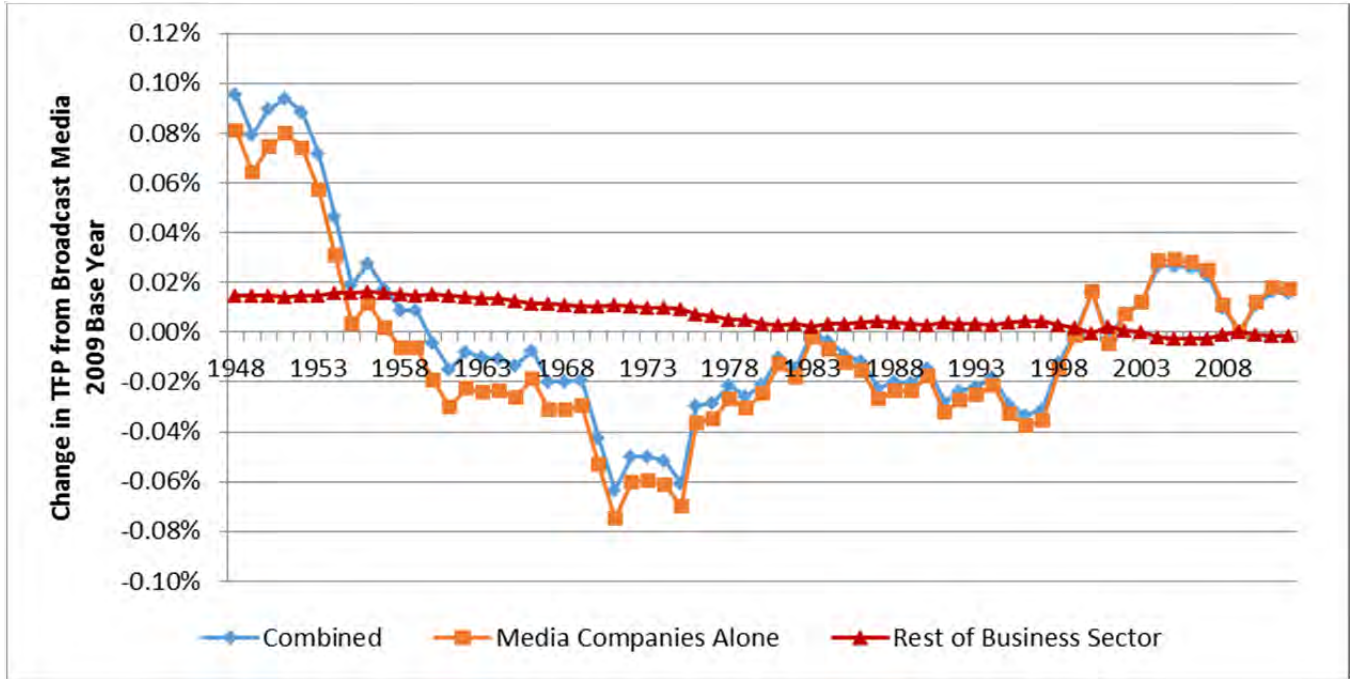


Figure 16: Change in Business Sector TFP from Cable Television

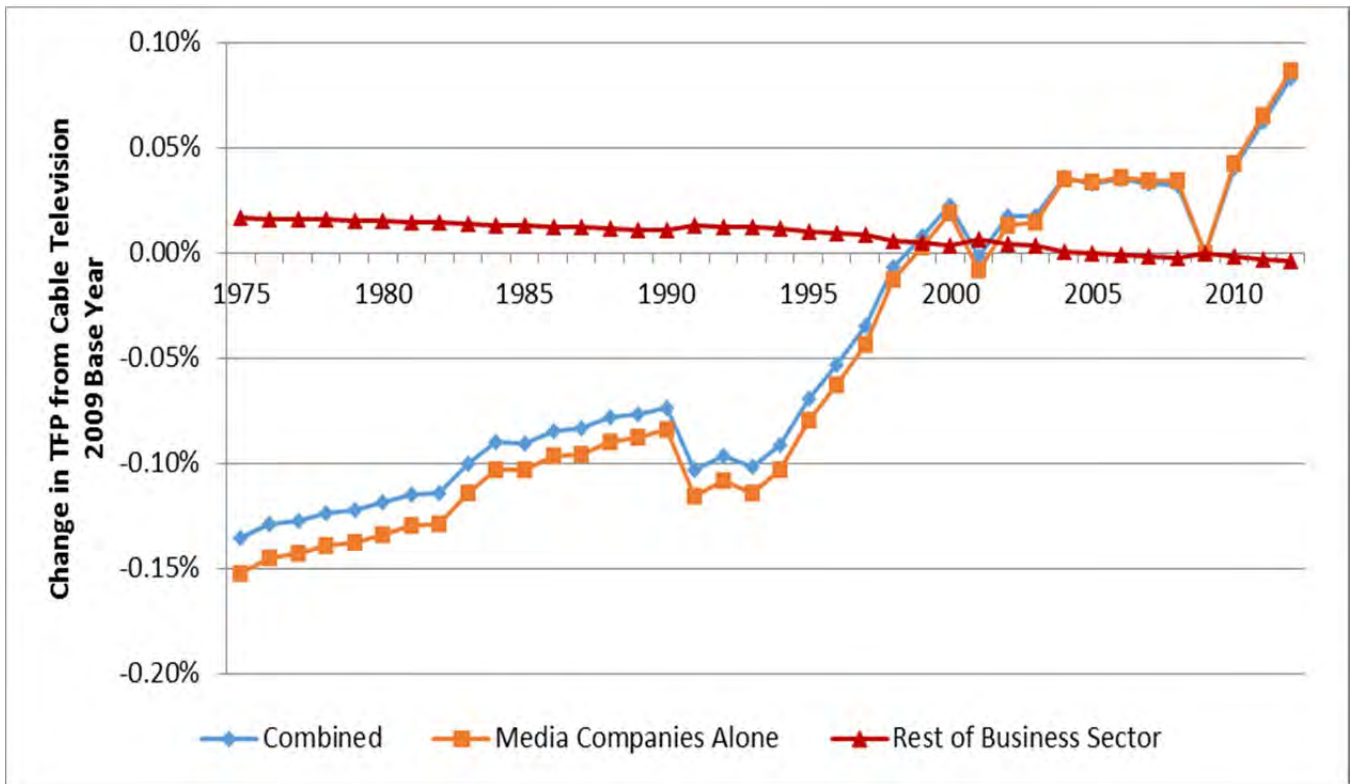


Figure 17: Change in Business Sector TFP from Non-Media Internet Start-Ups Supported by Venture Capital

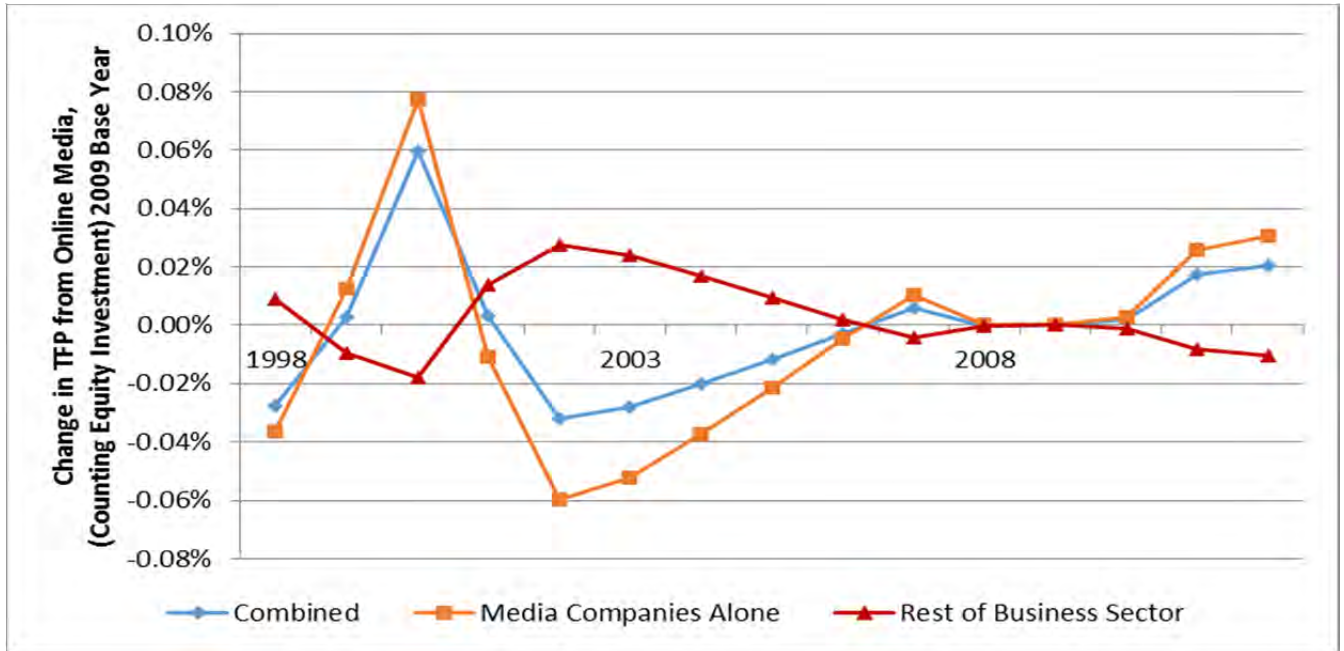


Table 1: New Funding of Internet Firms in Private Placements, U.S.

Total Internet Private Placements, in millions		Total Internet Private Placements, in millions		Total Internet Private Placements, in millions	
1998	\$5,484	2004	\$6,924	2010	\$9,285
1999	\$21,370	2005	\$6,404	2011	\$18,617
2000	\$44,629	2007	\$10,112	2012	\$11,954
2001	\$18,536	2008	\$11,161	2013	\$14,890
2002	\$5,903	2009	\$6,714	2014	\$26,082
2003	\$5,199				

Source: S&P Global Market Intelligence

Appendix A: A Primer on the Experimental Accounting for ‘Free’ Media

The basic premise of the economic accounting framework experimented with above is that values for ‘free’ media can be imputed in the Input-Output tables based on the advertising revenue which funds the ‘free’ media. Conceptually, the idea of imputing components of current production that are not paid out-of-pocket is not new to GDP accountants. The largest imputed estimate in the NIPA accounts is owner occupied housing services. For this component of GDP, there is no observed economic transaction between the owner of the dwelling and the owner-occupiers that consume the housing services. In this case, the rental equivalence method is used to impute the consumption of owner occupied housing services and the corresponding income used to pay for the current housing services.²⁸

The purpose of this section is to provide details and discussion of the experimental accounting framework for ‘free’ Media and how it relates to the current treatment in BEA’s accounts. We demonstrate our experimental approach to measuring ad-supported media by presenting a series of input-output tables that include the pertinent transactions. An advantage of viewing this through the input-output accounts is that these accounts form the foundation both for measuring GDP by industry and also for measuring productivity at the industry level.

We begin with a stylized example with four sectors: a sector (M) that produces media content (e.g. apps or books), a sector that produces advertising, broadcasting, and publishing (APB), an everything else sector (EE), and a household viewership sector (HV). GDP is measured two equivalent ways: 1) the sales to final demand (labeled C for Consumption) and 2) the sum of value added generated by industry. Value added is comprised of payments to factor services and taxes, but can be thought of as payments to labor services in this example.

We start with the case of direct sales of media to final demand, compare this to the case of advertising-supported media under our current methodology and then proceed to advertising-supported media under our experimental methodology. In all of our initial examples with ad-supported media, the full value of the media is supported by advertisements, so that the viewer

²⁸ Other examples include food furnished to employees and financial services indirectly measured (FISM). See the “Concepts and Methods of the U.S. National Income and Product Accounts”

pays zero for the content. Partially ad supported media can be treated within the same framework, but the free media highlights the conceptual issues involved.

Direct sales of media

Table A1 depicts the input-output table for this stylized economy with direct sales of the media to final demand. Nominal GDP is \$1,000, comprised of \$800 of industry EE sales to final demand and \$200 sales of media directly to final demand. Total final sales equal \$1,000, the value added generated by the four sectors. In this economy, advertising is required to sell industry EE’s output (Industry EE purchases \$250 worth of advertising services, think of this as direct mailings) and industry EE supplies \$200 worth of product used in producing the advertising. In this example, the \$200 of output of the media company M is sold directly to final demand. We imagine that this media comprises \$100 of print media, like short stories, and \$100 of digital media, like video games or apps. The household viewership sector (HV) has no role in this economy.

Table A1.

	EE	APB	M	HV	C	Commodity Output
EE	200				800	1000
APB	250					250
M					200	200
HV						0
VA	750 50 200					
Gross Output	1000 250 200					

Current treatment of Ad-supported media

To produce an input-output table with ad-supported media, we impose the following assumptions. First, actual consumption of the output of industry EE is unchanged from the case of direct sales. Second, real consumption and the price of apps is unchanged from the case of

direct sales. Third, by substituting the direct mailing with the media ad campaign, industry EE is able to save on labor dollar for dollar.²⁹

Table A2 lays out an example of an economy with ad-supported media and demonstrates some of the measurement drawbacks of the current approach to accounting for media’s role in the economy.³⁰ In this example, we imagine print media is used to distribute advertising, but the two are basically equivalent in this stylized model. Because the consumer values this print media at \$100, the APB industry must pay the media company at least \$100 for the media company to be willing to make the content free to consumers. We assume that the APB industry pays exactly \$100. In this economy, industry EE switches between direct marketing and advertising bundled with the print media. For this privilege, industry EE pays APB \$350 reflecting the value of the media content and the other ad related services. The viewership sector has no explicit role in this representation, even though the APB sector is implicitly serving as an intermediary in delivering ad viewership to sector EE.

Table A2.

	EE	APB	M	HV	C	Commodity Output
EE		200			800	1000
APB	350					350
M		100			100	200
HV						
VA	650	50	200			
Gross Output	1000	350	200			

²⁹ This precise assumption is made for modeling convenience. It ensures that GDP prices remain fixed. This may seem like a strong assumption, and it is, but it is relatively innocuous since the pertinent comparison is between the current treatment of ad-supported media and our proposed treatment with the barter transaction. When comparing those two approaches, we need not make this assumption. We impose this here to make a broad comparison between how the input-output accounts would look with direct sales of media to make the point that the value of the media to the consumer must be bid away. We do not make use of any evidence to tell us how industries adjust when with the introduction of ad supported media. We could have alternatively chosen to allow the value of the output of industry EE to increase, for example.

³⁰ We do not consider the underlying reason for the ad-supported approach to selling media or the role of media in selling industry output, but our approach does allow for this media to be used as a productive input.

It is worthwhile to compare the aggregate economy measured economy in Table A1 to Table A2 even though this comparison embeds the assumptions imposed above. Imposing fixed prices allows for an easy comparison of aggregate nominal and real GDP. By assumption, the ad-supported media does not increase the final sales of industry EE, thus consumption of industry EE's output is unchanged from the example of direct sales. Similarly, the consumption of digital media and its price is the same. It is obvious from Table A2 that real measured GDP is lower than the economy measured in Table A1 because the same quantity of industry EE output is consumed, while only the digital media is measured in final consumption. Under this set of assumptions, the consumer is indifferent between the economy in Table A1 and A2 (the same level of real consumption) and real production measured from final demand is the same, but measured GDP is lower. This is the crux of the measurement issue.

We note that this representation highlights the similarity between print and digital media. In this case, if the digital media was sold as an advertising device instead of the print media, Table A2 would look exactly the same.

Media consumption as a barter transaction

Our experimental treatment of ad-supported media recognizes the barter transaction that is implicit in the above example of ad-supported media.³¹ The role of our imputed barter transaction is highlighted in Table A3. One way to think about the exchange is that the consumer was spending \$100 for the print media (the direct sales case), but the current accounting does not capture this. Thus, we impute \$100 to consumption of the media, which in this case is provided by the APB industry to final consumers. How does the consumer fund this consumption? This \$100 of consumption is funded by an implicit payment from the from the APB industry which in exchange for this payment gets exposure to the household viewership sector (people watching their ads). Thus, the APB sector generates ad supported media (to be viewed by the household viewership sector) in addition to primary ad-services (which are purchased by the EE sector). Finally, the household viewership sector produces ad viewership output. Note that the digital media still is sold directly to consumers in this example.

³¹ Note that there are many barter transactions in the economy, but we focus only on the transaction between the ad viewers, advertisers, and media producers. It is this channel that delivers the media of interest in this paper.

Table A3.

	EE	APB	M	HV	C	Commodity Output
EE		200			800	1000
APB	350				100	450
M		100			100	200
HV		100				100
VA	650	50	200	100		
Gross Primary Output	1000	350	200			
Imputed Output of Ad-Supported Media		100				
Ad viewership Output				100		

A complimentary interpretation of the barter transaction in Table A3 is that the APB industry needs to deliver ad viewership to the EE industry. To deliver this ad viewership, the APB industry must compensate the HV sector. In this framework, the APB industry compensates the viewership sector exactly the amount that the viewer is willing to pay for the media content.

At this point, we highlight that in our application we do not observe the amount that the consumer is willing to pay for the media if it was sold directly. To estimate these values, we use observed advertising revenue.³² That is, we use observations on the output of the advertising industry (the \$350 in Table A3) to estimate the value of content to consumers and use this estimate as the value of the barter transaction. Note that as Table A3 shows, this value includes the value of the media. This is discussed below in more detail. The key point from Tables A1-A3 is that our experimental methodology imputes a barter transaction valued at our estimate of the consumption value of the media.

It is instructive to compare the measurement framework with the imputed barter transaction to the current treatment. First, value added across the private industries is the same in the two treatments. The implication of this is that the additional imputed consumption is balanced by the additional value added produced by the viewership sector. Second, the level of real value added is higher than in the current treatment. One interpretation of this is that in comparison to the current treatment, the value added of the viewership sector allows the

³² Advertising revenue in any given period may not equal ad spending, but this is a common problem in constructing balanced input-output accounts. Due to data constraints, we rely on ad revenue.

consumer a higher level of consumption compared to the treatment without the barter transaction.

It is immediately apparent that conditional on the assumptions listed above, our experimental approach produces the same nominal and real GDP as would have occurred under the direct sales model. This is the fundamental justification for our experimental approach. Conceptually, we believe that advertising-supported media is a very close substitute for directly purchased media – and so the two media types should be handled similarly in the National Income and Product Accounts. Under the current GDP formula, advertising-supported media is entirely excluded from final expenditures and contributes to GDP only indirectly. In contrast, our experimental approach includes both directly purchased media and also advertising-supported media in final expenditures. Furthermore, we argue that this is a useful feature since a significant portion of media consumed is through ad-supported media.

Viewership sector as part of the broader household sector

In these stylized examples, and in the analysis in the main text, we have introduced a viewership sector that is beyond the scope of BEA’s current set of economic accounts. To minimize the deviation of our analysis from BEA’s official accounts, we do not consider the production process for this viewership. Presumably, ad viewership requires other inputs, such as a television, a mobile phone, or a kitchen table to read the magazine. Measuring the output and inputs of this process is entangled with measuring overall household production and productivity in the household sector. We intentionally avoid this due to the plethora of issues involved in measuring household production. Our estimates of TFP at the industry level, however, are separable from measuring the inputs to household ad viewership, thus our focus is on the role of ad-supported media in industry TFP measurement.

Media Use by Business

Our examples in Tables A1-A3 assumed that media content was valuable only to consumers. Tables A4-A6 revisit the same conceptual issues when the final content is valuable to business. In Table A4, the media produced by industry M is purchased directly by industry EE. To clarify, we imagine a situation where the media itself is directly relevant to the production

process of industry EE, for example the Wall Street journal for a financial industry, or Waze apps for a moving company. This is distinct from the case above where the industry only valued the media as a conduit to reach ad viewers. Just like the earlier consumer entertainment example, businesses provide ad viewership in return for media content.

Table A4.

	EE	APB	M	HV	C	Commodity Output
EE	200				1000	1200
APB	250					250
M	200					200
HV						0
VA	750	50	200			
Gross Output	1200	250	200			

In this example economy with direct sales of media to business, nominal GDP is \$1000. Like the case above, industry EE requires \$250 worth of advertising to sell its output and the media producer makes \$200 worth of media. Unlike the case above, this media is purchased as an intermediate input into the production of EE.

Table A5 provides a demonstration on what happens to the IO account with ad-supported free media. Again, we imagine that \$100 of the media is provided by the APB media, and as above whether it is the digital or print media, the input-output accounting is the same. In this case, the industry EE values the media at \$100 so the APB industry must pay the media producer \$100 to bid this away. Given the value of the media content embedded in the ad services produced by the APB industry, industry EE pays the media industry \$350 for the ad services including the media content. Under this model, industry EE is indifferent between the direct sales model and the ad-supported media because it receives the same quantity of intermediate inputs for the same prices as under the direct sales. Because media is used as an intermediate input, aggregate GDP is unchanged with the ad-supported media model in comparison to the case where the media is purchased directly as an intermediate input.

Table A5.

	EE	APB	M	HV	C	Commodity Output
EE		200			1000	1200
APB	350					350
M	100	100				200
HV						
VA	750	50	200			
Gross Output	1200	350	200			

Like the case with media consumed by households, the ad-supported media model leaves out the implicit transaction between the viewer and producer of the ads. Table A6 highlights these barter transactions. In this case, industry EE produces ad viewership in addition to its primary output. Like in the case of consumers, the APB industries implicitly compensates the viewers \$100 which funds the business consumption of the ad supported media in sector EE. The APB industry has \$100 of imputed output of ad supported media, so that a total of \$450 of input from the APB industry is purchased by industry EE. The intuition for this is that the since industry APB paid \$100 to obtain the rights to use the media content, this must be worth at least \$100 to the APB industry. This value accounts for an implicit payment that must be made to the viewers of the ads. The account in Table A6 makes this payment explicit and produces an internally consistent accounting for ad supported media that reflects both the recorded and implicit payments for the media as an output and an input.³³

³³ Note that the household viewership sector is uninvolved in this example. The payment for ad viewership goes to the business sector, which produces the ad viewership as a secondary product. Thus, there is no entry in the value added of the HV column.

Table A6.

	EE	APB	M	HV	C	Commodity Output
EE		200			1000	1,200
APB	450					450
M	100	100				200
HV		100				100
VA	750	50	200			
Gross Primary Output	1200	350	200			
Imputed Output of Ad-Supported Media		100				
Ad viewership Output	100					

Industry and Aggregate Productivity measurement with our Experimental Approach

Given our reconstructed input-output table, measures of industry growth and productivity that reflect our experimental approach are relatively straight forward. Productivity measures require prices and quantities for the outputs and inputs of each sector. Productivity growth is defined as the growth rate of the ratio of the quantity index of output to the quantity index of input.

On the output side of each industry’s production account there potentially eight new outputs discussed in the main text: 1) Advertising supported print media, 2) advertising supported broadcast radio and television; 3) advertising supported cable television; 4) advertising supported online media, 5) print media viewership, 6) broadcast media viewership, 7) cable television viewership; 8) online media viewership. We construct new measures of the price and quantity of industry output as the tornqvist index of the original industry output with these six new outputs. Data for the prices and quantities for each of these is described in the body of the paper and Appendix B.

At first glance, it seems surprising create so many new outputs for each industry. In fact, having a single industry produce multiple outputs is not uncommon in productivity measures. The official BEA-BLS integrated industry-level accounts employs this approach and industries are classified by their primary production. For cases where a single industry produces multiple

outputs in the official BEA accounts, industry output growth is a chained index over multiple outputs

On the input side of the production account, each industry has these same eight potentially new inputs. We construct new measures of the price and quantity of industry input as the tornqvist index of the original industry input with these eight new inputs. Data for the prices and quantities for each of these is described in the data appendix.

We reiterate that by construction the nominal value of new outputs equals the nominal value of new inputs by industry. However, the price of each of these is different on the output side and the input side of the account, thus the barter transaction has implications for measured industry TFP. The government and viewership sectors complicate aggregation across industries to economy-wide totals. Thus, we focus on the measured productivity impact on the private economy.

Free media in the 2007 IO accounts

Table A7 demonstrates how the barter transactions impact the 2007 BEA input output table (modified to include a viewership sector) for fifteen broad sectors that encompass the U.S. GDP. We reiterate that the starting point for these values is data on advertising revenue. We do not have data on the spending on the media content directly. In the main text and Appendix B, we describe how we estimate the value of each form of media embedded in advertising revenue.

Table A7a shows the production and use of ad-supported media content, that is our estimate of the value of media content embedded in advertising revenue. In 2007, Print, Broadcast, and Online media combined for \$98 billion in media content. We estimate that \$79 billion accrued to the viewership sector. The remainder (about 20%) of the value was used by U.S. businesses and government. To be clear, by construction, the sum of the value added generated by the viewership sector plus the intermediate use of the media equals the estimated value of ad supported media. Table A7b highlights that the value ad-supported media content equals the value of viewership output across the economy, that is the total value of output from media viewership across all sectors equals the value of ad supported media content. The table makes it clear that within industries, the value of media being used equals the secondary production value of media viewership.

Table A7a

Commodities/Industries	11	21	22	23	31G	42	44RT	48TW	51	FIRE	PROF	6	7	81	G	HV
11: Agriculture, forestry, fishing, and hunting	71.1	0.1	0.0	1.7	202.9	1.5	1.6	0.1	0.0	0.0	1.1	0.5	5.7	0.1	1.8	
21: Mining	2.1	54.7	74.7	12.3	422.2	0.1	0.2	4.6	0.3	4.8	1.3	0.6	1.3	0.5	18.6	
22: Utilities	5.2	4.9	5.2	3.3	80.2	6.9	16.1	6.4	3.8	80.7	11.5	19.8	15.3	4.3	26.5	
23: Construction	2.3	7.2	7.4	0.2	13.9	1.5	2.9	4.3	2.2	111.5	2.1	2.2	2.5	3.0	57.0	
31G: Manufacturing	70.6	37.2	31.5	364.0	1897	40.7	44.7	162.0	82.3	82.5	131.1	149.5	119	47.6	337.1	
42: Wholesale trade	21.6	5.7	5.2	51.0	257.3	28.0	17.0	22.0	12.9	11.6	17.8	31.7	16.7	7.0	37.0	
44RT: Retail trade	0.2	0.2	0.5	76.8	11.4	0.6	5.0	4.2	0.3	7.4	2.0	1.0	6.2	4.1	0.5	
48TW: Transportation and warehousing	10.3	9.0	23.1	21.4	123.2	46.4	54.7	93.8	16.6	28.1	35.2	16.2	11.0	4.2	48.8	
51: Information	0.4	0.9	2.1	3.8	22.8	12.2	13.3	5.4	164.4	65.0	56.2	22.6	9.2	8.1	72.3	
FIRE: Finance, insurance, real estate, rental, and leasing	15.5	13.8	19.4	29.2	92.6	92.6	140.9	76.8	61.3	928.5	222.6	231.9	83.5	80.2	115.6	
PROF: Professional and business services	4.2	22.7	28.5	44.0	339.6	146.0	124.0	51.0	124.2	420.3	419.0	166.2	106	31.9	254.2	
6: Educ. services, health care, and social assist.	0.2	0.0	0.1	0.0	0.1	0.5	2.2	0.1	0.2	0.1	0.5	20.4	1.3	1.5	13.8	
7: Arts, entertain., rec., accomm., and food service	0.4	0.6	3.6	2.1	15.5	5.1	3.7	3.2	26.4	45.7	45.6	19.3	22.0	2.9	26.5	
81: Other services, except government	0.8	0.5	1.0	4.4	16.1	15.0	10.5	4.8	7.7	30.3	27.2	22.5	10.3	6.1	23.4	
G: Government	0.1	0.0	0.8	0.0	5.2	11.5	6.4	18.7	3.7	9.2	8.7	5.7	6.1	1.8	8.1	
Original Intermediate	205	157	203	614.4	3500	409	443	457	506	1826	982.0	710	416	203	1041	
Advertising-Supported Print Media	0.014	0.023	0.023	0.056	0.251	0.065	0.043	0.040	0.076	2.427	0.124	0.096	0.046	0.026	0.053	
Advertising-Supported Broadcast Media	0.002	0.012	0.013	0.030	0.136	0.035	0.023	0.022	0.041	6.382	0.067	0.052	0.025	0.014	0.029	
Advertising-Supported Cable Media	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Advertising-Supported Online Media	0.101	0.163	0.168	0.405	1.803	0.468	0.306	0.289	0.543	2.142	0.891	0.690	0.328	0.186	0.380	
Print Media Viewership	0.004	0.007	0.002	0.002	0.042	0.002	0.002	0.018	22.024	0.013	0.013	0.009	0.009	0.002	0.004	
Broadcast Media Viewership	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.511	0.000	0.000	0.000	0.000	0.000	0.000	
Cable Media Viewership	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	42.937	0.000	0.000	0.000	0.000	0.000	0.000	
Online Media Viewership	0.004	0.005	0.002	0.002	0.034	0.002	0.002	0.014	17.830	0.011	0.011	0.007	0.007	0.002	0.007	
Total Intermediate	205.1	157.6	203.4	614.9	3502.3	409.2	443.5	457.7	605.2	1836.6	983.1	710.9	416.3	203.5	1041.9	.
V001: Compensation of employees	41.5	62.7	63.1	439.8	944.4	429.2	506.1	255.8	260.4	730.0	1183.3	895.8	324.7	231.1	1541.0	.
V002: Taxes on production and imports, less subsidies	-2.5	33.6	54.6	7.9	60.2	175.3	184.3	24.6	43.1	247.9	49.8	32.0	70.5	17.3	-18.7	.
V003: Gross operating surplus	103.0	217.7	117.4	267.3	849.7	256.3	187.2	129.1	398.8	1899.2	424.1	136.8	137.0	82.1	382.9	.
Total Value Added	142.0	314.0	235.1	715.0	1854.3	860.8	877.6	409.6	702.4	2877.1	1657.2	1064.6	532.1	330.5	1905.2	79

Table A7b

Commodities/Industries	11	21	22	23	31G	42	44RT	48TW	51	FIRE	PROF	6	7	81	G	HV
Original Industry Output	346.9	471.4	438.2	1329.4	5354.4	1269.5	1320.7	866.9	1208.6	4702.8	2639.2	1774.7	948.0	533.8	2946.7	.
Media Related Output																
Advertising-Supported Print Media	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Advertising-Supported Broadcast Media	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Advertising-Supported Cable Media	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Advertising-Supported Online Media	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.8	0.0	0.0	0.0	0.0	0.0	0.0	0
Print Media Viewership	0.014	0.023	0.023	0.056	0.251	0.065	0.043	0.040	0.076	2.427	0.124	0.096	0.046	0.026	0.053	19
Broadcast Media Viewership	0.002	0.003	0.003	0.008	0.036	0.009	0.006	0.006	0.011	1.694	0.018	0.014	0.007	0.004	0.008	14
Cable Media Viewership	0.006	0.009	0.009	0.022	0.100	0.026	0.017	0.016	0.030	4.688	0.049	0.038	0.018	0.010	0.021	38
Online Media Viewership	0.101	0.163	0.168	0.405	1.803	0.468	0.306	0.289	0.543	2.142	0.891	0.690	0.328	0.186	0.380	9
Total Industry Output	347.1	471.6	438.4	1329.9	5356.6	1270.0	1321.1	867.3	1307.5	4713.7	2640.3	1775.5	948.4	534.1	2947.1	98

Appendix B: Detailed Discussion of Datasets Used

Production of Media By Industry: 1929-2014

Before the Internet, the mapping between media categories and industries was straightforward: publishers (NAICS 511) produced print media and networks (NAICS 5151 and 5152) produced cable television, and broadcast radio and television media. The Internet makes the situation more complicated. The majority of online media is produced by internet-only publishers like Google or Yahoo (NAICS 519). However, print media publishers also produce online content like digital news stories or blogs. Conversely, Internet publishers like YouTube sometimes host videos for a variety of professional content producers.³⁴

Unfortunately, the Economic Census does not report online advertising revenue for print publishers or video revenue for Internet publishers. The only data tracked is total advertising revenue for each industry.³⁵ We use a variety of datasets to split industry advertising revenue by media category. According to the Newspaper Association of America, digital advertising accounted for 15% of total advertising in 2012, 7% in 2007 and 2% in 2002.³⁶ We were not able to find similar data on magazines, but the Service Annual Survey does track the overall share of revenue earned online. This total includes both digital advertising revenue and also digital subscription revenue. We assume that both revenue sources have the same digital share.³⁷ Based on that assumption, we estimate that digital advertising accounted for 18% of magazine revenue in 2012, 9% in 2007 and 4% in 2002. Finally, we use annual reports published by the Internet Advertising Bureau (IAB) and other sources to track online radio and television advertising. Based on those datasets, we estimate that videos accounted for 10% of online advertising in 2012 and 1% in 2007.³⁸

³⁴ Many of the content producers are not yet profitable. Nevertheless, we classify them as professional because they are aspiring to earn money from their channel eventually. In addition, YouTube hosts many pure amateurs.

³⁵ The 2002 Economic Census does track online advertising revenue separately. But the numbers are very small and hard to extrapolate forward.

³⁶ The Newspaper Association of America only reports digital advertising back to 2003. Between 2003 and 2004, the digital share for newspapers grew 21%. We assume the same growth rate between 2002 and 2003.

³⁷ The Service Annual Survey data starts in 2005. We assume that the digital share grew 27% annually before 2005. For newspapers, the Service Annual Survey reports total online revenue smaller than the Newspaper Association of America reports for online advertising alone. We are not sure for the reason behind this difference.

³⁸ Advertising-supported online video always existed, but it was very small before YouTube was bought by Google in November 2006. IAB's data starts in 2007, when the digital video share was 1.34% of total online advertising.

Before 2002, we could not find any data on online advertising revenue by industry. We assume that the industry split is fixed at 79% internet-only publishers, 20% print publishers and 1% networks. Our TFP numbers do not currently extend after 2012, so it is not yet necessary to calculate the industry split after the 2012 Economic Census. Online advertising revenue is becoming a very large fraction of newspaper and magazine advertising revenue. We hope that the Census will eventually recognize the importance of online advertising and track it separately.

Nominal Advertising Revenue by Media: 1929-2014

Our primary dataset is the 2007 Economic Census. That Census reports advertising revenue for newspaper publishers (NAICS 51111), magazine publishers (NAICS 51112), radio broadcasters (NAICS 51511), television broadcasters (NAICS 51512), cable networks (NAICS 5152) and internet publishers (NAICS 516 in 2002 and 51913 in 2007 and 2012). At the time this draft was written, the final 2012 Economic Census was not yet available. Therefore, we benchmarked all of our numbers to the 2007 Economic Census. Results are very similar if we use the preliminary 2012 Economic Census for benchmarking. As we discussed earlier, the Economic Census tracks total advertising revenue by industry, but does not reliably split advertising revenue by media category. We used the media splits by industry calculated above to estimate advertising revenue by media category.

It is important to note that the advertising revenue tracked in the 2007 Economic Census represents only a portion of the resources devoted to media production. Media companies also earn significant sums from subscription revenue and single copy sales. In addition, many news organizations interview corporate public relation specialists when preparing their stories. These public relation specialists do not charge news organizations for the interview, and so the cost of their time is not included in the advertising revenue tracked by the 2007 Economic Census. However, the interviews frequently represent an implicit barter transaction: corporations provide information in return for an opportunity to shape news coverage. In a future paper, we hope to study non-advertising marketing. That paper may choose to include some portion of the salary for public relationship specialists in final expenditures and GDP. For print newspapers, the Newspaper Association of America provides our time series data from 1950 until 2013. This

data is available on their website for free.³⁹ Before 1950, we use estimates from the CS Ad Expenditure Dataset (Galbi 2008). That data is also available online for free.⁴⁰ Results are similar if we use data from the Service Annual Survey or the Economic Census – but those sources require more work to create a consistent time series.

For print magazines, the Service Annual Survey (SAS) provides our total magazine advertising from 2005 until 2013. The Economic Census provides total magazine advertising from 1947 until 2007. Finally, we use the CS Ad Expenditure Dataset before 1947 and as an interpolator between Economic Census years. None of these datasets splits online advertising revenue from print advertising revenue. We use the online share estimates developed earlier to estimate print revenue alone.

For radio, the SAS provides our time series from 2007 onwards. Before 2007, we use the CS Ad Expenditure Dataset. Neither of these datasets split online advertising from broadcast advertising. We subtract the online advertising estimates developed earlier to get off-line revenue alone.

For television, the SAS provides our time series from 2011 onwards. Before 2011, we use data collected earlier for a previous paper on long-lived television programs (Soloveichik 2013b). Unlike the print media and radio, advertising-supported television shows up in two NAICS codes: 5151 for broadcast television and 5152 for cable television. We add the two categories of television advertising to get total advertising. Just like the other media categories, we subtract the online advertising estimates developed earlier to get off-line revenue alone.

We do not have data on exports or imports of advertising-supported media. We believe that virtually all print newspapers, magazines, radio and television are consumed domestically, so there is no effect on the balance of payments from those media categories.⁴¹ The situation for online media is much more complicated. Unlike the other media categories, individuals in one country can easily view foreign websites. In theory, our experimental methodology requires that Internet use by foreigners should be treated as an export of advertising-supported media content and an import of advertising viewership. By construction, the nominal export value of media content equals the nominal import value of advertising viewership – and so advertising revenue

³⁹ <http://www.naa.org/Trends-and-Numbers/Newspaper-Revenue.aspx>

⁴⁰ <http://www.purplemotes.net/2008/09/14/us-advertising-expenditure-data/>

⁴¹ In many cases, the domestic media company buys content from foreign media companies or sells its content abroad. These transactions are already tracked as imports and exports in the Balance of Payments account. .

earned from foreign Internet users does not increase nominal GDP. Conversely, nominal GDP rises if US residents view foreign websites even if the associated advertising revenue is not tracked in the US Economic Census. We were not able to find any data on net exports of online media. For simplicity, our current calculations assume that imports are precisely equal to exports and therefore net exports are zero.⁴²

Forrester Data on Media Time Use: 1929-2014

Our primary data on time use is provided by Forrester, a survey company. They have been surveying Americans about their media time use since 1999. Our paper will use data from their questions on weekly time use for ‘reading newspapers (not online)’, ‘reading magazines (not online)’, ‘listening to the radio (not online)’, ‘Using the Internet for personal purposes’ and ‘Using the Internet for work purposes’. Like most surveys, Forrester relies on self-reported data and does not attempt to check their answers against objective source data like Internet cookies. We do not know either the size or direction of the possible misreporting. For now, we will use Forrester’s data on newspaper readership, magazine readership, radio listenership and total Internet usage without adjustment.

Forrester’s survey does not ask respondents for the exact amount of media usage. Instead, they are asked to check boxes giving the time use category. The lowest category is ‘none’ and the highest category is ‘30 or more hours’. In some of their published reports, Forrester creates a continuous variable by replacing each box with the midpoint of the range. In particular, the mapping is ‘none’ = 0, ‘less than 1 hour’ = 0.5, ‘1-4 hours’ = 2.5, ‘5-9 hours’ = 7, ‘10-14 hours’ = 12, ‘15-19 hours’ = 17, ‘20-24 hours’ = 22, ‘25-29 hours’ = 27 and ‘30 or more hours’ = 32. This average usage is held fixed over time. In this paper, we have used a statistical methodology described in von Hippel et al (forthcoming) to estimate the mean for the top-coded bin, using a pareto distribution for the top-coded bin (30 + hours per week) and the next-to-top-coded bin (27-29). For the non-top-coded bins, we used midpoints, as Forrester does. In future work, we plan to use a parametric methodology for estimating the mean using the generalized beta distribution to model the entire distribution of binned data. This has the advantage of not

⁴² One might think that the U.S. exports far more online media than it imports. After all, the U.S. is a world leader in online media technology. However, most large Internet companies have foreign branches which handle their non U.S. customers. Only small Internet websites are likely to have foreign viewers coming directly.

throwing away any information, but it leans much more heavily on distributional assumptions. Having two methods should enable us to have at least some notion of how sensitive our estimates are to the statistical methodology employed. Our imputed numbers should not be attributed to Forrester.

Forrester's survey also does not ask respondents to split media usage between advertising-supported media and subscription media. This is most problematic for the Internet, where subscription media websites like Netflix account for a large share of total time usage. In addition, many Internet users spend time on non-media websites like online shopping, or mobile banking. For now, we assume that advertising-supported media time tracks overall media time.

Other Data on Media Time and Media Consumption: 1929-2014

We use Nielsen data to track television viewership back to its beginning. We did not buy Nielsen's full data for this purpose, but rely on the summaries prepared by the non-profit trade association TVB. All of our Nielsen data was taken from their website, tvb.org, and it is available for free. Forrester also tracks television viewing time, and we could use their data from 2007 onwards. However, the Forrester data is much noisier than the Nielsen data and so our annual TFP numbers are a little more volatile.

We use a variety of datasets to track radio listenership. From 2007 to 2014, we use Forrester's survey question on 'radio listening (not online)'.⁴³ From 1980 until 2007, we use Arbitron data. Like the Nielsen data, we did not buy Arbitron's full dataset. Instead, we rely on a summary prepared by the Corporation for Public Broadcasting which reports total radio listenership for each year from 1980 to 2010.⁴⁴ We also found Arbitron data for 1972 cited in the book 'American Broadcasting' (Lichty and Topping 1975). Before 1972, we could not find any systematic ratings for radio. However, we found an article 'More Power' (Sponsor 1949) that reports radio listenership in 1949, 1946 and 1943. Before 1943, we could not find any useable

⁴³ Forrester reports a very small decline in offline listening between 2007 and 2014. Over the same time period, Arbitron's data show a much larger decline. This decline may be associated with measurement changes <http://rainnews.com/radio-aqh-decline-ppm/> rather than competition from online radio.

⁴⁴ In particular, we use the series '6a – Mid, 12+ Persons Using Radio AQH Rating'. That series reports the % of people who are listening to the radio at any given time.

data on listenership time. As a rough proxy, we use the percentage of households who own radio and the percentage of cars equipped with radios.⁴⁵

Neither the Nielsen TV viewership data nor the Arbitron radio listenership data split advertising from advertising-supported entertainment. For television, we use data from IMDB.com to split viewership between programs and advertising. IMDB does not directly report the amount of advertising viewership – but it does report the run-time for individual episodes. Between 1960 and 2013, the time devoted to commercials grew from 15% of broadcast time to 28% of broadcast time. We could not find similar data for radios, but the book ‘Radio After the Golden Age: The Evolution of American Broadcasting Since 1960’ (Cox 2013) suggests that radio commercial time grew at approximately the same rate as television advertising time. This increased advertising time lowers measured TFP growth. In Figure 14, we calculated that advertising-supported broadcasting raises TFP growth by 0.005% per year from 1960 to 2012. If the commercial time share had remained fixed, then advertising-supported broadcasting would have raised TFP 0.009% instead.

We use data from the Statistical Abstract of the United States to track Internet usage.⁴⁸ All of the tables in the Statistical Abstract explicitly focus on leisure Internet usage and do not include on-the-job Internet. Accordingly, we need to adjust the Statistical Abstract data for on-the-job Internet usage. We have not been able to find any data tracking on-the-job Internet time before 2007. As a proxy, we use data from the Current Population Survey (CPS) that tracks whether respondents have Internet **access** at work. During the 1990’s, Internet was more common on the workplace and workplace Internet tended to be faster. Based on that trend, we believe that on-the-job Internet accounted for a larger share of usage.

Newspapers and magazines are the hardest media category to track. From 2007 to 2014, we use Forrester’s survey on time usage. From 1965 until 2007, we use readership data from Pew surveys conducted periodically and reported in ‘In Changing News Landscape, Even Television is Vulnerable’ (Kohurt, et. al. 2012). Before the Pew survey data, we use the article

⁴⁵ For now, we give home radios and car radios an equal weight when calculating listenership. We multiply both proxies by population to get an estimate of total listenership.

⁴⁸ Taken from Table 1094 of the 2010 Statistical Abstract, Table 1089 of the 2009 Statistical Abstract, Table 1110 of the 2007 Statistical Abstract, Table 1119 of the 2004 Statistical Abstract, Table 1125 of the 2003 Statistical Abstract and Table 1102 of the 2002 Statistical Abstract. All of these tables explicitly focus on leisure Internet usage and do not include on-the-job Internet. We adjust for the on-the-job share to get total Internet usage.

“Radio declares: ‘Compare Me’” (Sponsor 1961)⁴⁹ to get a snapshot of readership in 1961. Between the years with data, we use newspaper and magazine circulation to interpolate annual readership. We also use newspaper and magazine circulation to extrapolate readership before 1961.⁵⁰

Splitting ‘Business Information’ and ‘Consumer Entertainment’: 1929-2014

Forrester’s reported split between ‘work Internet’ and ‘personal Internet’ is not equivalent to our split between ‘business information’ and ‘consumer entertainment’. Our paper is focused on measuring productivity by industry in the private business sector, so we consider ‘business information’ to be Internet used on-the-job for job related purposes. ‘Consumer entertainment’ covers both leisure activities like YouTube and household production like scheduling medical procedures or paying bills. In contrast, Forrester’s respondents appear to have a broader definition of ‘work Internet’. Approximately two thirds of full time students report using the Internet for work and many of those students report very high usage. These students are almost certainly reporting their homework and other study time as ‘work Internet’. In addition, retirees and other individuals not employed⁵¹ also frequently report using the Internet for work. These individuals are probably reporting household production activities as work. We calculated the true ‘business information’ share by replacing reported ‘work Internet’ with zero for all individuals not employed.

Forrester does not ask respondents to split print media readership, television viewing or radio listening between work and personal. In the absence of reliable time use data, we will use a variety of proxies to split ‘business information’ and ‘consumer entertainment’. For print media, we use genre data reported in the Economic Census and other sources. For example, we assume that scientific journals are used for work rather than leisure. Very few of the shows on

⁴⁹ This article gives an estimate for radio listenership. However, their estimate is much lower than Arbitron’s numbers. We believe that this difference is caused by survey respondents underreporting background radio while driving or doing other activities. Forrester’s survey shows the same underreporting relative to Arbitron.

⁵⁰ The Newspaper Association of America provides circulation 1940 <http://www.naa.org/Trends-and-Numbers/Circulation-Volume/Newspaper-Circulation-Volume.aspx>. The Census of Manufactures provides also data on circulation for both newspapers and magazines back to the 1920’s. In addition to that circulation data, the 1949 Sponsor article used earlier for radio also contains some data on print readership. However, that article is based only on two high education cities (Des Moines, Iowa and Springfield, Massachusetts), which we felt were too unrepresentative to use for readership tracking.

⁵¹ A few respondents report multiple employment categories. We drop those individuals.

broadcast radio or television are targeted towards business information. For now, we assume that on-the-job users account for only 1% of advertising.

Finally, we adjust for a conceptual difference between the NIPA's and everyday conversation. In BEA's GDP statistics, owner-occupied housing is treated as if it were part of the business sector. Consistent with that treatment, 'free' media products which help people buy, finance or maintain their homes should be treated as intermediate inputs rather than final consumption. However, the Forrester survey respondents and the Economic Census almost certainly define home purchases as a personal activity rather than a work activity. We will assume that the housing share of GDP is a proxy for the housing share of personal media usage.

Usage of Media By Industry: 1929-2014

Our primary data is the same Forrester survey described earlier. In 2013 and 2014, Forrester asked respondents 'In which industry/field do you work?' They provided only 30 codes for this question and a few of codes do not represent industries.⁵² We used our best judgment to match the Forrester codes with the 63 private sector industries tracked in the joint BLS-BEA production accounts. Reassuringly, reported time usage in the Forrester survey is highly correlated with reported Internet access in the CPS.⁵³

We were not able to find any data tracking usage of print media or broadcast media by industry. For now, we use Internet usage by industry as a proxy for those media categories. We were also unable to find any data on media usage by industry before 2013. For now, we use total industry output and total work Internet usage as extrapolators. For example, agriculture is assumed to use a very small share of print media output in 2013 – but it accounted for a much larger share of business information in 1948. Our aggregate TFP numbers are robust to changing the industry allocation procedure, but TFP for individual industries are more sensitive.

⁵² For example, one answer was 'non-profit', which could correspond with many industries. We do not match those codes to any NAICS codes. In addition, many of the Forrester codes are matched to multiple NAICS codes. Some individuals report multiple industry/field codes to Forrester. We drop all these individuals from our sample.

⁵³ The relationship between Internet access and usage is not one-to-one. In the CPS data, Internet access ranged from 15% for industries like agriculture to 70% for industries like publishing. The Forrester data show a much more compressed range of 'work Internet' time. We believe that this compression is caused by employees without work-provided Internet using their personal smartphones for work.