intangibles carefully to determine whether they too can be included in the Accounts. The second part of our paper therefore develops measures of advertising as a potential further intangible within each of our 61 industries and for the private U.S. economy. Data on the presence of advertising in each industry are based on the United States Input-Output (IO) tables covering the same 1987 to 2019 period. The IO tables assign advertising to each industry according to national income conventions, so the information on advertising is consistent with the existing measures of R&D, software, and artistic originals in the accounts. We hope that our study will be a useful step towards understanding whether and how advertising should be included as an additional intangible in the National Accounts.[8]

Our third goal is to compare, analyze, and understand the presence and impact of intangibles in each industry. We have conducted a thorough analysis of the effects of the existing intangibles, R&D, software, and artistic originals, on productivity growth in each industry. We add advertising as a further intangible, adjust income in each industry appropriately, alter rental prices, and calculate how the addition of advertising changes our estimate of the effect of intangibles.

The main line of work on intangibles currently emphasizes the use of national accounts and the associated input-output tables. This approach is based on establishment level data, often adjusted to a North American Industrial Classification (NAICS) basis, to provide internationally consistent data suitable for cross-country comparisons. Because national incomes measures are prepared on an establishment basis, our work shows that large proportions of advertising occur in retail and wholesale trade, finance, services, and the management of enterprises. One possibility is to follow Barth, Davis, Freeman, McElheran (2020), assign intangibles to specific establishments, and explore how the presence of intangibles affects productivity observed in establishments. It is sometimes difficult, though, to attribute intangibles to a specific establishment. BLS already conducts work on the dispersion of productivity among establishments within an industry (Cunningham et al., 2021), so a closer look at differences in establishment productivity might be warranted.[9]

More recently, economists have developed an alternative approach that emphasizes data on firms in specific industries. Such studies typically use the Compustat data on individual firms (Bloom, Schankerman, and Van Reenen (2013); Bessen, Denk, Kim, and Righi (2020); De Loecker, Eeckhout and Unger (2020)). This approach works well because the presence of intangibles can be measured in firms and because standard production function methods can often be used to understand these firm data.

The returns to intangibles may be greatly different at firm and industry levels. As Bloom, Schankerman and Van Reenen (2013)) and others demonstrate, social returns to R&D are far greater than private returns. Similarly, it is plausible that advertising by competitive firms cancels itself out, so that industry returns to advertising are less than firm returns. We need measures of firm productivity

[8] Strictly speaking, intangibles are components of capital so they affect labor productivity, but not multifactor productivity growth. We shall generally speak of the contribution of intangibles to output, but sometimes refer to contributions to productivity as an equivalent phrase.

[9] There is a considerable literature on why establishments in an industry differ in productivity (Syverson (2004a; 2004b) and Foster, Haltiwanger, and Syverson (2008)), but it may still be useful to examine how the presence of intangibles affects productivity in different establishments.

Intangible Capital and US Productivity Growth in 61 Industries

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Capital assets can be tangible, such as buildings, equipment, or inventories, or "intangible," such as R&D, software, artistic originals, and databases. Investments in intangible capital have grown more rapidly in recent years than those in tangible assets. Early analyses demonstrated the importance of intangible assets in U. S. national data.[2] More recently, attention has shifted towards the role of intangibles in specific industries and additional countries.[3] This more detailed work often uses input-output tables to measure the presence of certain types of intangibles.[4]

The first part of this study examines the productivity effect of R&D, software, and artistic originals within 61 industries which together comprise the U. S. private economy.[5] The analysis uses data on the presence of each of these three intangibles in each industry from 1987 to 2019. We rely on official BLS measures of the stock and rental price of each intangible in every industry and year.[6] BLS estimates of industry capital assets are based on investment data in the U.S. National Income Accounts.[7]

Early work by Corrado, Hulten, and Sichel (2005) considered several additional intangibles beyond the three forms which the Accounts already include. Economists will have to study these further

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[2] *See* Corrado, Hulten, and Sichel (2005, 2009).
[3] *See* Corrado, Haskel, Jona-Lasinio, and Massimiliano (2018) and Corrado, Haskel, Massimiliano, and Jona-Lasinio (2020).
[4] Many important studies measured intangibles within firm data. The intangibles pioneer Baruch Lev participated in an excellent early study, Lev and Radhakrishna (2005). Bessen, Denk, Kim, and Righi (2020) studied intangibles within firm data. Firm data is typically obtained from filings with stock market regulators, so most studies of firm data omit many midsize or small firms.
[5] These 61 industries are called NIPA-level industries within the National Income and Product Accounts.
[6] The term "rental price" in this paper means the same as "capital service price," which is calculated from the Hall-Jorgenson user cost model through standard methods.
[7] The estimates of the impact of each intangible are based on Bureau of Labor Statistics procedures of determining capital stocks and service prices as well as on the initial Bureau of Economic Analysis investment data. Section I.A below briefly describes how the BLS calculations build upon the BEA investment data.

and further data on firm inputs of intangibles to unravel differences between firm and industry estimates of the return to intangibles. Section III.C of this paper begins work on this important topic.

I. Intangible capital in official productivity statistics

This section describes the theoretical framework within which we measure the contribution of individual intangibles to output growth. Section I.C below uses these methods to determine the contributions of R&D, software, and artistic originals to output growth in the model used for official data from the BLS Productivity data.

IA. Theoretical Framework

It is relatively straightforward to measure the productivity contribution of each asset already included in the National Accounts. The Bureau of Economic Analysis has collected data on the amount of investment in every asset in each industry and year. The BEA also provides corresponding data on the price of each investment over time. The BLS Productivity program measures capital services using investment data from BEA, calculates capital stocks through standard perpetual inventory calculations,[10] uses data on property income to calculate internal rates of return[11], and then proceeds to calculate rental prices for each capital asset in every industry-year.

BLS estimates of capital stock and rental prices reflect the quantity and price of each capital asset. As in the case of any other form of growth accounting, the contribution of any asset, X, to growth is then:

$$\alpha_x \dot{X}/X \qquad (1)$$

where α_x is the share of capital asset x in output and $\dot{X}/X$ is the rate of growth of asset x.[12] Since the BLS measures both capital stocks and rental prices, this provides the quantity and rental price of each asset, x. Because the value of output is also known, it is easy to calculate the factor share, α_x, for each asset. The growth rate of any capital asset, $\dot{X}/X$, is also known from the perpetual inventory calculations, so equation (1) directly provides the annual contribution to output growth.[13]

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[10] The Bureau of Labor Statistics *Handbook of Methods* (2021, online) provides a detailed description of how the BLS prepares its measures of capital inputs and service prices. See “Productivity Measures: Business Sector and Major Subsectors,” page 4, at https://www.bls.gov/opub/hom/msp/pdf/msp.pdf.

[11] Property income is the same as “capital income”, “capital cost,” or “capital compensation.” These terms are also used in the literature. Considerable evidence shows that returns to R&D are concentrated in a relatively small number of projects, so BLS productivity statistics add a 4% risk premium to the rate of return tor R&D in each industry.

[12] When we measure the empirical effect of intangibles on output, the change in capital input is computed in natural log form. Capital and labor are also called input factors in this literature. The overall standard growth accounting equation has the form in equation (2).

[13] For some broader forms of capital, such as information technology capital, the type of capital in question is an aggregate of several different asset classes. The logic of equation (1) still holds true, but the category of capital of interest first has to be aggregated from the relevant individual assets through standard methods.

I.B. Data and methods to understand intangible capital growth

This section outlines current sources of data on intangible investment and capital services and suggest some areas where further research may be helpful.

Research and Development

Data for R&D expenditure for each of the 61 industries are drawn from the US National Accounts. R&D affects productivity in two ways, as discussed by Sveikauskas (2007). First, there is the private return to firms which invest in R&D, which the Bureau of Economic Analysis emphasizes in most of its publications on R&D. The BEA measures R&D investment, stocks, depreciation, and the return to private investments in R&D.[14] R&D by one firm also brings returns through a second channel, spillovers to other firms, many of which are presumably in the same industry. Bloom, Schankerman, and Van Reenen (2013) show that spillovers are extremely large in the United States. The spillover return, the amount by which social returns exceed private returns, is approximately as important as the private return to R&D. Lucking, Bloom, and Van Reenen (2019) report that, from 2000 onwards, R&D spillovers provided approximately three times the private return to R&D, an even greater proportion of the total returns to R&D; most of these spillovers presumably occur in the same industry. For many years, the Bureau of Labor Statistics has published estimates of how much R&D spillovers contribute to Multifactor Productivity Growth in the aggregate U.S. private nonfarm sector.[15]

Software

Since 1997 the National Accounts have included three different categories of software, pre-packaged, custom, and own-account software. The literature suggests that own-account software is an especially important component of software (Bessen (2020) and Bessen, Denk, Kim, and Righi (2020)). Off-the-shelf software, which can readily be matched by competitors, is unlikely to confer any lasting competitive advantage. A firm's commitment to its own-account software is more likely to bring lasting IT advantages, which competitors find more difficult to match.[16] Bessen (2020) measures the presence

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[14] The Bureau of Economic Analysis prepares separate measures of the private R&D stock in different industry categories. They allow this stock to depreciate at different rates in each industry as discussed in Li and Hall (2020.

[15] R&D brings important spillovers between firms, which suggests that the large amounts of R&D conducted by leading firms ultimately helps their smaller competitors. BLS Productivity program publishes direct and spillover estimates in Table B of news releases such as https://www.bls.gov/news.release/pdf/prod3.pdf. In contrast, Akcigit and Ades (2019) show that patents have become less ambitious and more protective since 2000 which suggests that patents now increasingly hinder smaller competitors.

An early BEA study of the returns to R&D (Fraumeni and Okubo (2005)) included measures of R&D spillovers at the aggregate level. We do not currently have reliable measures of R&D spillovers in each detailed industry (Bloom, Schankerman, and Van Reenen (2013, Appendix F). Since returns to R&D are substantial, and spillovers are likely to be even greater, it is a high priority to develop better measures of the magnitude of R&D spillovers in each industry.

[16] Expenditures on own-account software importantly include the wages and salaries paid to workers who develop software for each firm for its own use, not for sale.

of own-account software by employment of "computer systems analysts and computer scientists, operations and systems researchers and analysts, and computer software developers."[17]

Although the current practices of distributing own account software using employment in occupations such as software developers, there are other and potentially more reliable methods of allocating own-account software to specific industries. Bessen, Denk, Kim, and Righi (2020) and Barth, Davis, Freeman, and McElheran (2020) examine data on firm-level expenditures on software, including own-account software, from the Annual Capital Expenditures Survey (ACES). Barth *et al* assign these firm-level data to each specific establishment associated with a firm. Data from ACES are likely to improve measures of own-account software in specific industries considerably.[18] Future versions of Bessen, Denk, Kim, and Righi (2020) will presumably develop these improved measures. We mention these potential alternatives here to illustrate that measurement of intangibles is not an exact science and that gradual improvements in such measures are typical.

Artistic Originals

This work uses the investments and depreciation rates the Bureau of Economic Analysis currently uses for artistic originals. Depreciation rates differ across the different types of artistic creations considered but are largely centered around a handful of the 61 industries.

I.C. Empirical Evidence for Intangibles

Figure 1 shows a measure of importance of capital asset categories in official US productivity accounts. Panel A shows measures of the growth of capital services in the private U. S. economy. Capital services from intangibles consistently increased more rapidly than the flow of services from tangibles. This pattern is clear throughout the overall 1987 to 2019 period as well as in the 1990-2000, 2000-2007, and 2007-2019 subperiods; these subperiods are selected to describe broadly similar phases of the business cycle.

Panel B of Figure 1 compares the roles of intangibles (in red) with the impact of information, communications, technology (ICT, in light blue) and other forms of assets (in dark blue) in accounting for the growth of capital services. The growth of capital services from intangibles is broadly similar to that of ICT over the entire period, but the relative importance of intangibles has increased over time relative to ICT and other tangible assets, starting from the least large contributor to capital growth at 27% in the 1990-2000 period to the largest contributor to capital growth in the most recent business cycle at 40%. Other tangible assets have fallen in contribution to capital growth from a high of 39% contribution to growth in the 1990-2000 cycle to 35% contribution in the 2007-2019 cycle.

Figure 1, Panel A: Capital services growth of intangible and tangible assets in the private economy
Average annual growth

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[17] Bessen (2020) notes that the correlation between industry employment in IT and the software compensation share of gross output within the 61 BLS industries is .41.

[18] Barth et al. make the central assumption that each employee in a firm shares equally in that firm's stock of own-account software.

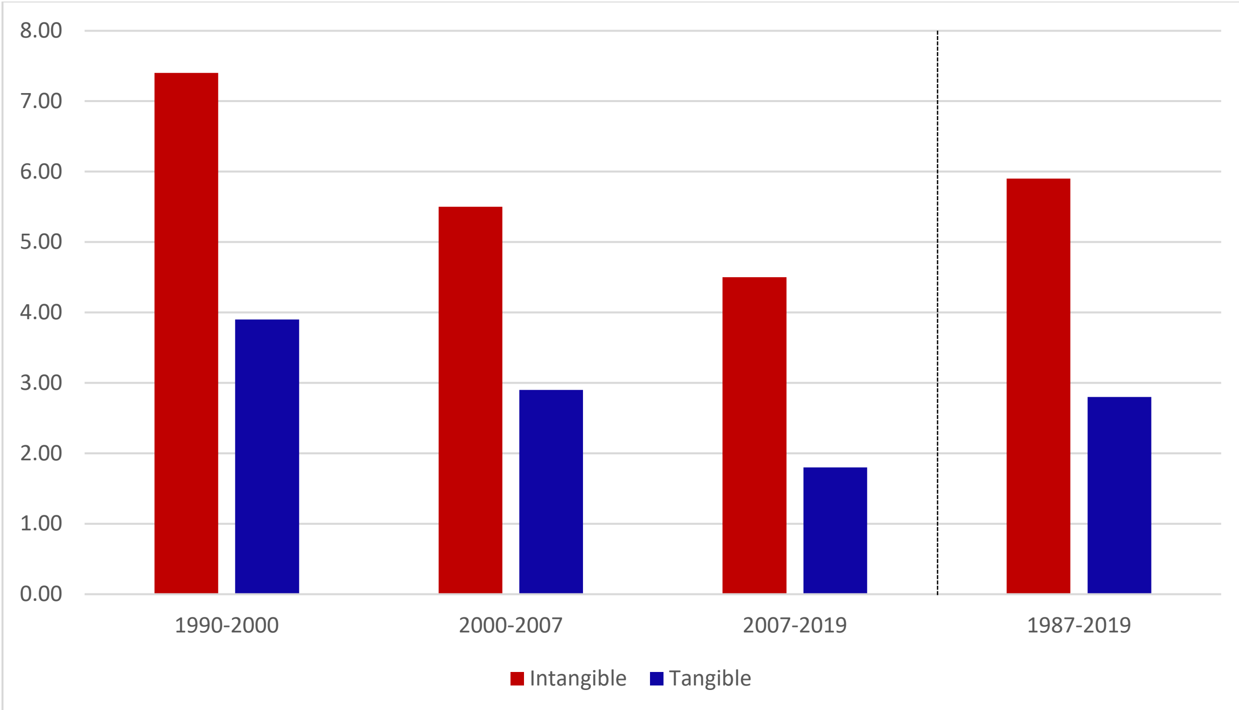

Figure 1, Panel B: Contributions of different types of assets to private business capital growth
Percentage point contribution, average annual growth

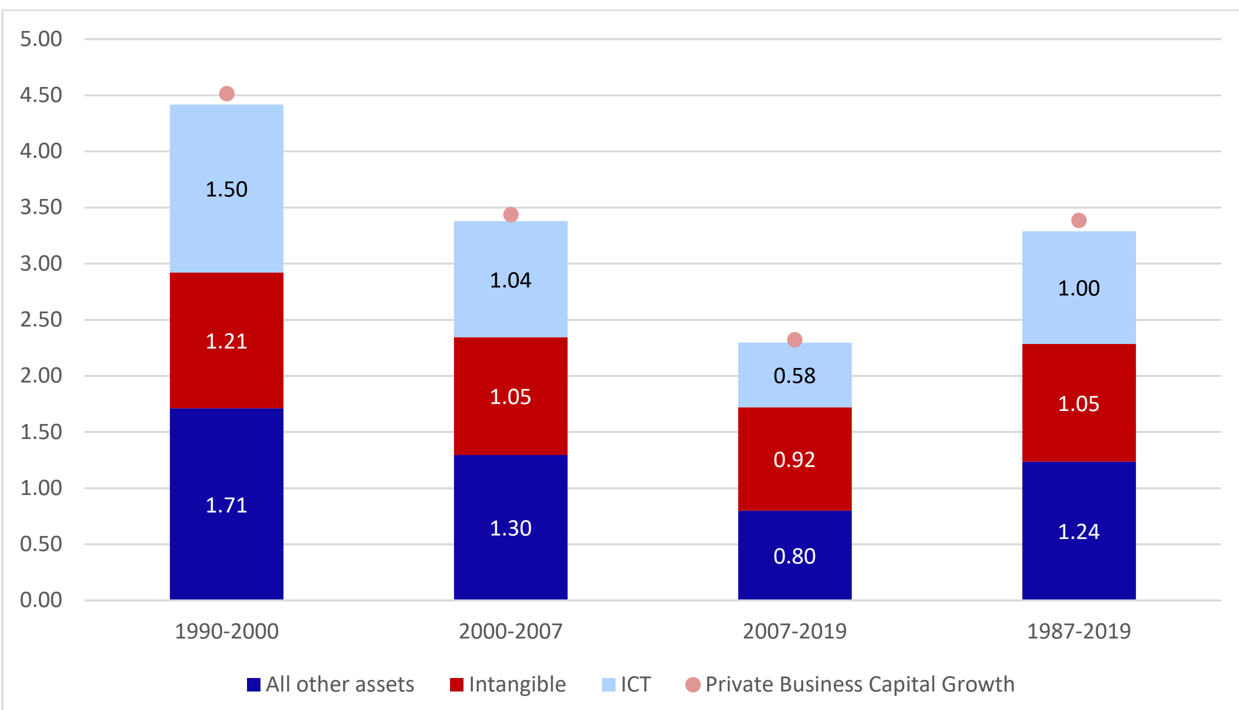

Table 1 reports how much each type of asset currently included as an intangible in the accounts contributes to the observed growth of capital services. For example, over the total 1987-2019 period the sum of the individual entries for each form of intangible in Table 1 adds up to the 1.05 percent effect reported on the right-hand side of Figure 1, Panel B-roughly just under a third of the observed growth in capital services. Not surprisingly R&D consistently makes the strongest contribution to the growth of capital services in the period studied.[19] Data on the impact of the different types of software are more novel. The Bessen (2020) hypothesis that own-account software is a crucial contributor to firm success because competitors cannot immediately match own-account investments is intuitively convincing. However, these calculations based on software investments included in the accounts suggest that prepackaged software, especially, and custom software are both more influential than own-account software. It is an interesting possibility that so many different firms purchase such large amounts of prepackaged software that this more prosaic form of software may perhaps have a greater impact on economic growth. Nevertheless, that is what this analysis based on the software investments recorded in the accounts tells us.[20] On the other hand, much remains to be learned about deflators and depreciation for the different types of software.[21] The present evidence suggests that it is worthwhile to take a closer look at the different forms of software investment.

Table 1: Contributions of each intangible asset to the growth of capital services for private business
Percentage point contribution, percent

Period	Artistic Originals	R&D	Pre-Packaged Software	Custom Software	Own-Account Software	All-asset growth
1987-2019	0.09	0.41	0.29	0.18	0.09	3.4%
1990-2000	0.12	0.47	0.33	0 .20	0.09	4.5%
2000-2007	0.12	0.39	0.28	0.15	0.11	3.4%
2007-2019	0.06	0.36	0.26	0.17	0.07	2.3%

Table 2 compares the contribution of intangibles to output growth with the impact of other forms of capital services and the well-established roles of labor input and multifactor productivity growth (MFP). For our purposes, the important result here is that intangibles accounted for 10% of United States private economic growth in the 1990-2000 period, but this contribution increased to 19% of overall growth by the more recent 2007 to 2019 period and further indicates more research in this area of economic measurement is worthwhile and important.

Table 2: Contribution of each factor of production to growth in private business output, as percentage of total growth

[19] Because there is substantial variance in the returns to R&D, the Bureau of Labor Statistics includes a 4% risk premium in their rate of return to R&D, which somewhat increases the implied service price for R&D.

[20] Although the Bureau of Labor Statistics Productivity Program has previously considered the effect of Information Technology, we believe that our work is the first attempt to understand the impact of different types of intangibles from the BLS asset and rental price data.

[21] Our coauthor, James Bessen, an expert on software, has emphasized that much work remains to be done on the deflators and depreciation rates for different types of software.

Percent, average annual growth

Period	Intangibles	ICT	All other assets	Labor	MFP	Private Industry Value-Added Output Growth
1987-2019	14%	13%	16%	31%	26%	2.80
1990-2000	10%	13%	15%	36%	25%	3.90
2000-2007	14%	14%	18%	10%	43%	2.60
2007-2019	19%	12%	17%	31%	20%	1.80

Table 3 lists the five industries for which the measured categories of intangible assets are the largest contributor to growth of capital. *Artistic originals* are most important in broadcasting-telecommunications, motion pictures-recording, and performing arts. *R&D* is important in many manufacturing industries, including chemicals (which contains pharmaceuticals), computer and electronic products, and motor vehicles. *Pre-packaged software* is influential in insurance, miscellaneous professional and scientific services, and data processing. While *custom software* contributions to capital growth in wholesale trade, chemicals, professional and scientific services, and data processing are among the largest. Finally, *own-account* software is important in some facets of banking and insurance, and in retail and wholesale trade.

Appendix Table 1 reports how much these intangibles contributed to capital services growth in each of our 61 industries. Appendix Table 2 reports the percentage of the total stock of each intangible which was associated with manufacturing, other goods (agriculture, mining, and construction), trade, finance, and other services in 2017.[22] This table also reports a similar distribution of each stock across industries in 1987 and 2019. Finally, Appendix Table 3 reports the correlation matrix between the 2017 stocks of these five intangibles observed across all industries. The correlation matrix also includes correlations with the 2017 advertising stock.

Table 3: Industries ranked by intangible contribution to capital services growth from 1987 to 2019

Rank	Artistic Originals	R&D	Pre-Packaged Software	Custom Software	Own-Account Software
1	Broadcasting and telecommunications	Chemical products	Insurance carriers and related activities	Wholesale trade	Federal Reserve banks, credit intermediation, and related activities
2	Motion picture and sound recording industries	Publishing industries, except internet (includes software)	Miscellaneous professional, scientific, and technical services	Chemical products	Insurance carriers and related activities

[22] We report calculations for 2017 here because 2017 is the last year for which firm information is available in our Compustat data. Appendix Tables 4 and 5 compare the broad distribution of assets across industries in the national income and Compustat data.

3	Performing arts, spectator sports, museums, and related activities	Computer and electronic products	Data processing, internet publishing, and other information services	Miscellaneous professional, scientific, and technical services	Broadcasting and telecommunications
4	Publishing industries, except internet (includes software)	Miscellaneous professional, scientific, and technical services	Federal Reserve banks, credit intermediation, and related activities	Data processing, internet publishing, and other information services	Retail trade
5	Miscellaneous professional, scientific, and technical services	Motor vehicles, bodies and trailers, and parts	Wholesale trade	Real estate	Wholesale trade

II. Advertising as a Capital Asset

Several steps are necessary to add advertising as an asset in capital services measures and productivity accounts. There is ambiguity in what measurement and growth concepts to use, and we discuss some alternatives.

II.A. Theoretical Framework

In their study of R&D, Fraumeni and Okubo (2005) explain how to change growth accounting when a further intangible is added as a new asset. As their equation (16) indicates, when advertising is the new asset rather than R&D, the growth accounting equation becomes:

$$\dot{V}/V \; = \; \alpha_{AD}\, \dot{AD}/AD \; + \; \alpha_K\, \dot{K}/K \; + \; \alpha_L\, \dot{L}/L \; + \text{TFP} \qquad (2)$$

in which K is all assets except advertising,[23] L is labor, and AD is the stock of advertising. As Fraumeni and Okubo imply in their footnote 45 and mention on page 298, total property income is unchanged when a new asset is included. This implies that *part* of the property income originally attributed to capital in a two input K and L model is now assigned to the new advertising asset. In equation (2), $\alpha_{AD} + \alpha_K$ is equal to the total share originally attributed to capital in general.[24]

[23] In this case, where we are adding a further asset, all other assets already contains R&D, software, and intangibles, which are included in existing measures of capital input.

[24] When we add advertising as an additional capital asset, we recalculate all BLS rental prices to include this further asset in the capital stock.

Data on property income can be used to calculate the internal rate of return and service price for each asset. However, it is much more difficult to determine the spillover rate of return, using Fraumeni and Okubo's terminology, within each industry. Appendix F of Bloom, Schankerman, and Van Reenen (2013) show that their procedures can determine spillovers for only three broad industries. Researchers will have to determine the magnitude of spillovers in many industries to understand the full effects of R&D, including spillovers, in each industry.

Adding a new intangible asset type to our capital stocks, based on the advertising data, requires several further adjustments. First, investment is altered when a new intangible is introduced into the Accounts.[25] We treat a fraction of business advertising expenditures as investment that lasts beyond the calendar year in which it occurs. The results we show use estimates that capitalize 60% of advertising investment, and assuming that the remaining 40% is consumed by industry within the same calendar year as the expenditure and therefore does not qualify as investment and therefore is not included in value-added output. Data on advertising expenditures from a version of the input-output tables prepared by the BLS Office of Employment Projections that are based on and consistent with the BEA national accounts IO accounts. Annual use table data are available for 1997-2019 and describe each industry's current expenditures on the "Advertising, public relations, and related services" commodity. The benefit of using the BLS Employment Projections data are that their tables also have a set of constant dollar estimates so that industry specific advertising prices can be easily calculated by dividing current dollar by constant dollar expenditures.

To prepare capital stock measures, we need time series data on investment as far back as possible to include advertising already present when the BLS measures begin in 1987. We constructed a full 61 NIPA-industry current and constant dollar investment series by using the BEA historical input/output tables and SIC industry deflators. Historical BEA input/output tables exist for 1963-1996 and describe industry expenditures in the "Miscellaneous professional, scientific, and technical services" commodity, in which advertising is one of the miscellaneous professional services. We use the 1997 ratio of industry expenditures on the "Advertising, public relations, and related services" commodity to all "Miscellaneous professional, scientific, and technical services" commodities to estimate current dollar advertising expenditures by industry.

Each industry's current dollar expenditures are then deflated using the SIC based PPI "Advertising, public relations, and related services" commodity deflator,[26] which are available for 1973-2001 from the BLS. Using this deflator, an estimate of both current dollar and constant dollar estimates for advertising by industry for 1973-1996 are generated. Given our depreciation rate, all investment prior to 1983 has depreciated by the time our advertising stocks begin in 1987.

Add 60% of advertising expenditures to industry GDP and subtract it from intermediate input

To capitalize advertising investment, 60% of each industry's expenditure on advertising must be added to value-added output since it will be used in another time period. This requires moving this element of advertising from the purchased services category of intermediate inputs to capital in the value-added output framework.

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[25] This account of adding a further intangible to the accounts in many respects follows the Fraumeni and Okubo (2005) discussion of how R&D is added to the accounts. Since the present study considers productivity growth only within the private business sector, we do not include assets within the government and nonprofit sectors which Fraumeni and Okubo (2005) include.

[26] SIC and NAICS definitions for the "Advertising, public relations, and related services" commodity match, so the data do not need to be adjusted for the transition from SIC to NAICS.

We start with each industry's current dollar and chain-type quantity indexes of gross output, purchased services and advertising investment. 60% of advertising intermediate expenditures are removed from each industry's purchased services and then moved to the capital investment. By construction this removal will necessitate a recomputing of the industry intermediate input price so that the price of industry intermediates now only has 40% of the advertising input. This new price is then used to compute adjusted quantities to achieve an adjusted intermediate inputs measure. The 60% of advertising adjusted intermediate inputs are then moved from industry intermediate input to capital services input and included in value added output, becoming part of measured GDP. The double deflation method described in Moyer, Planting, Fahim-Nader and Lum (2004) is used to remove advertising from purchased services and to remove adjusted intermediate inputs from gross output.

The challenge of relocating income into value-added is that important choices need to be made as to where the income appears in the capital input measurement. This work assumes that all capitalized advertising goes to gross operating surplus as either corporate profits or mixed income to proprietors. Employee compensation is unchanged. We assume that all advertising expenditures are contracted services that are capitalized and that none are "own account" and therefore are not included in employee compensation. The ratio of corporate other (gross) operating surplus to other (gross) operating surplus, in each industry, is used to determine the proportion of capitalized advertising that is assigned to corporate profits. The remaining value of advertising is distributed to the mixed (between capital and labor) income of proprietors. We use each industry's ratio of corporate to noncorporate profits from the National Accounts to distribute the greater output to corporate capital income, proprietor capital cost and proprietor labor compensation.

Adding advertising to capital services

We next determine the flow of services that each industry obtains from its investments in advertising. The first step is to calculate the stock of each capital asset in each year. We use the perpetual inventory method that begins with the stock in the previous year, adds on new investment, and subtracts the deterioration and depreciation of previous investments.[27]

One key decision in determining capital stocks of advertising is selecting the rate of depreciation and deterioration, which shows how effective one dollar of current investment in advertising is in subsequent years. Based on Villalongo (2004) and Corrado, Hulten, and Sichel (2009) we select two depreciation rates, 45% and 60%. These rates of depreciation are equivalent to service lives of 4 and 2 years, respectively. As in other work which develops the BLS capital stocks, we apply a hyperbolic decay function to constant dollar investment to determine deterioration of the asset and a distribution of service lives; combining deterioration with depreciation we calculate annual stocks of advertising for each industry.

Once annual stocks of advertising are established for each industry, we need a way to value these stocks. To determine the relevant rental prices of each asset in each industry, we treat advertising like other capital assets. As is standard, we begin with property income for each industry and each year,

[27] Overview of Capital Inputs for the BLS Multifactor Productivity Measures, 2017, https://www.bls.gov/mfp/mprcaptl.pdf, page 4

determine an internal rate of return for each industry, and then estimate rental prices reflecting asset price changes, rates of depreciation, and tax considerations.

II.B. Data for Advertising

For many years, economists have emphasized the difficulty of obtaining reliable information on the presence of advertising, at either the industry or aggregate level. Rogers and Tokle (1995) discussed the difficulty of obtaining reasonable measures of the amount of advertising in each industry; their paper first reviewed initial work based on Internal Revenue Service data, and then considered data that the BEA prepared for IO tables. More recently, Silk and Berndt (2020) reviewed difficulties in determining the quantity of aggregate advertising; their study emphasizes that it is important to include both advertising and marketing services and purchases of advertising from media firms.

The BEA IO tables provide useful information on the amount of aggregate advertising expenditures. The BEA presents information for NAICS industry and commodity 541800, advertising, public relations, and related services, in their 405-order IO tables. The product codes included in NAICS 541800 skew towards advertising and marketing services.[28] The crucial point, however, is that, at the commodity level, the BEA input-output tables provide further information on total purchased advertising services which also includes advertising purchased from media industries or from the Internet. The BEA IO tables can consequently provide a comprehensive picture of industry and aggregate advertising expenditures. Advertising measures used in this paper cover purchases from all establishments. However, the IO tables do not include in-house advertising activities.

To illustrate how the IO commodity data measure aggregate advertising, consider data for the year 2012. Figure 3 on page 47 of Silk and Berndt (2020) suggests that in 2012 expenditures from advertising and marketing services were approximately $90 billion, and expenditures on media and internet services were about a further $180 billion, implying total expenditures of approximately $270 billion dollars. The graph in Figure 3 of their paper suggests that total IRS advertising expenditures are perhaps a little closer to $280 billion. The data used in this work for the private economy at the commodity level measures roughly that advertising expenditures were $305 billion in 2012.[29]

The commodity version of the IO tables also provides the basic information on advertising expenditures in each of our 61 industries. The BLS Employment Projections Program has prepared a version of these input-output tables on a 202-order basis for every Census year between 1997 and 2019; we use their version of these tables. For years prior to 1997 we use less detailed IO tables which combine advertising with certain other industries. We collect data on advertising expenditures within

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[28] BEA helpfully sent a list of the product codes contained in NAICS industry 541800. These include items such as advertising placement services, advertising creative services, public relations services, media planning and buying services, display advertising services, distribution of advertising materials, display and lettering services, custom fabrication of signs, and marketing research services. Many of these codes coincide closely with the advertising and marketing industries which Silk and Berndt (2020) list in Appendix Table 1 on page 54 of their paper.

[29] These data show that the commodity version of advertising and related services lists expenditures which are reasonably close to the amounts implied by other prominent data sources. The BEA commodity data clearly include both advertising and marketing services and revenues received by media and Internet industries. This study therefore adopts the aggregate advertising expenditures suggested by the commodity version of the IO table.

each of our industries for every year since 1972 and use the time-series data from these tables as the basis for advertising stocks between 1987 and 2017.[30]

The literature contains various estimates of the rate of depreciation for advertising. On depreciation, there is contrasting information about the life span and rate of depreciation of expenditures on advertising. Vitorino (2014, page 21) suggests that experts have recently agreed on a depreciation rate close to 20 percent. However, Corrado, Hulten, and Sichel (2005; 2009), Villalongo (2004), Corrado, Haskel, Jona-Lasinio, and Iommi (2018), and Bessen, Denk, Kim, and Righi (2020) use much greater rates of depreciation, in the range of 45 to 60 percent. Following Corrado, Hulten, and Sichel (2008), our primary estimate assumes depreciation of 60 percent, although we also experiment with a 45 percent rate. Following this literature, we also assume that 60 percent of advertising expenditures have a longer-term effect and represent investment.

II.C. Empirical Evidence for Advertising relative to existing measures

This subsection describes how advertising, if capitalized, would affect output and capital growth within each industry and in the total private business sector and more importantly, compares it to existing measures. The analysis redistributes property income and capital service prices within each industry to accommodate the addition of advertising as a further intangible, recalculates new service prices, and aggregates the new capital stock. Moving advertising investments from intermediate inputs to a capital account requires treating it as part of output in the earlier period.

Advertising in Value-added output

As Table 4 shows, over the 1987-2019 time period, advertising contributed only slightly to the growth of output in the private business sector, adding only about two hundredths of a percentage point to output growth. Growth increased from an annual rate of 2.76 percent a year to 2.78 percent. Moreover, the positive contribution of advertising was solely due to the 1990-2000 business cycle when it added 0.045 percent point contribution to annual growth. In the next two business cycles adding advertising as an intangible actually caused a decline in output growth.

Table 4. Growth of Real Value-added in the Private Business Sector

Average annual growth

Period	Private Industry Without Advertising	Private Industry With Advertising
1987-2019	2.762	2.776
1990-2000	3.939	3.984
2000-2007	2.575	2.572
2007-2019	1.823	1.819

Data on the growth of real advertising investment over the last three business cycles explains why its impact on output growth varied across the different periods. Table 6 shows that during 1990-2000,

[30] The BLS's Occupational Outlook models assume a linear rate of growth to estimate advertising expenditure between Census years. For some industries it may be possible to estimate advertising expenditures in intervening years more precisely from firm data.

investment in real advertising (Table 5, column 1) grew more than two percentage points faster than output (Table 4, column 1) than output. However, Tables 4 and 5 also show that in the two latter business cycles growth in advertising investment grew less than output and was thus a drag.

Table 5. Growth of Advertising Investment
Average annual growth

Period	Constant Investment	Current Investment	Price
1987-2019	3.26	5.352	2.026
1990-2000	5.854	8.641	2.633
2000-2007	2.065	4.056	1.951
2007-2019	1.649	2.538	0.874

Advertising capital services

Over the 1987-2019 period Table 6 shows that capital services of advertising in private industry grew 3.18% a year, which is slightly less than capital growth in private business (3.38%); consequently, adding advertising as a further intangible reduced the growth of capital services in overall private business.

Table 6. Capital Services Growth
Average annual growth

Period	Private Industry without Advertising	Advertising	Private Industry with Advertising
1987-2019	3.385	3.183	3.368
1990-2000	4.513	4.755	4.546
2000-2007	3.436	2.532	3.363
2007-2019	2.322	1.388	2.25

Advertising did not always reduce the overall flow of capital services. As Table 7 indicates, during 1990-2000 capital services in advertising grew more rapidly than other forms of capital services, driven by large increases in advertising spending in service-providing industries.

Table 7. Contribution of advertising to capital growth by sector[31]
Percentage point contribution

Sector	ICT	FIRE	Goods producing	Service providing
1990-2000	0.684	0.945	-0.319	3.306

[31] The ICT sector includes the computer and electronic products, broadcasting and telecommunications, data processing, internet publishing, and other information services, and computer systems design and related services industries. Software is not included in ICT. The FIRE sector includes industries within financial services and real estate. The goods producing sector includes industries within agriculture, mining, utilities, construction, and manufacturing (except computer and electronic products). The service providing sector includes all service providing industries except those in ICT.

2000-2007	0.236	0.684	-0.208	1.789
2007-2019	0.709	0.330	-0.241	0.581

Now that we have measures of the growth and impact of advertising, we can compare the role of the other intangibles with the influence of advertising.

Table 8: Asset type investment growth

Asset Type	1990-2000	2000-2007	2007-2019	1987-2019
Advertising	0.20	4.06	3.83	0.39
Artistic Originals	7.27	3.44	2.14	4.55
Research and Development (R&D)	8.25	4.33	5.34	6.43
Pre-Packaged Software	15.47	5.07	6.57	11.04
Custom Software	16.29	3.66	5.60	9.08
Own-Account Software	7.46	2.54	3.85	5.08
Tangible	0.15	3.59	3.65	0.30

Table 8 shows that, in the overall 1987-2019 period and especially in 1990-2000, investment grew more quickly for most intangibles than for tangibles. In contrast, advertising grew at approximately the same rate as tangibles.

Table 9: Asset share of productive capital stock by major sector, 2017

Sector	Artistic Originals	R&D	Pre-Packaged Software	Custom Software	Own-Account Software	Other Assets	Advertising
Other Goods	0.0%	0.3%	0.2%	0.1%	0.0%	99.3%	0.1%
Manufacturing	0.0%	25.9%	0.5%	0.8%	0.2%	72.2%	0.3%
Trade	0.0%	1.2%	0.7%	0.8%	0.4%	94.5%	2.3%
Other Services	3.9%	3.3%	0.8%	1.5%	0.7%	88.8%	1.0%
Finance	0.0%	1.8%	4.8%	3.7%	1.1%	86.9%	1.7%

Other goods represent agriculture, mining, and construction. Other services include services other than trade and finance.

Table 9 illustrates the dominant role of R&D in the stock of intangibles in manufacturing. In conjunction with Table App-2, which shows the important role of manufacturing in intangibles, these data indicate that R&D stocks are a crucial element in intangibles.

Table 10: Asset type capital price growth

Asset Type	1990-2000	2000-2007	2007-2019	1987-2019
Artistic Original	1.50	4.42	-1.41	0.87
Research and Development (R&D)	1.21	3.18	2.10	2.44
Pre-Packaged Software	-8.09	-3.10	-2.60	-5.69

Custom Software	-0.32	0.94	0.59	0.23
Own-Account Software	-0.25	1.70	-0.88	-0.26
Advertising	0.07	2.84	0.64	0.14
Tangible	0.02	3.45	2.48	0.14

Figure 2. Implicit Price Deflator for Rental Prices

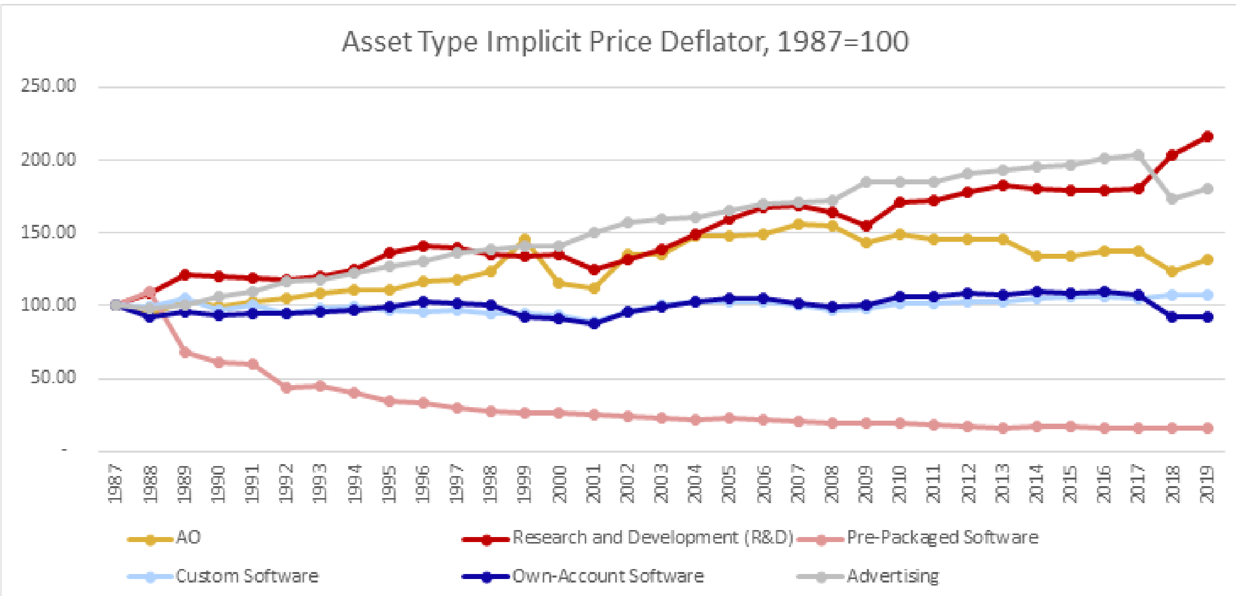

Figure 2 shows service price indexes for all intangible assets. The price for R&D increased substantially from 1987 to 2017. There is related evidence that productivity in producing R&D has declined sharply (Bloom, Jones, Van Reenen, and Webb (2020)). Prices declined rapidly for Pre-Packaged Software, which may have benefited from economies of scale. Prices for custom and own-account software do not share in these declines. The implicit price changes for advertising are more puzzling. Advertising prices rise rapidly, and begin to decline only after 2017. In contrast, Mandel (2019, page 13) suggests that the price of advertising has declined sharply in recent years because digital ads are “40 percent cheaper than print ads of equivalent effectiveness”. This is an issue which requires much more thorough analysis. Mandel’s comments raise the possibility that the increase in advertising prices may have been overstated in recent years, so that advertising has actually grown more rapidly and contributed more to output growth than current data on advertising prices suggest.

II.D. Does Advertising Belong in Measures of Productive Capital?

Here we address the theoretical issue of whether advertising should be counted as an intangible asset which is part of GDP. An alternative view is that for productivity purposes, the production function inherently describe production from the cost or supply side, whereas advertising attempts to influence consumer demand. In that sense, investment in advertising is different from investment in software which is mainly intended to support production. Nevertheless, anecdotally, there is a reason that people choose highly marketed items- stimulating demand and production. There is ambiguity here. So far, our findings suggest that advertising, as currently measured, does not generate the same returns as R&D or software. However, firm level data may suggest different patterns, because advertising may predominantly affect firm demand.

In response, work by Sutton (1991) suggests that R&D and advertising are alternative methods through which firms differentiate their products, improving consumer perceptions of the quality of their output. Similarly, many firms currently use information technology systems, and the own-account software on which these systems are based,[32] as another method of improving their product. Several of the major intangibles therefore each work by increasing demand, primarily by improving the quality of their products, distinguishing their products from competitors, and thereby developing increased market power. Each of these major channels, not just advertising, works through influencing the quality of the product and therefore increasing consumer demand.[33] Advertising is also useful to consumers because it signals that firms have a brand name and are therefore willing to guarantee a certain level of quality. Despite these qualifications, though, advertising fundamentally still works through influencing the demand curve. It is a good question whether directly influencing demand in this way is compatible with a production function framework in which other intangibles reflect genuine improvements in the underlying product rather than just product perceptions. Is advertising different if it only changes perceptions and does not genuinely alter the product supplied? We would like to ask our colleagues and fellow participants in this conference for their thoughts on the basic question of whether advertising still qualifies as an intangible even though its basic purpose is to affect the demand curve, not the underlying product supplied.

III. Estimating Spillovers from Intangibles within Firm and industry Data

Section III begins work on understanding the relationship between the rate of return to intangibles in firm and industry data. Section IIIA outlines some relevant theory. Section IIIB considers data issues. Section IIIC presents some results using standard production functions and Section IIID examines so-called structural estimates such the Olley-Pakes, Levinsohn-Petrin, and Ackerberg, Caves, and Frazer methods.

III.A. Theoretical Framework

Analysis of the rate of return to advertising follows the work on R&D conducted by Bloom, Schankerman, and Van Reenen (2013). Consider a Cobb-Douglas production function in which value

[32] Bessen (2020) emphasizes the importance of own-account software.

[33] Foster, Haltiwanger, and Syverson (2008) and Kehrig and Vincent (2021) report that demand differences, such as occur if high productivity firms benefit from especially high output prices or low productivity firms face low prices, are already widely reflected in current productivity measures.

added is produced by capital, which includes all assets except advertising, labor, and advertising.[34] Specifically:

$$V_{it} = A_t\, K_{i,t-1}^{\alpha}\, L_{i,t-1}^{\beta}\, AD_{i,t-1}^{\gamma} \tag{3}$$

in which V_{it} is (appropriately deflated) value added in firm i in year t, K_{it} is capital input other than advertising, L_{it} is labor input, and AD_{it} is the stock of advertising. α, β, and γ are parameters and, since this is a Cobb-Douglas function, each parameter reflects factor shares. Note that all the inputs $(K, L, \text{and } AD)$ are measured in the previous year to avoid simultaneity. In our empirical implementation of equation (3) all the inputs (again $K, L, \text{and } AD$) are measured from Compustat data as of the beginning of the year, BOY. When equation (3) is estimated:

$$\gamma = rAD_{i,t-1}\ AD_{i,t-1}/V_{i,t-1} \tag{4}$$

where rAD_{it} is the rate of return to advertising.[35] Bloom, Sicherman, and Van Reenen (2013) select the ratio of AD_{it}/V_{it} for the median firm and use this to calculate rAD_{it} from equation (4) for the Cobb-Douglas parameter γ estimated in equation (3). This is the estimated rate of return on advertising for the median firm.

We can prepare estimates based on γ from equations (3) and (4) for industry data and compare the results with similar estimates made from firm data. Such procedures potentially offer a way to compare the rate of return to advertising within firm and industry data. However, it is sometimes helpful to estimate industry effects instead from the much more detailed firm data. In that case we use equation (5), as discussed immediately below. Section III.C. considers firm and industry effects as estimated from several variant of equations (3) and (5).

Another very common method of avoiding the simultaneity issues raised by Olley-Pakes is to use the so-called structural methods introduced by Olley-Pakes (OP), Levinsohn-Petrin (LP), and Ackerberg, Caves, and Frazer (ACF). These methods also correct for the possibility that annual shocks to productivity partially drive observed changes in factor inputs; this is potentially a serious matter since our analysis of the rate of return in equation (3) depends on accurate estimation of the advertising share γ. Section IIID follows Bessen, Denk, Kim, and Righi (2020) by examining measures of Olley-Pakes adjusted productivity increases (ω_{it})in each observation.[36]

Olley-Pakes methods depend on firm adjustment and are less appropriate for industry data. Therefore, in some variants, instead of trying to understand industry effects by estimating a separate industry production function, we shall approach industry effects by separating advertising into two

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[34] Bloom, Schankerman, and Van Reenen (2013) examine the impact of R&D using a Cobb-Douglas function.

[35] These returns are gross returns in the sense that they include both net returns and related costs such as depreciation, taxes, and various other elements of cost. Our equation (3) is most closely related to equation (4.6) and Table V in Bloom, Schankerman, and Van Reenen (2013).

[36] Bessen, Denk, Kim, and Righi (2020) estimate a Hicks-neutral productivity parameter, ω_{it}, for each observation i in year t using standard Olley-Pakes procedures (Mollisi and Rovigatti (2017)).

components, the firm's advertising and all other advertising within the industry. In that case, the production function (3) becomes:

$$V_{it} = A_t K_{i,t-1}^{\alpha} L_{i,t-1}^{\beta} AD_{i,t-1}^{\gamma} INDAD_{i.t-1}^{\varepsilon} \quad (5)$$

where $INDAD_{it}$ represents the advertising stock of all other firms in the industry. Equation (5), which follows Bessen, Denk, Kim and Righi (2020), allows us to examine broader industry effects while relying only on firm specific data. Sections III.C and III.D both sometimes use equation (5).

IIIB. Firm Data on Intangibles

This section discusses firm data on intangibles in our sample from Compustat, which comes largely from reports to the SEC, and therefore oversamples companies which are publicly-held. These firm data include information on firm value added, firm labor, and on traditional stocks of capital, primarily plant and equipment. Capital data for firms typically does not include the value of inventories and land. Turning to intangibles, the available data are the same stocks used in Bessen, Denk, Kim, and Roghi (2020). These data contain stocks of advertising and of R&D. Compustat does not contain firm information on investments into software or artistic originals. The Compustat firm data do report broad expenditures on selling, general, and administrative expenses (SGA), which are often used as a measure of overall business or administrative expenses. This item includes all operating expenses not directly involved in the production of goods or the delivery of services. That includes salaries of management and administrative staff, rent, some payments for utilities, advertising, marketing and distribution costs, and other elements of overhead. However, the present paper concentrates on measures of the presence of specific intangibles. For the present purposes, SGA does not provide sufficient detail for expenditures on specific intangibles, so we do not rely heavily on the SGA variable in this paper.

The version of firm data used here allocates all of a firm's data to one specific industry, which is quite different from national accounts data which assign firm data to many different industries. As a result, Compustat firm data will be more heavily concentrated in a few large industries, especially in manufacturing. The Compustat data cover data from 1976 to 2017, although data are often thin in the earlier years. Information on production, stocks of tangibles, and stocks of R&D and of advertising are from Bessen, Denk, Kim, and Roghi (2020). Importantly all stocks of inputs are as of the beginning of the year, thereby avoiding simultaneity

III.C. Estimates of Firm Production Functions

As a first step, we provide illustrative results from estimating equation (3) within 2017 firm data. Inputs are tangible capital as of the beginning of that year, employees, also at the beginning of the year, and, when data permits, advertising and R&D stocks. All variables are measured in logs.

From Bessen, Denk, Kim, and Roghi (2020) we have data on advertising and R&D expenditures by the top four firms in each 2-digit NAICS industry. We include these as predictors because these large firms are expected to be especially important providers of spillovers. We expect spillovers to be positive for R&D and potentially negative for advertising. could capture the effect of spillovers, which we expect to be positive for R&D and may be negative for advertising. Effects vary by industry and are not consistent across different years. We illustrate with 2017 data for three large industries from our 61 industries.

Table 11 shows we see that for chemical products, which include pharmaceuticals, the tangible capital and labor inputs have the expected effect on output. The firm's own R&D capital and the R&D of the top-4 firms are positive and significant predictors of more output. Advertising capital of the firm is a significantly positive predictor of output, but the ad capital of the top 4 of the industry, which includes mainly competing firms, does not increase output of the reference firm. Because the coefficients in this column add to significantly more than 1.0 – approximately 1.2 – we see economies of scale. That may result from large pharmaceutical and chemical companies producing on a large scale while the smallest ones are just starting out with new products but no significant revenue etc.

The two further industries considered are retail trade and accommodation. These two additional industries do not conduct significant amounts of R&D within our data. Labor and capital have the expected sign and approximately expected magnitudes. Advertising in these industries does not appear to increase value added. Advertising by competitors reduces output but not to a statistically significant extent; we include this as a predictor to represent pressure or constraints on production.

Table 11 Illustrative Production Functions for Firms in Three Industries, 2017

Dependent variable is industry value-added output in 2017	Chemical Products (NAICS 325)	Retail trade (NAICS 44-45)	Accommodation (NAICS 721)
Log real capital (mill 2009$)	0.238***	0.308***	0.384***
	(0.067)	(0.088)	(0.098)
Log employees (1000s)	0.664***	0.690***	0.489***
	(0.092)	(0.099)	(0.064)
Log R&D expenses (mill. 2009$)	0.135***		
	(0.041)		
Top 4 BOY real sum R&D	0.105**		
	(0.048)		
BOY real log ad stock	0.101***	-0.001	-0.025
	(0.032)	(0.044)	(0.084)
Top 4 BOY real sum ad stock	-0.033**	-0.261**	-0.064
	(0.015)	(0.111)	(0.052)
Constant	2.623***	4.976***	3.220***
	(0.516)	(0.894)	(0.507)
Firm observations	178	53	26
R-squared	0.908	0.941	0.912

Spillovers are such an important part of the overall effect of intangibles that it is worth carrying out a detailed microeconomic investigation of this topic. These tests are only examples of the approach to be taken. First, as in Bessen et al. (2020), data will be pooled for many years, which will increase sample sizes substantially. Second, we know from Bloom, Schankerman, and Van Reenen (2013) that spillovers from closely related firms are considerably stronger. Within a broad 2-digit NAICS industry we expect that spillovers from the same 3-digit NAICS industry and especially from the same 4-digit NAICS industry will have a much greater impact. . In addition, once we select final versions of the production function, we still will have to calculate and discuss the corresponding implied rates of return.

III.D Firm Results from Olley-Pakes and Related Methods

Tables 12 and 13 illustrate some early results from estimating structural production functions for two industries. These use Compustat data for 1976 to 2017 augmented by Peters & Taylor (2017) variables for R&D and intangibles, inferred from SG&A expenditures by firms, and by Bessen et al.'s (2020) computation of advertising stocks. In these runs we measure all intangibles by selling, general, and administrative expenses (SGA) and then extract advertising from SGA as a separate variable. As is frequently the case, the SGA variable is highly significant, but it is somewhat difficult to interpret what SGA means. The separate advertising variable also influences value added. However, estimates are somewhat unstable and relatively small changes in the data can alter coefficients substantially. This is more of a problem in industries where the number of firms is smaller.

Money values are in 2009 dollars. Capital measures are in real terms, as of the beginning of the year (BOY). The estimates are not from OLS, but more advanced econometric methods designed to estimate firm-production function relations, called "control function" approaches:

- Olley-Pakes method: Capital is a state variable, fixed before output levels are chosen (inherited). Firms are selected by success in prior years. Labor is chosen during the year, after firms know the productivity shock for that year.
- Levinsohn-Petrin method: Because capital investment is often lumpy or zero, determines the productivity shock from materials inputs. In the literature sometimes finds greater economic of scale.
- ACF correction: This is an extension of the Levinsohn-Petrin method that makes additional timing assumptions about firm's labor and intermediate materials inputs which are chosen once capital and the productivity shock are known.
- GO versions measure output by gross output, instead of value added, and include approximate estimates of real materials.

Table 12 shows that using these methods, in the chemical products, stocks of both R&D and advertising have statistically significant positive effects on output.

Table 12: Dependent variable is ln(Value-added output) for chemical products firms, all years

	(1) Olley-Pakes	(2) Olley-Pakes	(3) Levinsohn-Petrin	(4) LP with ACF	(5) OLS	(6) Gross Output
Log employees (1000s)	0.639***	0.696***	0.697***	0.761***	0.763***	0.550***
	(0.017)	(0.013)	(0.012)	(0.007)	(0.019)	(0.019)
Real log capital	0.062**	0.132***	0.184***	0.227***	0.254***	0.159***
	(0.029)	(0.009)	(0.012)	(0.027)	(0.015)	(0.013)
Real log R&D		0.085***	0.040***	0.055***	0.018**	-0.006
		(0.005)	(0.013)	(0.018)	(0.007)	(0.006)

Real log ad stock		0.059***	0.029***	0.031***	0.022**	0.009
		(0.003)	(0.011)	(0.005)	(0.009)	(0.007)
Ln real intangible stock	0.299***					
	(0.025)					
Log real intermediates						0.298***
						(0.017)
Observations	10,262	10,262	10,451	10,451	10,451	10,451
R-squared					0.935	0.968
Number of groups	1,045	1,045	1,064	1,064		

In retail trade, the structural methods indicate that, in Table 13, that advertising stocks have a statistically significantly effect on output, but R&D capital does not.

Table 13: Dependent variable is ln(Value-added output) for retail trade firms, all years

	Olley-Pakes	Olley-Pakes	Levinsohn-Petrin	LP with ACF	OLS	Gross Output
Log employees (1000s)	0.658***	0.709***	0.750***	0.770***	0.776***	0.341***
	(0.022)	(0.021)	(0.022)	(0.016)	(0.022)	(0.057)
BOY real log capital	0.026	0.114**	0.229***	0.208***	0.220***	0.193***
	(0.070)	(0.045)	(0.011)	(0.012)	(0.017)	(0.031)
BOY real log R&D		0.037	-0.026	0.007	0.013	0.007
		(0.030)	(0.018)	(0.009)	(0.015)	(0.017)
BOY real log adstock		0.060***	0.044**	0.029***	0.022**	0.007
		(0.014)	(0.018)	(0.003)	(0.009)	(0.008)
Log real BOY intangible stock	0.233***					
	(0.038)					
Log real intermediates						0.464***
						(0.083)
Observations	6,846	6,846	6,881	6,881	6,881	6,881
R-squared					0.959	0.963
Number of groups	620	620	622	622		

*** p<0.01, ** p<0.05, * p<0.1

IV. Conclusions

Our analysis of intangibles covering 61 industries in the United States private sector between 1987 and 2019 leads to several main conclusions. First, it is possible to develop consistent measures of stocks of advertising and of the effect of advertising within the private business sector and in its constituent 61 industries. Adding advertising as a further intangible does not greatly alter the growth of capital, output, or MFP. Advertising does not affect growth much, in part, because 40% of advertising is still treated as intermediate purchases and because advertising depreciates rapidly. We still need to complete our comparison of the effects of advertising in firm and industry data in order to understand advertising more fully. The analysis reported here uses data on advertising that are consistent with the data on other intangibles presently included in the Accounts. We hope that our work spurs serious interest in including advertising as a further intangible in the Accounts. We also think that our work will permit new BLS analysis of the effect of certain intangibles.

Second, our work shows that software has a strong impact on capital and output growth. Among the components of software, off-the-shelf software somewhat surprisingly has a stronger impact than own-account software. This suggests that the numerous small purchases of off-the-shelf software throughout the economy may have a greater impact on growth than generally realized. Of course, this evidence is based solely on stocks of software obtained from investment data in the Accounts. Much more work remains to be done on determining deflators and depreciation rates for the different types of software.

Third, our results suggest that stocks of R&D, especially in manufacturing, play an important role in the overall impact of intangibles. R&D represents a large expenditure and depreciates more slowly than most other forms of intangibles. Evidence on stocks and on the flow of capital services shows that R&D is a central element in intangibles.[37] The central role that R&D plays in overall intangibles emphasizes once again how important it is to understand the industry distribution of R&D spillovers, which are at least as important as private returns to R&D.

Fourth, our work suggests that it is useful to supplement current studies of intangibles which emphasize National Income or input-output data by detailed analysis of firm data. In our judgment, researchers can develop a more detailed understanding of how intangibles work using standard production function methods within data for large numbers of firms. In addition, firm data make it possible to distinguish between rates of return at the firm and industry levels.

[37] Table 9 above shows that R&D plays a dominant role in the intangibles in manufacturing and is also influential outside manufacturing. Appendix Table 2 shows that manufacturing accounts for an important share of intangibles.

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Appendix Table 1. Intangible capital services growth by industry, for selected time periods

NAICS Industry	Average annual growth			
	1987-2019	1990-2000	2000-2007	2007-2019
Crop & animal production (Farms)	19.5	19.9	-18.0	4.2
Forestry, fishing, and related activities	10.5	4.5	31.6	2.1
Oil and gas extraction	8.5	21.1	3.7	4.7
Mining, except oil and gas	9.6	26.4	-6.7	3.0
Support activities for mining	7.0	18.5	-2.0	7.4
Utilities	7.3	10.8	-1.3	8.7
Construction	15.2	34.9	-3.7	7.2
Wood products	2.6	4.8	2.4	1.8
Nonmetallic mineral products	2.9	3.7	0.2	2.7
Primary metals	1.8	2.8	-1.6	2.9
Fabricated metal products	2.9	4.5	-0.1	2.8
Machinery	2.3	5.0	-2.0	2.6
Computer and electronic products	4.7	8.4	3.9	2.1
Electrical equipment, appliances, and components	1.1	0.5	1.0	2.8
Motor vehicles, bodies and trailers, and parts	2.1	4.8	-0.9	0.9
Other transportation equipment	1.5	-0.2	2.5	1.7
Furniture and related products	4.8	6.0	4.6	3.5
Miscellaneous manufacturing	3.5	3.6	1.7	3.4
Food and beverage and tobacco products	3.5	4.8	1.0	2.9
Textile mills and textile product mills	3.8	7.4	-1.4	3.0
Apparel and leather and allied products	3.2	5.5	-0.1	2.6
Paper products	2.6	4.2	0.0	2.4
Printing and related support activities	5.1	7.9	6.4	1.8
Petroleum and coal products	2.3	1.6	1.1	3.5
Chemical products	6.3	8.0	6.3	4.6
Plastics and rubber products	2.6	3.2	2.2	2.8
Wholesale trade	10.1	14.8	13.0	3.7
Retail trade	11.5	13.1	15.4	6.9
Air transportation	9.9	27.3	-12.4	8.9
Rail transportation	11.2	27.3	-6.7	6.7
Water transportation	14.1	31.5	-2.4	9.8
Truck transportation	16.2	36.8	8.5	3.5
Transit and ground passenger transportation	17.7	30.4	-11.5	14.9
Pipeline transportation	11.0	19.8	-2.0	11.7
Other transportation and support activities	18.2	43.7	-2.5	7.3
Warehousing and storage	22.1	36.1	10.6	15.3
Publishing industries, except internet (includes software)	5.7	5.8	8.8	3.7

Motion picture and sound recording industries	3.7	5.2	4.7	1.5
Broadcasting and telecommunications	5.4	8.0	1.5	4.5
Data processing, internet publishing, and other information services	15.5	20.2	14.6	12.5
Federal Reserve banks, credit intermediation, and related activities	11.8	14.2	7.2	8.4
Securities, commodity contracts, and investments	6.0	-2.1	10.5	8.1
Insurance carriers and related activities	10.4	13.2	11.6	6.1
Funds, trusts, and other financial vehicles	12.6	5.8	-3.2	27.2
Real estate	11.1	10.6	7.7	10.8
Rental and leasing services and lessors of intangible assets	8.3	10.9	3.7	6.4
Legal services	15.3	24.6	13.0	6.6
Computer systems design and related services	7.9	12.3	9.9	0.7
Miscellaneous professional, scientific, and technical services	7.6	10.3	7.4	3.8
Management of companies and enterprises	9.1	9.7	8.8	7.8
Administrative and support services	12.1	13.3	16.5	7.3
Waste management and remediation services	9.9	16.9	-0.8	5.6
Educational services	11.7	11.7	17.9	8.2
Ambulatory health care services	6.5	6.9	4.2	5.0
Hospitals and nursing and residential care facilities	9.5	13.7	4.5	7.6
Social assistance	9.1	13.2	6.3	5.2
Performing arts, spectator sports, museums, and related activities	1.4	2.7	1.1	0.1
Amusements, gambling, and recreation industries	11.3	14.3	11.2	9.5
Accommodation	9.7	12.9	7.3	7.8
Food services and drinking places	9.1	15.3	1.3	6.2
Other services, except government	9.3	15.0	8.0	4.6

As Appendix Table 1 indicates, the 1987-2019 growth in capital services from intangibles has been greatest in various services industries. The low growth of intangibles in manufacturing industries is striking; the most rapid growth in capital services is 4.8% in Furniture and Related Products and 4.7% in Computer and Electronic Products. In contrast, the growth of capital services from intangibles is greater than 10% in 18 specific industries, including such large industries as Wholesale and Retail Trade.

Appendix Table 1A. Research and development capital services growth by industry, selected time periods

NAICS Industry	Average annual growth			
	1987-2019	1990-2000	2000-2007	2007-2019
Crop & animal production (Farms)	…	…	…	…
Forestry, fishing, and related activities	…	…	…	…
Oil and gas extraction	11.3	24.5	2.9	5.6
Mining, except oil and gas	10.0	26.2	0.9	2.9
Support activities for mining	10.7	24.5	1.5	5.1
Utilities	1.6	5.1	-6.6	1.1
Construction	9.0	21.7	8.9	-1.3
Wood products	-1.4	-5.2	0.0	2.6
Nonmetallic mineral products	2.9	3.0	1.1	2.6
Primary metals	1.6	1.1	1.0	2.6
Fabricated metal products	2.1	1.9	1.0	2.6
Machinery	1.8	1.2	1.0	2.6
Computer and electronic products	4.3	6.5	3.8	2.7
Electrical equipment, appliances, and components	0.6	-0.8	0.9	2.6
Motor vehicles, bodies and trailers, and parts	1.9	3.8	-0.2	0.8
Other transportation equipment	0.8	-1.5	3.4	0.6
Furniture and related products	2.5	2.7	1.2	2.6
Miscellaneous manufacturing	2.6	2.5	1.0	2.6
Food and beverage and tobacco products	2.6	2.6	1.1	2.6
Textile mills and textile product mills	2.5	2.6	1.1	2.6
Apparel and leather and allied products	2.5	2.6	1.1	2.6
Paper products	1.4	0.6	0.2	2.7
Printing and related support activities	2.0	1.0	2.6	2.4
Petroleum and coal products	1.7	1.1	0.9	2.6
Chemical products	6.1	7.3	7.3	4.5
Plastics and rubber products	1.5	0.8	0.9	2.6
Wholesale trade	5.8	8.0	2.0	4.5
Retail trade	7.6	8.0	4.1	8.0
Air transportation	6.4	24.2	6.7	-8.4
Rail transportation	4.5	16.8	4.0	-6.1
Water transportation	3.5	17.0	3.3	-8.1
Truck transportation	6.4	20.9	5.4	-5.9
Transit and ground passenger transportation	6.0	22.9	5.8	-8.7
Pipeline transportation	7.6	19.6	6.1	-1.5
Other transportation and support activities	3.8	17.5	4.4	-8.8
Warehousing and storage	7.7	22.3	6.6	-4.4
Publishing industries, except internet (includes software)	17.1	17.0	17.3	6.6

Motion picture and sound recording industries	8.8	20.7	4.3	0.5
Broadcasting and telecommunications	0.9	3.4	-9.0	2.1
Data processing, internet publishing, and other information services	10.6	16.9	9.1	5.9
Federal Reserve banks, credit intermediation, and related activities	19.2	26.4	-0.7	2.4
Securities, commodity contracts, and investments	19.1	26.3	-0.7	2.4
Insurance carriers and related activities	19.1	26.4	-0.7	2.4
Funds, trusts, and other financial vehicles	19.3	26.8	-0.7	2.3
Real estate	19.0	26.3	-0.7	2.4
Rental and leasing services and lessors of intangible assets	19.0	26.1	-0.7	2.4
Legal services	…	…	…	…
Computer systems design and related services	17.3	15.9	20.6	-1.0
Miscellaneous professional, scientific, and technical services	8.8	13.7	5.1	4.6
Management of companies and enterprises	1.4	6.6	-7.3	-0.3
Administrative and support services	…	…	…	…
Waste management and remediation services	6.8	17.0	1.2	-0.7
Educational services	…	…	…	…
Ambulatory health care services	4.3	6.4	2.5	1.4
Hospitals and nursing and residential care facilities	6.9	6.9	7.4	5.2
Social assistance	9.8	18.5	6.8	3.7
Performing arts, spectator sports, museums, and related activities	8.5	18.8	5.1	1.9
Amusements, gambling, and recreation industries	10.0	20.6	7.7	3.0
Accommodation	8.4	17.4	4.3	2.7
Food services and drinking places	7.1	17.8	2.5	-0.1
Other services, except government	7.7	17.1	4.7	1.1

Appendix Table 1A suggests that, while stocks of R&D are still very important in manufacturing, the BLS productivity data suggest that R&D services growth has been considerably greater outside manufacturing.

Appendix Table 2: Intangible share of capital stock by major sector, 2017

Sector	Intangible Stock ($millions)	Tangible Stock ($millions)	% Intangible
Other Goods	65,749	9,319,058	1%
Manufacturing	1,734,320	4,511,265	28%
Trade	282,552	4,900,574	5%
Other Services	1,949,448	15,466,035	11%
Finance	259,786	1,718,178	13%

The Other Goods group includes agriculture, mining, and construction. The Other Services group includes all of services except trade and finance. The data show that intangibles are most heavily concentrated in manufacturing. As Table 9 in the text above indicates, most of the intangibles found in manufacturing consist of R&D.

Appendix Table 3. Correlation Matrix Between Stocks of 6 Intangibles and Tangibles Across 61 Industries, 1987-2019

Assets	**Advertising**	**Art Originals**	**Custom Software**	**Own Account Software**	**Pre-Packaged Software**	**R&D**	**Tangible**
Advertising	1.000	0.886	0.884	0.930	0.932	0.917	0.934
Art Originals		1.000	0.964	0.983	0.928	0.982	0.984
Custom Software			1.000	0.982	0.980	0.992	0.984
Own Account Software				1.000	0.971	0.997	0.994
Pre-Packaged Software					1.000	0.980	0.976
R&D						1.000	0.996
Tangible							1.000

Appendix Table 4. Industry Research and Development Stock in proportion to tangible capital

This portion of the Appendix considers the importance of two intangibles, R&D and advertising compared to traditional tangibles, structures and equipment. We limit the tangibles considered to structures and equipment because the Compustat data generally contain structures and equipment as traditional forms of capital. By considering the importance of stocks of R&D and advertising, we show the importance of these newer forms of capital relative to traditional measures of capital.

We conduct these comparisons across the 61 NIPA industries in our sample. We contrast the stocks derived from national income data with the corresponding stocks obtained from the Compustat firm data. The data shown under "BLS Productivity" are BLS estimates of capital stocks based on data from the National Income and Product Accounts. The data reported for Compustat come from a sample of approximately 300,000 firms which overrepresents large firms. The Compustat measure of tangible capital comes from Property, plant, and equipment (PP&E) figures reported to the SEC.

Both data sets jump around considerably from year to year, suggesting that measure of Research and Development are not consistent either within the data sets or over time. Note that the Compustat data are based on firm reports, while the BLS Productivity data are for establishments, so that there is a fundamental mismatch between the data sets. The version of Compustat that we are using assigns all of a firm's data to a single industry. In addition, firm coverage may vary from year to year and is especially thin in earlier years. The Compustat data have no observations for NAICS 55, Management of Companies and Enterprises, which is a considerable source of intangibles in the BLS Productivity data. because one data set has establishment data, and the other has firm data, and that NAICS 55 means the sum of motor vehicle establishments won't cover the headquarters of the firm but the Compustat data will include it. Because of these conceptual differences, it is not surprising that the data from the two sources are quite dissimilar. Nevertheless, the various measures are correlated. Across the panel of industries, the two 1987 measures have a 0.47 correlation, and the two 2017 measures have a 0.82 correlation. The BLS measures for 1987 and 2017 have a 0.51 correlation, and the 1987 and 2017 Compustat measure have a 0.88 correlation.

	1987		2017	
NAICS Industry	**BLS Productivity**	**Compustat**	**BLS Productivity**	**Compustat**
Crop & animal production (Farms)	.	26.1%	.	40.4%
Forestry, fishing, and related activities	.	0.1%	.	0.0%
Oil and gas extraction	0.0%	1.5%	0.7%	0.0%
Mining, except oil and gas	0.1%	4.7%	0.9%	0.1%
Support activities for mining	0.0%	0.3%	0.9%	0.1%
Utilities	0.1%	0.0%	0.1%	0.0%
Construction	0.2%	22.1%	1.5%	8.8%
Wood products	2.0%	1.3%	1.2%	3.4%
Nonmetallic mineral products	11.0%	20.9%	26.1%	0.3%
Primary metals	4.4%	9.9%	9.4%	0.3%
Fabricated metal products	8.7%	30.7%	12.1%	10.5%
Machinery	30.2%	43.5%	33.0%	33.3%

Computer and electronic products	38.2%	105.9%	75.0%	55.1%
Electrical equipment, appliances, and components	39.5%	65.3%	42.7%	17.4%
Motor vehicles, bodies and trailers, and parts	41.0%	61.8%	30.9%	1.7%
Other transportation equipment	67.3%	92.8%	59.4%	53.0%
Furniture and related products	8.4%	14.0%	12.2%	5.9%
Miscellaneous manufacturing	29.9%	64.3%	47.5%	28.7%
Food and beverage and tobacco products	5.7%	8.9%	8.9%	1.9%
Textile mills and textile product mills	2.2%	15.3%	8.0%	0.6%
Apparel and leather and allied products	6.5%	3.6%	18.6%	1.4%
Paper products	4.7%	11.4%	7.6%	16.4%
Printing and related support activities	4.8%	4.7%	8.4%	17.1%
Petroleum and coal products	18.6%	6.5%	21.5%	0.0%
Chemical products	42.6%	64.8%	163.3%	30.0%
Plastics and rubber products	15.5%	36.3%	14.7%	4.6%
Wholesale trade	1.7%	3.8%	4.2%	0.2%
Retail trade	0.5%	0.2%	2.0%	0.0%
Air transportation	0.1%	0.0%	0.2%	0.0%
Rail transportation	0.0%	0.0%	0.1%	0.0%
Water transportation	0.1%	0.0%	0.2%	0.0%
Truck transportation	0.1%	0.1%	0.2%	0.0%
Transit and ground passenger transportation	0.0%	0.0%	0.2%	0.0%
Pipeline transportation	0.0%	0.3%	0.1%	0.0%
Other transportation and support activities	0.0%	0.1%	0.2%	0.0%
Warehousing and storage	0.0%	0.1%	0.2%	*
Publishing industries, except internet (includes software)	2.5%	246.3%	202.0%	213.6%
Motion picture and sound recording industries	0.2%	0.3%	0.9%	1.5%
Broadcasting and telecommunications	6.4%	4.2%	2.5%	0.6%
Data processing, internet publishing, and other information services	36.9%	6.0%	30.2%	53.4%
Federal Reserve banks, credit intermediation, and related activities	0.0%	0.0%	1.2%	0.0%
Securities, commodity contracts, and investments	0.1%	1.1%	3.9%	1.5%
Insurance carriers and related activities	0.1%	23.3%	5.4%	0.0%
Funds, trusts, and other financial vehicles	0.0%	*	1.3%	0.0%
Real estate	0.0%	0.0%	0.0%	2.1%
Rental and leasing services and lessors of intangible assets	0.0%	0.0%	0.1%	0.0%
Legal services	.	0.0%	.	0.0%
Computer systems design and related services	1.9%	71.6%	60.0%	7.1%
Miscellaneous professional, scientific, and technical services	15.8%	14.6%	46.1%	20.1%
Management of companies and enterprises	0.5%	*	0.5%	*
Administrative and support services	.	24.4%	.	0.1%

Waste management and remediation services	0.1%	0.3%	0.6%	0.0%
Educational services	.	15.7%	.	0.7%
Ambulatory health care services	2.3%	11.1%	3.3%	0.4%
Hospitals and nursing and residential care facilities	1.1%	0.0%	1.7%	0.0%
Social assistance	0.4%	0.0%	2.2%	0.0%
Performing arts, spectator sports, museums, and related activities	0.2%	0.0%	0.6%	0.0%
Amusements, gambling, and recreation industries	0.2%	1.2%	0.8%	0.0%
Accommodation	0.1%	0.0%	0.6%	0.0%
Food services and drinking places	0.1%	0.0%	0.6%	0.0%
Other services, except government	0.9%	1.6%	4.9%	0.0%

Appendix Table 5. Firm Advertising Stock in proportion to tangible capital in two data sets

Appendix Table 5 reports similar comparisons between the BLS Productivity data and the Compustat firm data for stocks of advertising. As in Appendix Table 4 which considered R&D, stocks in Table 5 compare advertising stocks with stocks of traditional capital, fundamentally structures and equipment. Comparisons are again based on 1987 and 2017 stocks among the 61 industries considered

Once again, for advertising as well, stocks jump around from year to year, suggesting stocks of advertising vary for reasons similar to that considered for R&D. However, advertising stocks typically depreciate much more quickly, which makes them depend more heavily on recent investment, and so they are volatile. Nevertheless, the various measures of advertising stocks are still correlated with each other. Across the 61 industries, the two 1987 measures of advertising have .32 correlation and the two 2017 measures have .45 correlation. The BLS measure for 1987 and 2017 have .10 correlation, and the two Compustat measure have a correlation of .54.

These differences illustrate the potential difficulties involved in using the Compustat firm data to draw conclusions about national trends solely from firm data. Nevertheless, we believe that we will be able to obtain additions insights about intangibles from firm data. We also plan to work with more comprehensive sources of information on firm data.

	1987		2017	
NAICS Industry	**BLS Productivity**	**Compustat**	**BLS Productivity**	**Compustat**
Crop & animal production (Farms)	0.0%	7.1%	0.0%	1.1%
Forestry, fishing, and related activities	0.0%	0.0%	0.0%	0.0%
Oil and gas extraction	0.0%	0.0%	0.0%	0.0%
Mining, except oil and gas	0.0%	3.3%	0.0%	0.0%
Support activities for mining	0.0%	0.0%	0.1%	0.0%
Utilities	0.0%	0.0%	0.1%	0.0%
Construction	5.4%	1.8%	0.9%	1.4%
Wood products	0.3%	0.8%	0.6%	1.1%
Nonmetallic mineral products	0.5%	1.6%	0.3%	0.4%
Primary metals	0.1%	0.2%	0.1%	0.2%
Fabricated metal products	0.8%	8.5%	0.7%	4.8%
Machinery	1.0%	3.7%	0.4%	3.6%
Computer and electronic products	1.1%	7.0%	0.6%	4.3%
Electrical equipment, appliances, and components	1.3%	10.7%	0.4%	24.6%
Motor vehicles, bodies and trailers, and parts	0.6%	7.3%	0.1%	5.9%
Other transportation equipment	0.5%	1.1%	0.2%	0.7%
Furniture and related products	4.6%	13.9%	2.0%	48.5%
Miscellaneous manufacturing	2.5%	25.1%	1.8%	31.2%
Food and beverage and tobacco products	2.6%	27.3%	0.8%	16.6%
Textile mills and textile product mills	0.2%	6.7%	0.4%	4.7%
Apparel and leather and allied products	1.6%	32.6%	0.7%	71.3%
Paper products	0.1%	1.4%	0.2%	3.5%

Printing and related support activities	2.5%	0.7%	0.6%	18.5%
Petroleum and coal products	0.2%	0.0%	0.1%	0.0%
Chemical products	2.1%	12.7%	0.8%	17.7%
Plastics and rubber products	0.5%	8.0%	0.5%	6.0%
Wholesale trade	3.2%	3.0%	7.2%	2.4%
Retail trade	3.4%	12.8%	3.8%	9.2%
Air transportation	1.0%	4.2%	0.1%	1.3%
Rail transportation	0.0%	0.0%	0.1%	0.0%
Water transportation	1.8%	1.0%	1.2%	1.7%
Truck transportation	0.2%	0.1%	0.5%	0.4%
Transit and ground passenger transportation	0.3%	9.0%	0.6%	10.1%
Pipeline transportation	0.0%	0.0%	0.0%	0.0%
Other transportation and support activities	0.4%	1.8%	0.5%	1.8%
Warehousing and storage	0.2%	0.0%	0.6%	
Publishing industries, except internet (includes software)	2.4%	33.1%	8.1%	30.4%
Motion picture and sound recording industries	3.6%	17.3%	9.4%	61.1%
Broadcasting and telecommunications	0.1%	0.5%	1.5%	7.1%
Data processing, internet publishing, and other information services	3.3%	11.5%	7.9%	44.8%
Federal Reserve banks, credit intermediation, and related activities	0.7%	0.5%	1.7%	9.2%
Securities, commodity contracts, and investments	2.4%	17.1%	4.7%	7.6%
Insurance carriers and related activities	3.0%	3.2%	2.1%	5.4%
Funds, trusts, and other financial vehicles	0.3%		2.5%	0.0%
Real estate	0.0%	1.6%	0.4%	2.3%
Rental and leasing services and lessors of intangible assets	0.9%	1.7%	0.7%	2.0%
Legal services	16.5%	14.3%	8.2%	0.0%
Computer systems design and related services	0.4%	3.1%	4.2%	1.4%
Miscellaneous professional, scientific, and technical services	3.0%	4.8%	3.8%	11.2%
Management of companies and enterprises	1.8%		4.3%	
Administrative and support services	4.9%	3.5%	5.9%	99.5%
Waste management and remediation services	0.0%	0.1%	0.3%	0.1%
Educational services	0.7%	13.9%	0.3%	24.5%
Ambulatory health care services	0.5%	6.8%	1.2%	2.0%
Hospitals and nursing and residential care facilities	0.2%	0.8%	0.3%	0.1%
Social assistance	1.7%	2.3%	0.8%	0.0%
Performing arts, spectator sports, museums, and related activities	6.5%	4.8%	1.9%	16.4%
Amusements, gambling, and recreation industries	1.8%	8.7%	1.1%	7.5%
Accommodation	1.3%	4.8%	1.3%	2.6%
Food services and drinking places	4.2%	8.7%	5.9%	11.1%
Other services, except government	1.6%	10.4%	1.7%	20.5%

"Intangible Capital and US Productivity Growth in 61 Industries"

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