Understanding the Uneven Growth of Intellectual Property Products Investment in the U.S.

Authors Dennis Fixler and Eva de Francisco, U.S. Bureau of Economic Analysis*

Contact Dennis.Fixler@bea.gov

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Abstract Given the attention to intangible capital in studying industry dynamics and aggregate investment trends in the last couple of decades, this paper provides a descriptive analysis of Intellectual Property Products (IPP) as measured in the National Income and Product Accounts (NIPAs) by the Bureau of Economic Analysis (BEA), with attention directed to their three components—Research and development (R&D); Entertainment, literary, and artistic originals (ELAO); and Software—as well as the relationship among investment in IPP, equipment, and structures within some key sectors in the economy. In particular, we show that for the seven sectors studied in this paper, there was, and still is a lot of heterogeneity in the types of IPP capital that sectors use to produce and deliver goods and services. We also illustrate that this heterogeneity seems to be the combination of different forces: first, the initial composition of the production function in 1980 among structures, equipment, and IPP components is quite persistent; and second, the different evolution of prices of these three types of IPP capital has played an important role in the pace of investment and transformation in these sectors.

Keywords Intangible capital, IPP investment, GDP growth

JEL Code E220, E230, E240

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Bureau of Economic Analysis
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1. Introduction

Measuring the accuracy of national account estimates is challenging because the true values of the estimates are unknowable. Regular revisions to estimates usually arise from the flow of source data; that is, partial and preliminary data are replaced with more complete data. Other revisions arise from changes in the economic concepts and methods underlying the estimates that are necessary to provide an accurate picture of the evolving U.S. economy. For example, the accounts contain no entry for business investment in computer software before 1959, since the amount of software prior to that year was negligible.

When software investment was first included in the accounts in the late 1990s, the level and rates of growth of the economy were raised, and by 2012, business investment in software was 1.7 percent of the size of gross domestic product (GDP). In 2013, BEA took on a comprehensive revision of the national income and product accounts (NIPAs) to fulfill its mission of providing a timely and accurate picture of the conditions of the U.S. economy. Among other changes and additions, a new category of investment, "Intellectual Property Products" (IPP), was formed. This new category consists of Research and development (R&D); Entertainment, literary, and artistic originals (ELAO); and Software. Before this revision, R&D expenses were recorded as intermediate inputs, and as mentioned above, software was already being measured, but was being bundled with equipment, in a category called "Equipment and software." Again, the introduction of IPP investment came with changes in the recorded levels and growth rates of other types of investments and GDP, and was not just a mere accounting reclassification.

Meanwhile, the measured weight of IPP in GDP has slowly increased from 5.2% at the beginning of 2013 to 5.8% by 2020. Moreover, as part of the 2018 comprehensive NIPA update, BEA also began including the value of the return to fixed capital (that is, capital services) into estimates of private fixed investment in own-account software and in own-account R&D dating back to 2007.

In this paper we show how IPP investment has transformed the way industries produce and deliver goods and services at an astonishing pace and to different degrees, highlighting a considerable heterogeneity that is hard to see when looking at aggregate data.

Because intangible capital has a shorter life span, is more mobile, and is easier to reproduce than tangible capital, measuring it correctly is harder. Moreover, investment in intangibles is usually financed internally, making its valuation difficult.

However, previous empirical work has documented that intangible investment is large, as in Corrado

et.al (2009), and that, at least at the firm level, is highly correlated with investment in plants and equipment, as McGrattan and Prescott (2014) showed.

Thus, a growing number of papers have tried to come up with more accurate estimates of intangible investment and economic growth using these facts. Leon et. al (2021) use firm-level balance sheet data for the Nethearlands, and McGrattan (2020) for the U.S., exploits the high correlation between hours worked and investment, and the fact that hours worked are easier to measure than investment in intangibles.

Moreover, other papers have studied the productivity implications of this measurement problem. For example, Corrado, Hulten, and Sichel (2009) and Corrado et. al (2016) focus on the importance of the intangible omissions in the NIPAs and its effects on accounting for the sources of growth and labor productivity. In a similar fashion, Crouzet and Eberly (2021) examine to what extent, the mismeasurement of intangible capital and rising markups have contributed to the recent decline in total factor productivity (TFP) growth.

Taking a different perspective, in this paper we concentrate on how investments' trends in different types of intangibles have transformed the production function of some of the key sectors in the economy. We use the investment data recorded in the NIPAs by BEA.

More specifically, we consider seven sectors that we think are key to understanding the transformation of the U.S. economy since 1980. We include four sectors that are either big producers or big users of IPP capital. These sectors are Information; Finance and insurance; Professional, scientific, and technical services; and Management of enterprises and companies. We also study the IPP investment trends in two traditional labor-intensive sectors: Healthcare, with a high proportion of high-skilled labor; and Consumer services, where most of the labor employed is low skilled. Lastly, we include the Manufacturing sector, a very capital-intensive sector, and an early investor in R&D.

Generally we find that in the 1980s, at the beginning of our data sample, the sectors whose total investment was highest were also the sectors whose investment in IPP started to increase first, and the bulk of IPP investment was concentrated in R&D. The leading sectors in IPP investment were Professional, scientific, and technical services and Durables manufacturing.

However, as production processes for many sectors became more mobile, as indicated by the decrease in the use of capital structures and equipment, by the end of our sample in 2020, the share of the IPP investment dedicated to software had increased enormously, and most of the sectors with the highest investment in software did not invest heavily in capital structures and equipment as well. These

were sectors such as: Management of enterprises and companies; Finance and insurance; Professional, scientific, and technical services; and Information.

Moreover, all sectors without exception had greatly increased the share of IPP investment and capital used in production, significantly transforming the way they deliver commodities and services.

However, this increase in IPP investment was very heterogeneous, especially in its composition. Investment in software soared in the 1990s all the way to the burst of the high tech bubble in 2001, while at the same time prices of software decreased significantly but prices of R&D did not, benefiting some sectors more than others.

We find that the sectors more reliant on R&D or labor at the beginning of our sample, did not increase investment in IPP to the same extent that sectors whose IPP investment was centered around software.

Lastly, for the seven sectors that we examine, we have not found any clear relationship between the subcomponents of IPP capital stock or investment measures compiled by BEA and the labor productivity measured by the Bureau of Labor Statistics (BLS).

2. Background

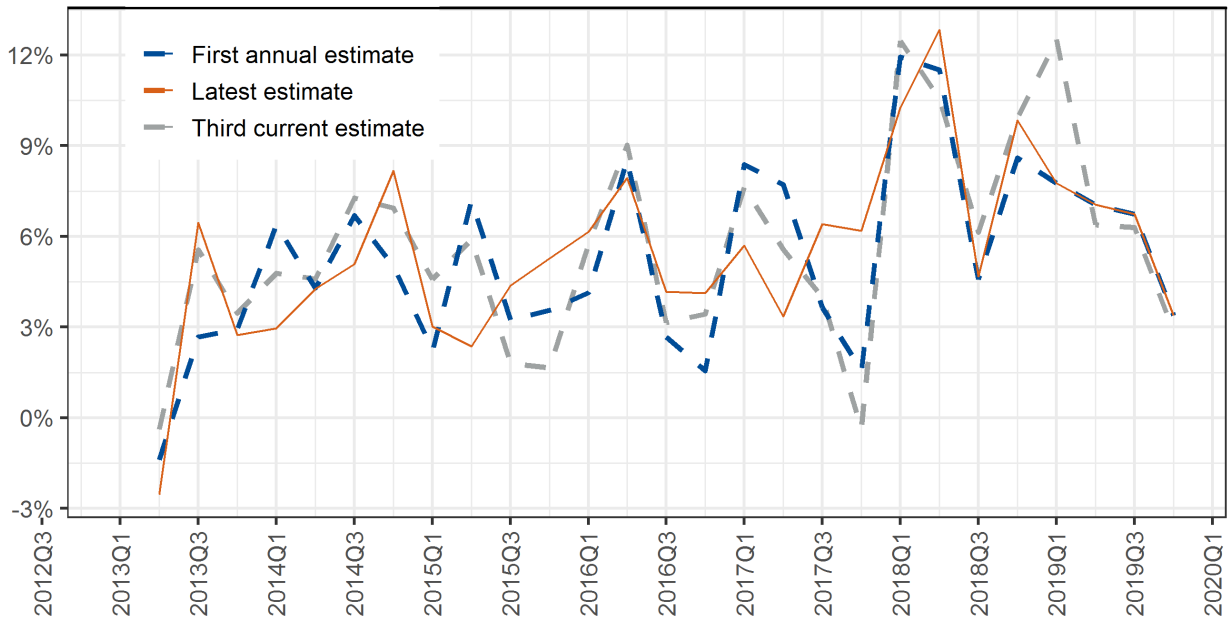
Before delving into the sectors, it is useful to provide some context on the role of IPP investment relative to total investment.

2.1. Measuring Nominal IPP Growth

Because the advance estimate, which is released 30 days after the end of the reference quarter, relays on incomplete source data, Figure 1 shows the third quarterly estimate, which is released about 90 days after the the reference quarter. Figure 1 also shows the first annual estimate, usually released about a year after the corresponding quarter and which is the latest estimate available of IPP quarterly growth.

As one can see in Figure 1, the quarterly annualized rate of nominal IPP in our sample ranges from around -3% in the second quarter of 2013, to more than 12% in the second quarter of 2018. Moreover, the average growth for the sample period was 5.5% and the standard deviation was almost 3%.

Figure 1. Nominal IPP Growth by Vintage



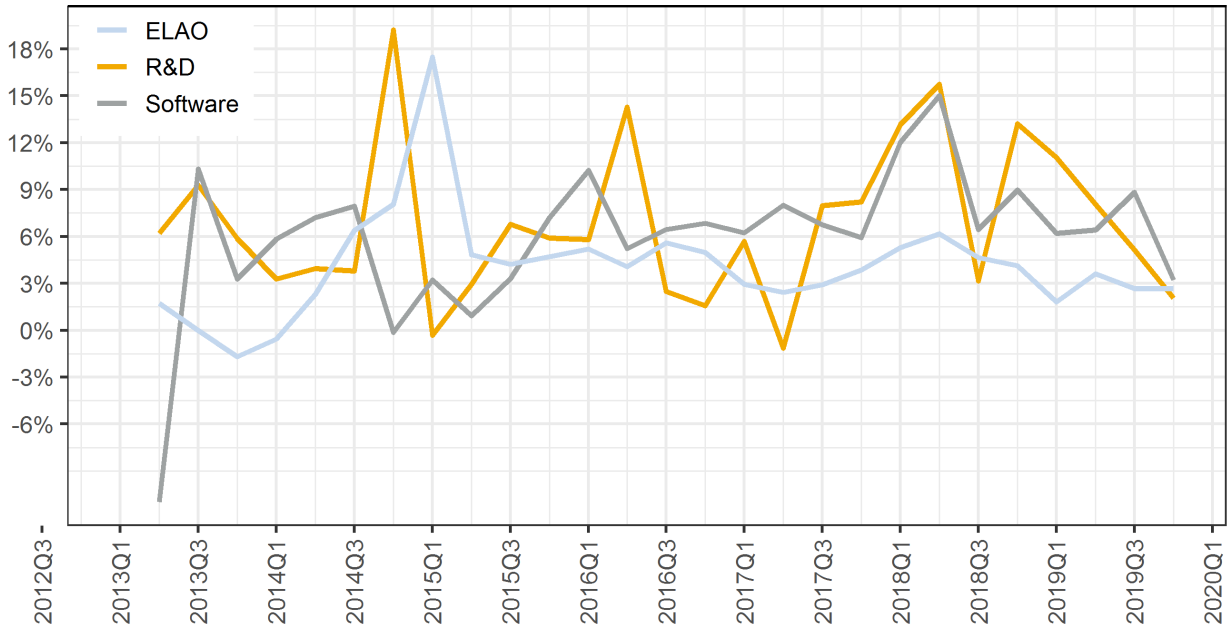
As mentioned above, the value of IPP as a percentage of GDP has been increasing through our sample period from 5.2% at the beginning of 2013 to 5.8% by 2020. This 0.6% increase in value is coming solely from an increase in private IPP, such that by the beginning of 2020, private IPP constituted around 4.7% of GDP and government funded IPP the remaining 1.1%.

For the whole sample period, the average private IPP growth was 6.1%, with a standard deviation of 3%, while the average government IPP growth was 3.1%, with a standard deviation of 2.7%.

As mentioned before, the major components of private IPP are Software, R&D, and ELAO. The weight of ELAO as a percentage of GDP remained stable, around 0.4% in our sample period, while the weights of Software and R&D increased from 1.7% to 1.9%, and from 2% to 2.3%, respectively.

Figure 2 shows the annualized quarterly growth rates of these three components. The average growth rates for Software and R&D are relatively similar, 6 and 6.8 percent respectively, while the average growth rate of ELAO is 4.1 percent. In terms of volatility, the standard deviations of Sofware and ELAO are slightly above 3 percent, while the standard deviation of R&D is higher, around 5 percent.

Figure 2. Major Components of Private IPP Nominal Growth



Moreover, the correlation between Software and R&D growth was 0.15, indicating that these two subcomponents are somehow complements of firms' investment endeavors, while the correlation of Software and R&D growth with ELAO was almost 0.

2.2. Nominal Versus Real IPP Growth

To try to disentangle the growth in quantities and the growth in prices, we show next the real growth of total IPP, private and government funded IPP, and the major components of private IPP.

The distinction between nominal and real growth is especially important for IPP since the bumpy and uneven adoption of technological products is usually linked to sharp decreases in prices and rapid innovation.

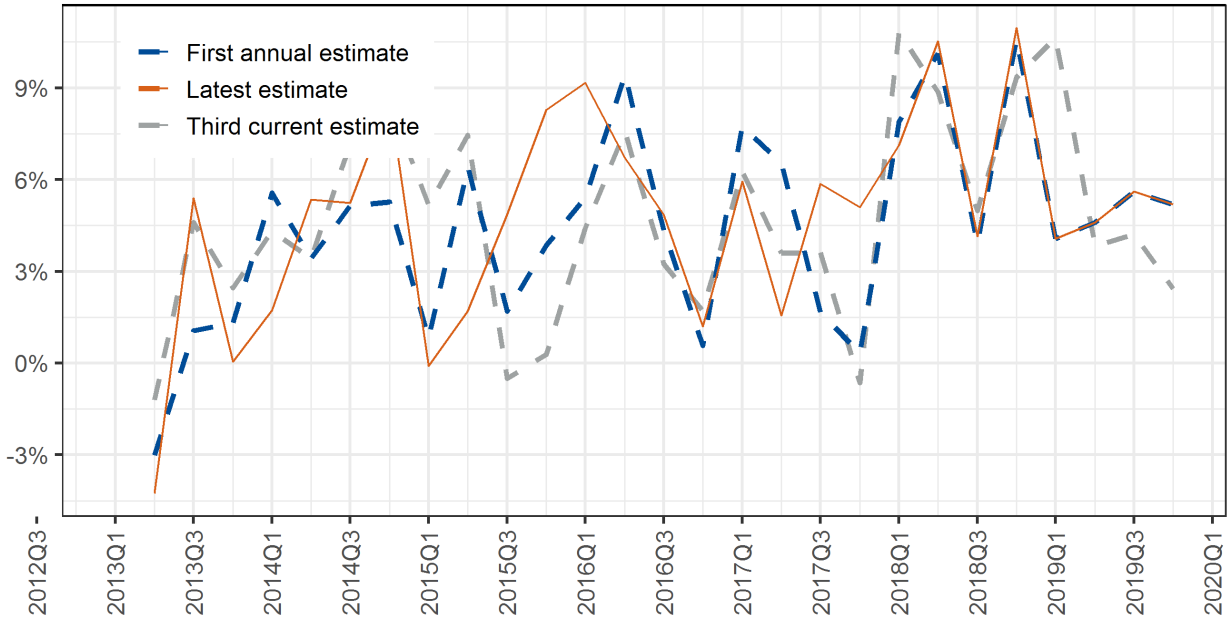
Figure 3 shows the annualized quarterly growth of real IPP for our whole sample period computed using the third current estimate, the first annual estimate, and the latest estimate available. The broad picture of growth for the whole period does not change much no matter which of these three estimates we use to compute growth, although the comprehensive revisions included in the latest estimate have changed our understanding of growth in the second half of 2015 and 2018.

As one can see in Figure 1, the quarterly annualized rate of real IPP in our sample ranges from around −3% in the second quarter of 2013, to around 10% in the second quarter of 2018.

A quick comparison between nominal and real IPP growth between Figures 1 and 3 shows that the average real growth of IPP was lower, 4.8% versus 5.5%, and more volatile, 3.4% versus 3% than the nominal growth of IPP.

A lower real growth during this period indicates that prices of IPP grew faster than the actual quantities of IPP produced during this period, showing a strong demand for this kind of investment.

Figure 3. Real IPP Growth by Vintage



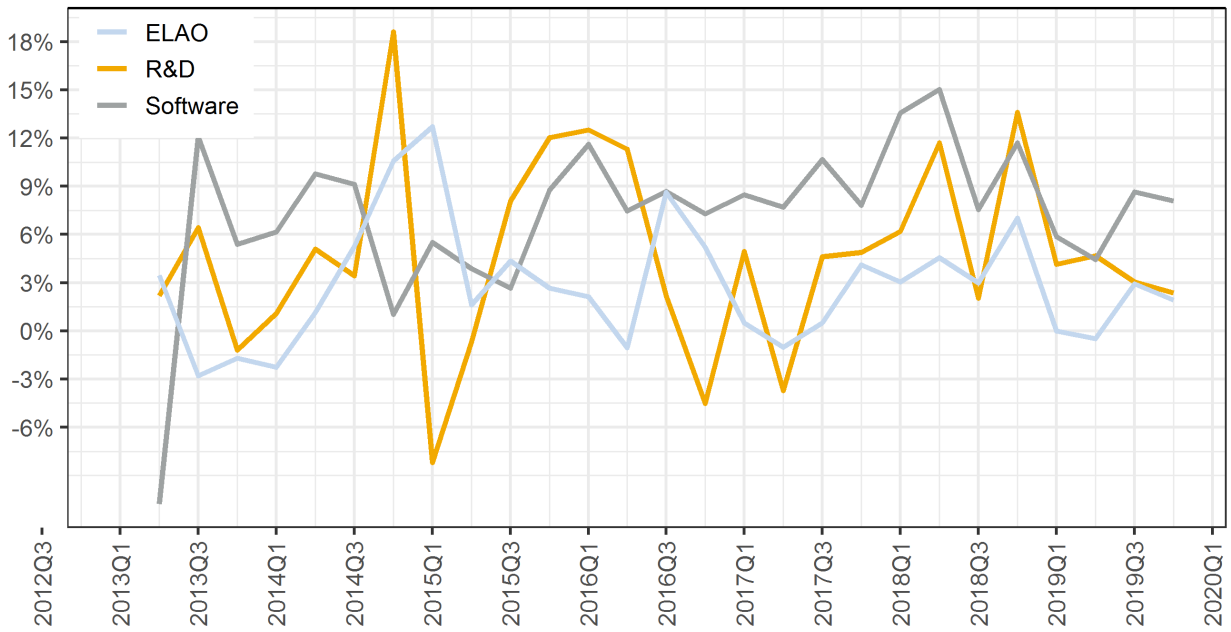
As in their nominal counterparts, real growth of government IPP was lower than that of the private sector, 2% and 5.5%, respectively, and as for total IPP, real growth rates were lower than nominal ones, but their volatility was higher.

Looking at each of the growth rates of the major subcomponents of real private IPP, and comparing then with their nominal counterparts, gives us information about the relative evolution of prices of Software, R&D, and ELAO.

Figure 4 shows that as was the case for nominal growth, average real growth of R&D and Software is higher than ELAO (4.7%, 7.3%, and 2.8%, respectively). However, Software is the only subcomponent

for which real growth is higher than nominal growth, 7.3% versus 6%, pointing to a decrease in Software prices during our sample period.

Figure 4. Major Components of Private IPP Nominal Growth



3. Sector Analysis

As De Loecker and Syverson (2021) point out, the access to microdata since the beginning of this century has exploded, making firm-level data more easily available. However, most firm-level studies rely on balance sheet data associated to mergers and don't capture the investments' spillovers among firms, especially those belonging to the same sector.

Thus, we think it is important to understand the role of intangibles at the sector level, where spillovers are likely larger.

To illustrate the heterogeneity of investment patterns in IPP by sector, we examine the seven sectors listed in Table 1, as we think they are a good representation of the U.S. economy as a whole and help us understand the heterogeneity and evolution of IPP investment at the sector level.

All our sectors are standard, except the Healthcare sector, where social assistance has been excluded,

and the Consumer services sector, that we have built ad hoc, so Table 1 shows the industries that comprise these two sectors.

Table 1. Nominal Gross Output in 1998

NAICS Code	Sector	$Millions
	Healthcare	
621	Ambulatory health care services	107,288
622	Hospitals	84,241
623	Nursing and residential care facilities	44,581
	Consumer services	
72	Accommodation and food services	56,514
61	Educational services	60,120
485	Transit and ground passenger transportation	72,368
44-45	Retail trade	72,655
71	Arts, entertainment, and recreation	100,623
482	Rail transportation	179,896
481	Air transportation	218,167
55	Management of companies and enterprises	140,202
54	Professional, scientific, and technical services	154,016
52	Finance and insurance	209,307
	Manufacturing	
32-33	Durable goods	211,371
31-32	Nondurable goods	260,428
51	Information	266,353

Source: Bureau of Economic Analysis

Without loss of generality, from now on, we will use the first year of available data as a reference year to construct relative or indexed measures. This means that for tables or figures using nominal and real gross output, and labor productivity from the BEA database, 1998 will be our year of reference. For series such as investment and capital, the earliest year of available data is 1980.

Also, since we are interested in long-term trends, Table 2 uses data up to 2019, to exclude the effects of COVID-19 in our study. The first column of Table 2 shows nominal output per worker in 1998, in each industry relative to All Industries, a category not shown, and that has been normalized to 1. The second column shows relative real output per worker both in 1998 and 2019 to see the evolution of this variable through time.

Table 2. Relative Output per Worker in 1998, Normalized to 1.00 for All Industries

Sector	Nominal 1998	Real 1998-2019
Healthcare		
Nursing and residential care facilities	0.32	0.36 - 0.30
Hospitals	0.61	0.66 - 0.70
Ambulatory health care services	0.78	0.76 - 0.64
Consumer services		
Accommodation and food services	0.41	0.43 - 0.36
Educational services	0.44	0.49 - 0.40
Transit and ground passenger transportation	0.53	0.62 - 0.78
Retail trade	0.53	0.47 - 0.54
Arts, entertainment, and recreation	0.73	0.77 - 0.65
Rail transportation	1.31	1.60 - 1.87
Air transportation	1.58	2.16 - 2.10
Management of companies and enterprises	1.02	1.16 - 1.21
Professional, scientific, and technical services	1.12	1.08 - 1.01
Finance and insurance	1.52	1.34 - 1.59
Manufacturing		
Durable goods	1.53	1.15 - 1.49
Nondurable goods	1.89	2.59 - 2.75
Information	1.93	1.35 - 3.08

Source: Bureau of Economic Analysis

Here, it is interesting to notice that the majority of industries inside labor-intensive sectors, such as Healthcare and Consumer services, have relatively lower output per worker compared to other sectors. Also, industries and sectors with the highest real output per worker at the beginning of our sample, such as Air transportation, Finance and insurance, Manufacturing, or Information, continue to be so by 2019.

This striking persistence in relative real output per worker is in contrast with the noticeable large and heterogeneous IPP investment patterns these sectors have experienced in the years in our sample.

All the data on investment flows by industry and type is publicly available and comes from nonresidential detailed estimates produced by BEA. For some sectors, investment in structures and equipment is available since 1901. However, the first investment in software recorded for most industries starts in 1980, so when we can, we use data since that time[2].

Table 3. Evolution of Real Capital Stock by Type and Sector in Millions of 2012 Dollars

(a) Real Capital Stock in 1980

	Sector	Total	ST	EQ	**IPP**
1	**Durables**	1,076,595	463,055	**446,159**	**167,381**
2	Information	539,008	334,064	84,253	120,691
3	Nondurables	899,284	405,879	391,202	102,203
4	**Consumer**	**1,695,435**	**1,317,595**	348,288	29,552
5	Profe&Tech	99,979	52,684	21,847	25,448
6	Fin&Ins	287,540	179,478	103,076	4,986
7	Healthcare	424,549	361,580	58,759	4,210
8	Management	213,286	185,995	25,095	2,196

(b) Real Capital Stock in 2020

	Sector	Total	ST	EQ	**IPP**
1	**Information**	2,812,819	971,912	**934,071**	**906,836**
2	Nondurables	1,877,581	478,243	651,033	748,305
3	Durables	1,852,224	549,860	751,875	550,489
4	Profe&Tech	814,082	216,513	219,493	378,076
5	Fin&Ins	1,504,832	654,363	618,256	232,213
6	**Consumer**	**3,630,513**	**2,559,678**	878,195	192,640
7	Management	380,786	245,912	63,848	71,026
8	Healthcare	1,547,005	963,806	524,396	58,803

Source: BEA at https://apps.bea.gov/national/FA2004/Details/Index.htm

The two panels of Table 3 show us a cross-sectoral picture of real capital at the beginning and at the end of our sample. The two panels present the sectors studied in descending order with respect to IPP capital, and the numbers and sectors in bold are the largest of each category. For example, in 1980, Durables had the largest equipment and IPP capital stock, while the consumer services sector had the largest structures and total capital stock. By 2020, the Information sector had amply surpassed both Durables and Nondurables manufacturing to become the sector with the largest stock of IPP and

[2]Eckert et. al (2021) study the combination of ITC investment and the high skill wage premium of the 1980s to explain the urban concentration of some sectors.

equipment in our sample. Interestingly, the consumer services sector remained the sector with the largest stock of structures and total capital, while making the bottom three sectors in terms of the value of the equipment and IPP capital used in production.

Other insights from Table 3 are, first, that capital structures are relatively expensive, or at least bulkier than equipment and IPP capital because sectors with the highest valuation of capital structures tend to have the highest valuation of total capital. And second, sectors with high IPP capital intensity also tend to use a lot of capital equipment.

However, as we know, capital stock, especially structures and equipment, are slow moving variables, where capital increases with new investments, and decreases with depreciation. Table 4 shows the share of IPP over total investment for our sectors of study, at the beginning and end of our sample. For example, in 1980 for every $100 invested in the Professional, scientific, and technical services sector, $46 was invested in IPP, while the corresponding number for the Consumer services sector was only $2.

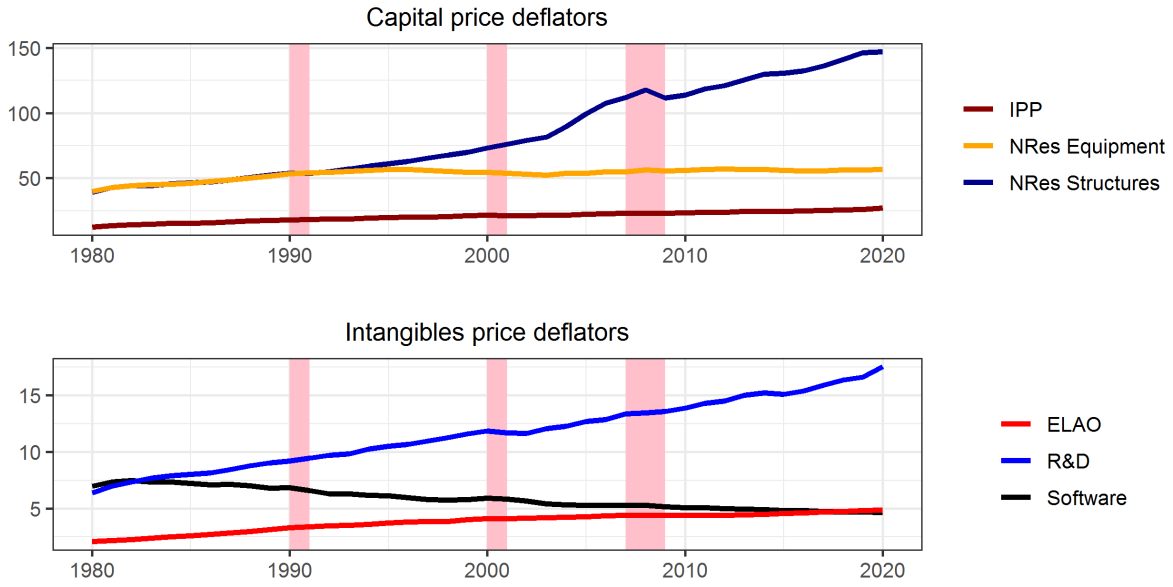
Table 4. IPP Investment Shares as Fraction of Total Investment

Rank 1980	IPP 1980	Rank 2020	IPP 2020
Prof&Tech	0.46	Management	0.72
Durables	0.35	Prof&Tech	0.68
Information	**0.24**	Durables	0.64
Nondurables	0.22	Nondurables	0.61
Management	0.11	Fin&Ins	0.49
Fin&Ins	0.10	**Information**	**0.41**
Healthcare	0.04	Consumer	0.23
Consumer	0.02	Healthcare	0.14

What is more, comparing all sectors' IPP investment shares in 1980 and in 2020, one can see that in 1980, the majority of total investment in *all* sectors went to investment in structures and equipment, but by 2020, the majority of total investment in almost all sectors went exclusively to IPP capital, with the exception of our 2 most labor-intensive sectors, Consumer services and Healthcare.

The top panel of Figure 5 helps explain the slow but steady reduction in nonresidential structures, and the consequent decrease in the share of capital structures used in production in all sectors by the end of our sample. Prices of nonresidential structures increased much faster than prices of equipment and IPP, especially after 2000, pushed by the even higher prices of residential structures (not shown in the graph).

Figure 5. Evolution of Capital Deflators



Source: Bureau of Economic Analysis.

The top panel of Figure 5 also shows that the price aggregates of equipment and IPP were growing at very similar pace for most of the sample. However, the bottom panel shows that within IPP capital, software prices were falling, while prices of R&D and ELAO capital were increasing, making software much cheaper in relative terms.

Lastly, and given the incredible ascent of IPP capital at the expense of structures and equipment capital during the last 40 years, it is important to notice the tremendous investment heterogeneity in the types of IPP investment different sectors invest in. Thus, Table 5 shows how the investment in IPP and its two main components as a fraction of total investment stand by 2020.[3]

As mentioned before, the economic literature has had a hard time finding evidence to show a positive causality between investments in IPP capital and increases in labor and total factor productivity, and we ourselves have encountered the same problems the literature has when running regressions between our different measures of IPP capital and investment and the different productivity measures computed by BLS.

[3]For some of the sectors, Software and R&D, shares don't add up to IPP shares because the ELAO share is not shown.

Table 5. Investment Shares of Total Investment, 2020

Sector	IPP	Software	R&D
Prof&Tech*	0.69	0.26	0.42
Durables	0.64	0.08	0.56
Information	0.41	0.21	0.20
Nondurables	0.61	0.04	0.56
Management	0.72	0.69	0.02
Fin&Ins	0.49	0.44	0.04
Healthcare	0.14	0.08	0.06
Consumer*	0.23	0.12	0.08

* For some of the sectors, Software and R&D, shares don't add up to IPP shares because the ELAO share is not shown.

However, what seems to transpire from our cross-sector analysis is that IPP investment is indeed important to explain the evolution of relative measures of output per worker among sectors, as those sectors with higher levels of IPP investment, whether in software or R&D, are able to maintain or increase relatively high levels of output per worker continuously and persistently.

In the following sections, we will dive into a more detailed analysis of the types of IPP investment these sectors experienced, but before we do that, we want to look briefly at the evolution of employment in these sectors to have an idea about how demand for the goods and services produced by these sectors has been changing over time too.

Table 6 shows the initial full-time employment levels in 1998 and their average annual growth.[4]

It is worth noticing two trends: first, that the employment growth in the sectors with lowest relative productivity in 1998, the Consumer services and the Healthcare sector have seen a positive growth in employment throughout our sample, so demand for those services consistently grew; and second, that the three most productive sectors in 1998, this is, Durables, Nondurables, and Information have suffered significant employment losses by the end of 2019.

[4] Average annual growth between years t+T and t has been constructed as $(\frac{Employment_{t+T}}{Employment_t} - 1)/T$.

Table 6. Evolution of Full-Time Employment by Sectors

	Employment 1998	Annual growth 2019-1998
Durables	10,781	-1.28 %
Nondurables	6,465	-1.35 %
Information	3,035	-0.62 %
Fin&Ins	5,318	0.88 %
Prof&Tech	5,776	2.85 %
Management	1,581	2.04 %
Consumer	24,686	1.38 %
Healthcare	9,532	2.72 %

Source: BEA. Full-time equivalent employees in thousands.

4. Manufacturing Sector

The manufacturing sector is comprised of many different industries, so we are going to use the durable (NAICS 33) and nondurable goods (NAICS 31 and 32) sub-aggregates.

The durables manufacturing sector is also comprised of many industries. These industries are Wood products (NAICS 321), Nonmetallic mineral products (NAICS 327), Primary metals (NAICS 331), Fabricated metal products (NAICS 332), Machinery (NAICS 333), Electronic and computer products (NAICS 334), Electrical equipment, appliances, and components (NAICS 335), Motor vehicles, bodies and trailers, and parts (NAICS 3361-3), Other transportation equipment (NAICS 3361-3), Furniture and related products (NAICS 337), and lastly Miscellaneous manufacturing (NAICS 339). The industries with highest investment throughout our sample are Electronics products and computers, and Motor vehicles, bodies and trailers, and parts.

As shown in Table 4, the durable and nondurable industries were among the leaders in IPP investment in 1980, with the durable industries investing 35% of total investment in IPP, and the nondurable industries 22%.

Table 7 shows how IPP capital and its shares compare in 1980 in the first line, versus 2020, in the second line. For all the capital shares in Table 7 and in the remaining tables of the paper, the shares of capital of type k in the broader category of capital K at time t, $s_{t,k}$, have been constructed as $s_{t,k} = \frac{k_t}{K_t}$.

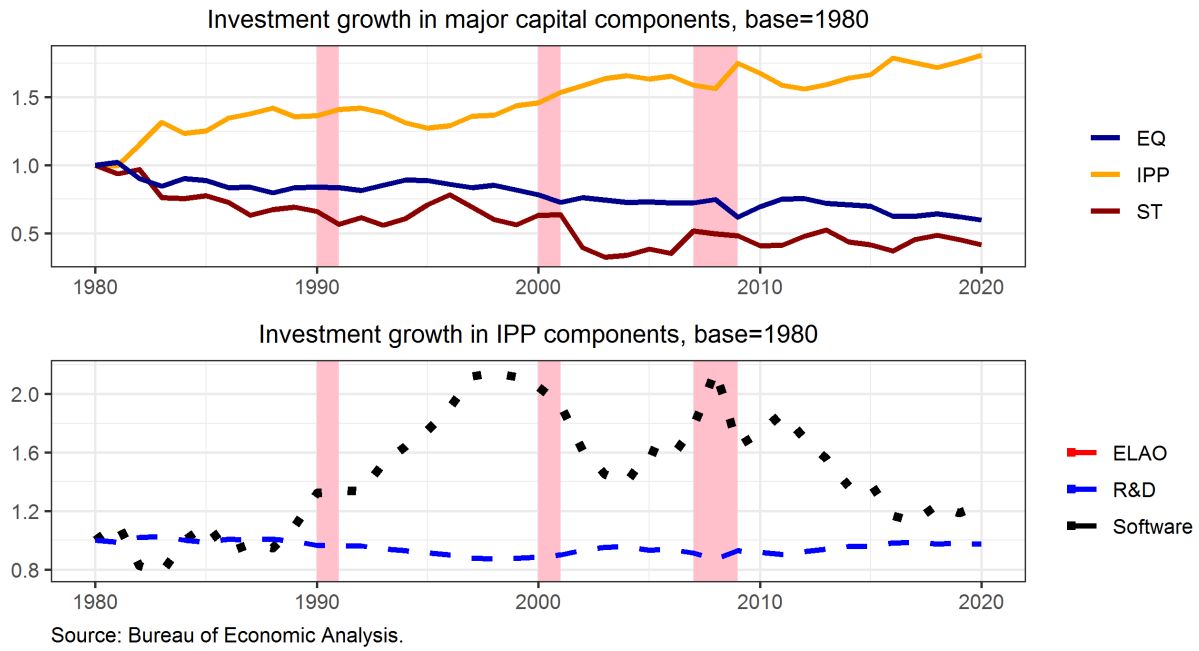
For example, in Table 7, the IPP share of total capital stock almost doubles between 1980 and 2020, from 0.16 to 0.30. Moreover, the numbers in the far left of the table refer to the corresponding ranks in panels (a) and (b) in Table 3. Note that ELAO does not play any role in this sector.

Table 7. Evolution of Real Intangibles Capital Stock and Capital Shares 1980-2020

	IPP	Software	R&D	ELAO	IPP share	Soft share	R&D share	ELAO share
1	167,381	4,524	162,858	0	0.16	0.03	0.97	0
3	550,489	49,268	501,219	0	0.30	0.09	0.91	0

The share of the subcomponents of IPP, the last three columns of Table 7, are with respect to IPP. Notice that consistent with the evolution of prices shown in Figure 5, investment in software outgrew investment in R&D for most of the years in our sample, as shown in the bottom panel of Figure 6, and by 2020,table 7 shows that the share of capital software had increased from 3 to 9 percent, while the share of R&D had decreased from 97 to 91 percent.

Figure 6. Durables Manufacturing Sector



In Figure 6 and in the rest of the figures in the paper, the investment growth of capital of type k at time t shown, $I_{t,i}$, has been indexed to the first year of investment data, usually year 1980 or t=80, so $I_{t,k} = \frac{Inv_{t,k}}{Inv_{80,k}}$.

So the indexed series shown in Figure 6 all start in 1980 and have a value of 1, and the difference between two points in time, t_1 and t_2 can be interpreted as the growth in investment shares of type i between t_1 and t_2, as in, $I_{t_2,k} - Is_{t_1,k}$.

However, bear in mind that the initial shares of the investment allocated in different types of capital in each sector differs significantly. For example, the initial shares of investment among structures, equipment, and IPP in 1980 was 14, 51, and 35 percent, respectively.

The top panel of Figure 6 shows that the importance of IPP investment relative to investment in equipment and structures during our sample period grew steadily. By 2020, the investment share into IPP had almost doubled and absorbed 64% of the funds dedicated to new investments.

Within the IPP investment category, in 1980, 90 percent of it went to R&D, and remaining 10 percent went to software.

The lower panel shows that in 1980, although IPP investment in software outgrew investment in R&D for most of our sample, especially from the early 1990s until the high tech bust, and then again immediately before and after the Great Recession.

Still, by 2020, the Durables sector, together with the Healthcare and Nondurables sectors was at the bottom of software investment, dedicating "only" 8% of total investment to software (see Table 5).

The Nondurables manufacturing sector is also composed of many industries: Food, beverage, and tobacco products (NAICS 311 and 312), Textile mills and textile product mills (NAICS 313 and 314), Apparel and leather and allied products (NAICS 315 and 316), Paper products (NAICS 322), Printing and related support activities (NAICS 323), Petroleum and coal products (NAICS 324), Chemical products (NAICS 325), and finally Plastics and rubber products (NAICS 326). The industries with highest investment throughout our sample are Chemical products and Food, beverage, and tobacco products.

Table 8. Evolution of Real Intangibles Capital Stock and Sapital Share 1980-2020

	IPP	Software	R&D	ELAO	IPP share	Soft share	R&D share	ELAO share
3	102,203	1,231	100,975	0	0.11	0.01	0.99	0
2	748,305	19,520	728,786	0	0.40	0.03	0.97	0

As mentioned above, the layout of Table 8 and the similar tables that follow, are the same as Table 7. Note that the IPP share of total capital stock between 1980 and 2020 has increased 263%. Again ELAO plays no role in this sector. And even though the share of software capital in IPP has more than

doubled, thanks to the consistently higher investment pattern shown in the lower panel of Figure 7, it is relatively small compared to the R&D capital.

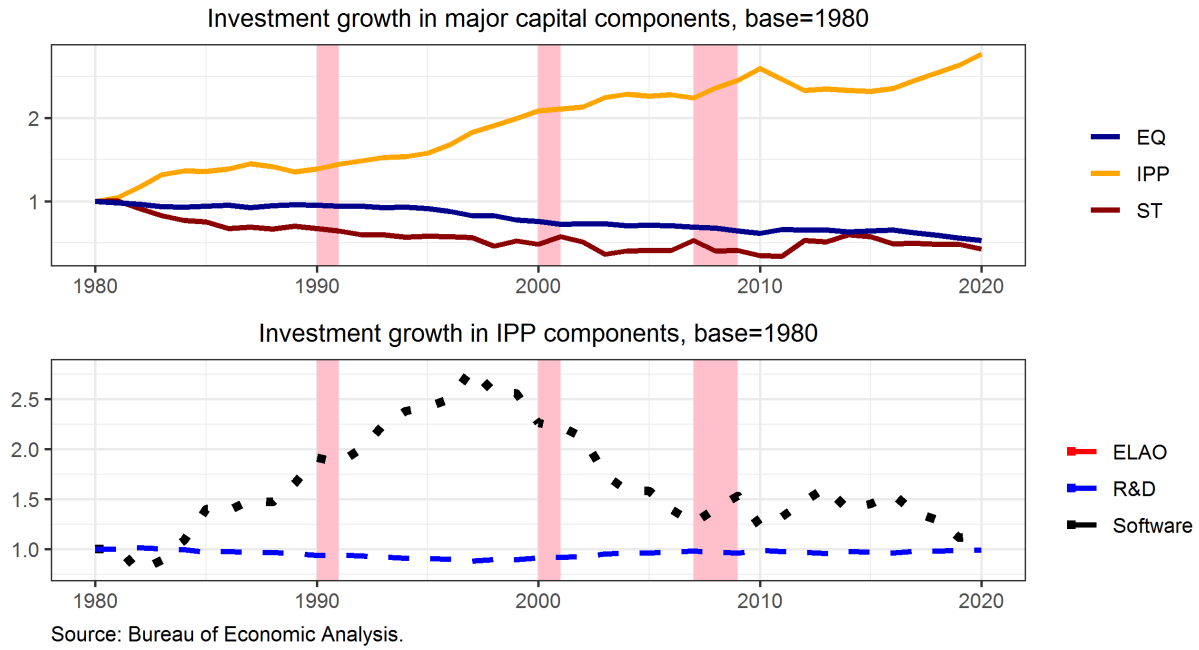
Similarly to what happened in the Durables sector, the top panel of Figure 7 shows that IPP investment grew considerably, and its importance relative to investment in equipment and structures grew continuously.

However, bear in mind that for Durables, the initial shares of the investment allocated among structures, equipment, and IPP in 1980 was 18, 61, and 22 percent, respectively, (as opposed to 14, 51, and 35 percent, respectively, for Nondurables).

Here also, by 1980, the Nondurables manufacturing sector dedicated 94 percent of IPP investment into R&D, and the remaining 4% into software.

Meanwhile, the lower panel of Figure 7 shows that even though there was an increase in the share of IPP investment in software until the end of the 1990s, by 2020, this trend had reversed almost completely.

Figure 7. Nondurables Manufacturing Sector



Source: Bureau of Economic Analysis.

5. Consumer Services

This sector comprises Retail (NAICS 44 and 45), Accommodation, food, and education services (NAICS 72 and 61), Arts, entertainment, and recreation (NAICS 71), and Air, rail, transit and ground transportation (NAICS 481, 482, and 485). Table 9 shows the evolution of IPP real capital and capital shares in this sector.

As opposed to the manufacturing sector, ELAO has played a significant role in the composition of IPP capital. The change in the share of ELAO is remarkable. In 1980, almost all of the IPP capital was in ELAO. By 2020 it had fallen to 25%, while the shares of software and R&D capital drastically increased.

The change in ELAO capital is due to two factors. First the relative importance of Arts, entertainment and recreation has changed relative to the other industries that make up this sector and this would explain the decrease in the share of ELAO, as this industry was and still is the sole user of ELAO capital in this sector. And second, the digitization of the arts and the decline in software prices previously shown, have also played a role, substituting ELAO in favor of software investment, as one can see looking at the investment patterns in the bottom panel of Figure 8, especially the the second half of the 1990s coming into the high tech bust of 2000-2001.

This suggests there may be an issue of classification where digital art is not considered ELAO but just software.

Table 9. Evolution of Real Intangibles Capital Stock and Capital Shares 1980-2020

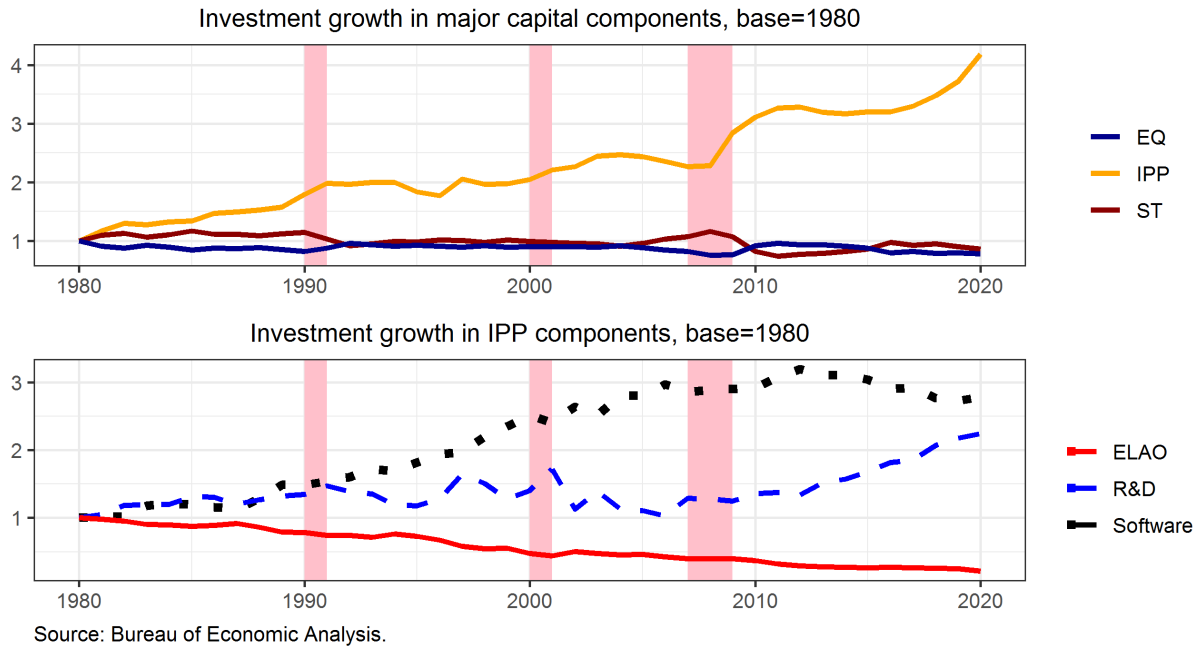
	IPP	Software	R&D	ELAO	IPP share	Soft share	R&D share	ELAO share
4	29,552	876	2,972	25,702	0.02	0.03	0.10	0.87
6	192,640	69,229	74,490	48,920	0.05	0.36	0.39	0.25

In this sector, the initial shares of the investment allocated among structures, equipment, and IPP in 1980 were 39, 55, and 6 percent, respectively, numbers remarkably different from the Manufacturing sector.

However, in the top panel of Figure 8, we see that IPP investment steadily grew over time.

Of the meager 6 percent investment in IPP capital in 1980, 66 percent went to ELAO, and was concentrated on Arts, entertainment, and recreation, 19 percent to software, and 14 percent to R&D.

Figure 8. Consumer Services Sector



Source: Bureau of Economic Analysis.

The lower panel of Figure 8 shows that since the beginning of our sample until the Great Recession, investment in software has been increasing, slowly displacing investment in ELAO. After the Great Recession, the share of ELAO investment has stabilized, and the share of R&D investment has steadily increased eroding the share of software investment.

6. Information Sector

As mentioned above, the Information sector has received special attention in the most recent decades as a growing employer of highly-skilled labor and for experiencing continuous productivity increases. The sector grew at a rapid pace up to the 2001 high tech bubble bust but continued to grow at a considerable pace after that.

The Information sector is composed of Publishing industries (NAICS 511, including software), Motion picture and sound recording industries (NAICS 512), Broadcasting and telecommunications (NAICS 515 and 517), and Information and data processing services (NAICS 518 and 519). Up to 2000, investment in Broadcasting and telecommunications accounted for more than 60% of total investment in this sector,

but since then, its share has been shrinking steadily in favor of Information and data processing services and publishing industries.

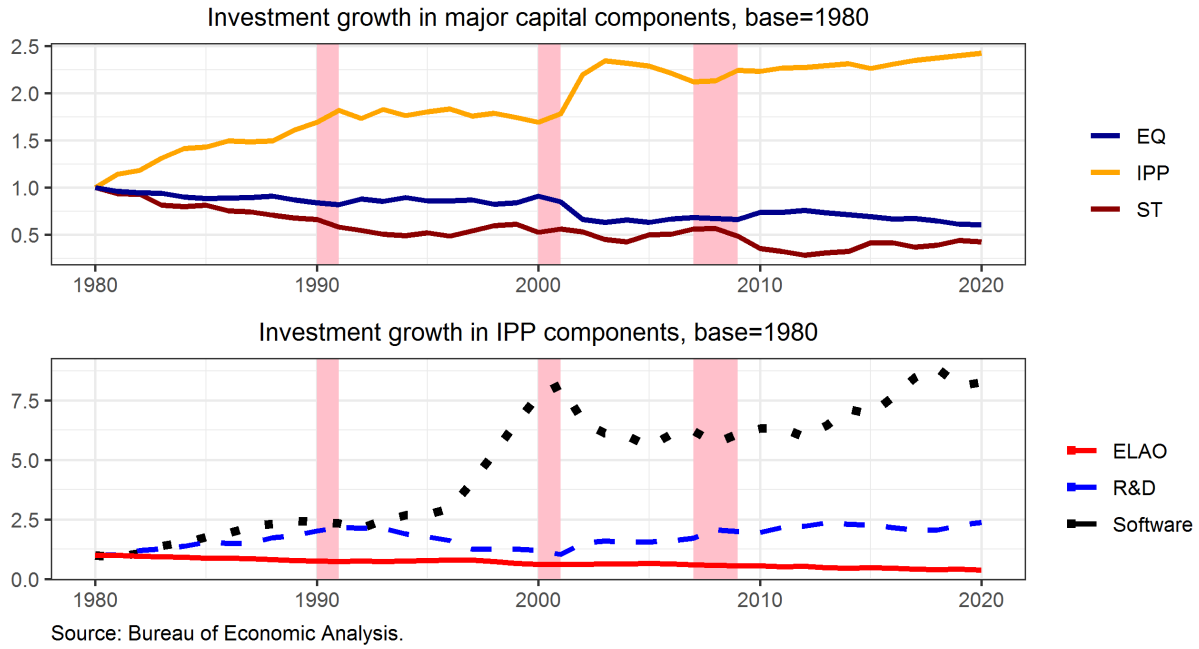
The last three columns in Table 10 show that there has been a remarkable change in the composition of IPP capital in this diverse sector. The IPP shares of software and R&D have dramatically increase while the share of ELAO has decreased 47%. The price movements in Figure 5 do not fully explain this change in composition as the prices of both R&D and ELAO have increased in absolute and relative terms compared to the prices of software.

Table 10. Evolution of Real Intangibles Capital Stock and Capital Shares 1980-2020

	IPP	Software	R&D	ELAO	IPP share	Soft share	R&D share	ELAO share
2	120691	873	8967	110853	0.22	0.01	0.07	0.92
1	906836	190989	267066	448785	0.32	0.21	0.29	0.49

A change in the composition of the sector can explain the decrease in ELAO capital and investment, as the importance and value added of the Information and data processing services industries was very small in 1980 and became one of the major players of the sector by 2020.

Figure 9. Information Sector



Source: Bureau of Economic Analysis.

The investment patterns in the bottom panel of Figure 9 show the tremendous and rapid increase in

software investment that occurred in the late 1990s, and the continuous outflow of investment into software that has remained high since 2000.

In this sector, the initial shares of the investment allocated among structures, equipment, and IPP in 1980 was 26, 49, and 24 percent, respectively, numbers remarkably similar to the Nonduables manufacturing sector above.

However, the top panel of Figure 9 illustrates the growth decomposition of total investment among structures, equipment, and IPP, throughout our sample, and as one can see, investment growth in IPP in the Information sector was greater.

As mentioned before, the Information sector, together with the Arts, entertainment, and recreation industry inside the Consumer services sector, is one of the few sectors in which investment in artistic and entertainment originals plays a significant role. But we see in the lower panel of Figure 9 that investment in software has grown the most since 1980.

The lower panel decomposes the investment growth of the IPP category into Software, R&D, and ELAO. Consistent with the importance of broadcasting and telecommunications industries within the Information sector at the beginning of the 1980s, the initial share of investment in artistic and entertainment originals was very high, 82 percent, while the corresponding shares for R&D and software were 14 and 4 percent, respectively. However, by looking at the lower panel, we can see that investment in software took off by the mid 1990s and has remained very high compared to R&D and ELAO. By 2020, the capital shares of the three major subcomponents of IPP inside the Information sector was much more balanced, as shown in the second row of Table 10.

7. Healthcare Sector

This sector is composed of Ambulatory services (NAICS 621), Hospital care (NAICS 622), and Nursing and other residential facilities (NAICS 623).

In Table 11, we can see that in this sector, there has been a 300% increase in the IPP share of capital, though the IPP share is still small compared to other sectors, and there has also been a noticeable change in the composition inside IPP capital since 1980.

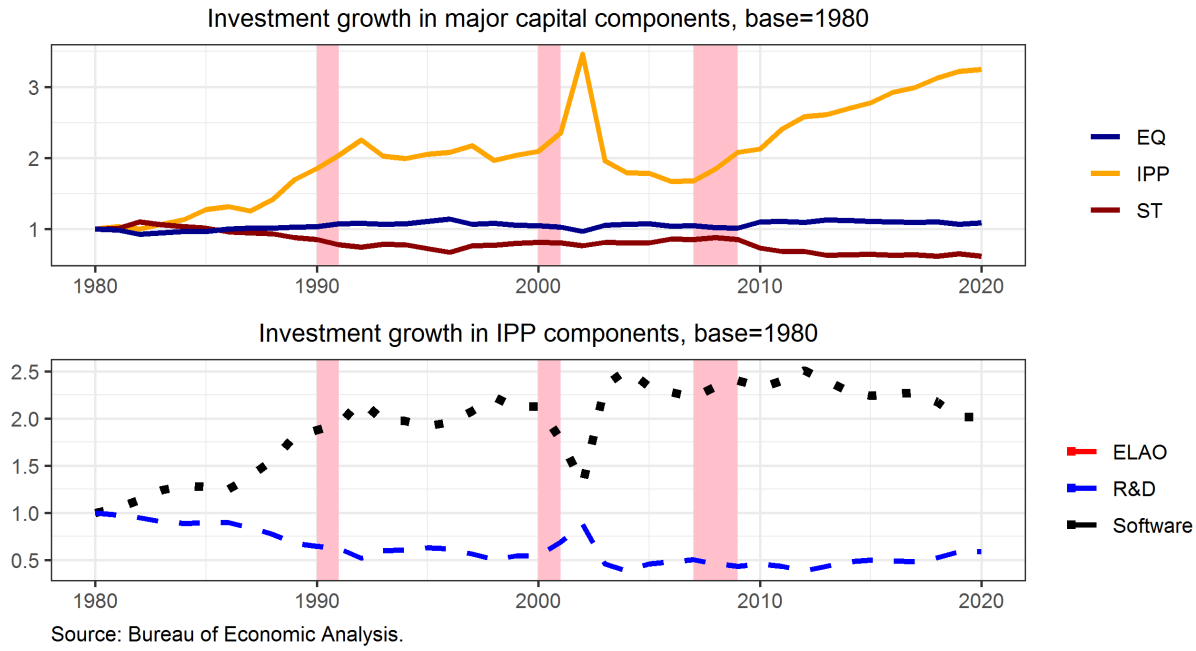
In 1980, 56% of investment that year was used to buy equipment, 39% went to structures, and only

Table 11. Evolution of Real Intangibles Capital Stock and Capital Shares 1980-2020

	IPP	Software	R&D	ELAO	IPP share	Soft share	R&D share	ELAO share
7	4,210	279	3,932	0	0.01	0.07	0.93	0
8	58,803	24,996	33,808	0	0.04	0.43	0.57	0

the remaining 4% was invested in IPP. However, as the top panel of Figure 10 shows, investment flows into structures as a percentage of total investments suffered a slow but steady decline in favor of IPP investment during the period analyzed, changing the composition of the three major types of capital used in production in this sector.

Figure 10. Healthcare Sector



As shown in the first row of Table 11, most of the IPP capital in 1980 was composed of R&D, 93 percent, but by 2020, the R&D share had decreased 46% and the software share had increase over 500%.

These remarkable changes in the types of IPP capital shares used in production are explained by the attending investment patterns in the bottom panel of Figure 10, where one can see the increase in software investment through our sample period.

In 1980, the majority of IPP investment in the healthcare sector went into R&D, 71 percent, while the remaining 29 percent went into software. However, consistent with the bottom panel of Figure 11, by 2020, software had become the major subcomponent of IPP investment, absorbing about 60 percent of the new investments in IPP in the sector[5].

The relative increase in software investment over R&D is consistent with the movements in prices previously shown in Figure 5.

One should keep in mind that this sector is composed of three industries with very different production functions and the use and investment in the different types of intangible capital has not been homogeneous among them.

8. Professional, Scientific, and Technical Services Sector

This sector is comprised of three industries: Legal services (NAICS 5411), Computer systems design and related services (NAICS 5415), and Miscellaneous professional, scientific, and technical services (NAICS 5412).

This sector also consists of very different industries and the IPP share of total capital has increased substantially, 84%. In Table 12, note the sharp decline in the share of ELAO capital between 1980 and 2020. While IPP capital has increased considerably during our sample period, constituting 25% of total capital in 1980 and 46% in 2020, the R&D capital share in IPP has remained almost constant, while the software share increased almost as much as the ELAO share declined. Here too, as in the Arts and entertainment industry in the Consumer services sector, there may be an issue of classification where digital art and services are not considered ELAO but just software.

Table 12. Evolution of Real Intangibles Capital Stock and Capital Shares 1980-2020

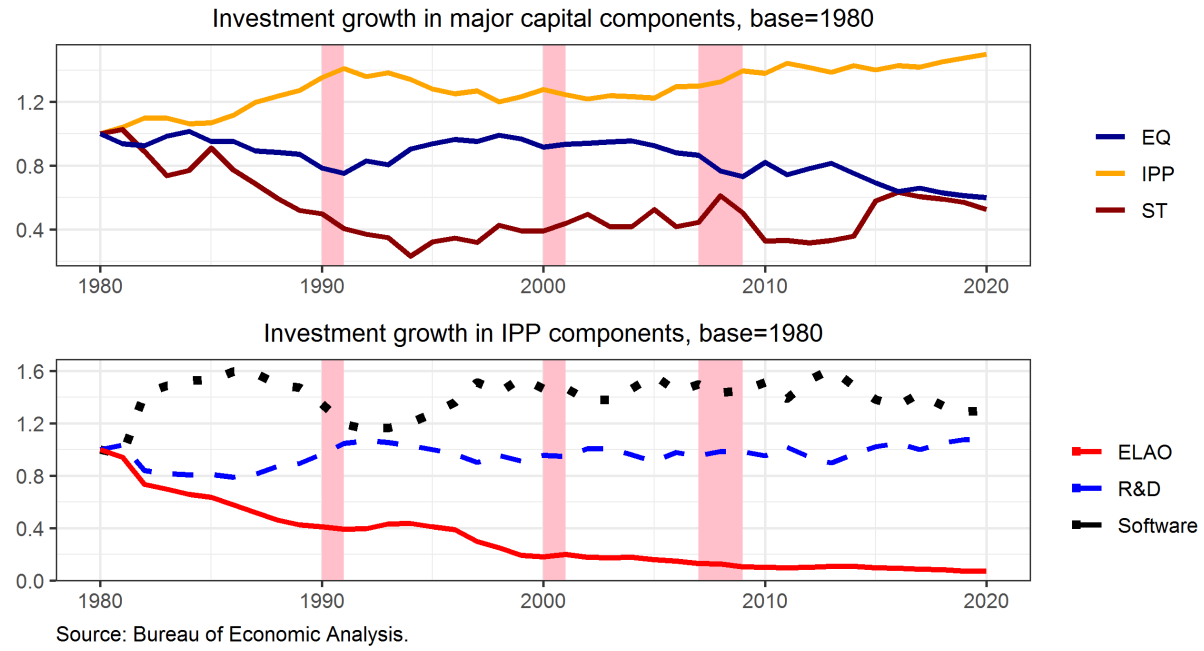
	IPP	Software	R&D	ELAO	IPP share	Soft share	R&D share	ELAO share
5	25,448	1,699	17,138	6,612	0.25	0.07	0.67	0.26
4	378,076	107,708	259,390	10,976	0.46	0.28	0.69	0.03

Consistent with the high IPP capital share in 1980 shown in Table 12 of 25 percent, the 1980 share

[5] In 2002, the huge spike in IPP investments came from R&D investment expenses. We plan to investigate this in the next versions of this paper.

of investment in IPP in this sector was already high, at 46 percent, while equipment and structures absorbed 39 and 16 percent, respectively, of the remaining investment funds.

Figure 11. Professional Services Sector



The top panel of Figure 11 shows that through time, investment flows into IPP grew even more, increasing their share of total investment, taking up funds from investment in both equipment and structures.

In 1980, 56 percent of IPP investment was invested in R&D, 30 percent in software, and the remaining 14 percent in ELAO.

The lower panel of Figure 11 shows how these trends evolved over time. Notice that investment in R&D remained at similar levels, while investment in software grew some, but mostly at the expense of artistic and entertainment originals.

Moreover, the investment patterns illustrated in the bottom panel of Figure 11 are consistent with increases in price of ELAO and R&D, and the decrease in the price of software.

9. Finance and Insurance

The finance and insurance sector in the economy has received special attention since the 1980s due mostly to the innovation of financial products introduced during the 1990s. This sector is composed of Federal Reserve banks (NAICS 521), Credit, intermediation and related activities (NAICS 522), Securities, commodity contracts, and investments (NAICS 523), Insurance carriers and related activities (NAICS 524), and Funds, trusts, and other financial vehicles (NAICS 525).

During our time period, investment flows into equipment and structures as a percentage of total investments suffered a slow but steady decline in favor of IPP investment, changing the composition of the capital used in production in this sector.

The first line of Table 13 highlights that IPP capital in 1990 consisted only of software, and IPP capital was a tiny fraction of the capital used in this sector. However, by 2020 we see that IPP share of total capital has grown to 15%, and that R&D capital is 16% of IPP.

Table 13. Evolution of Real Intangibles Capital Stock and Capital Shares 1980-2020

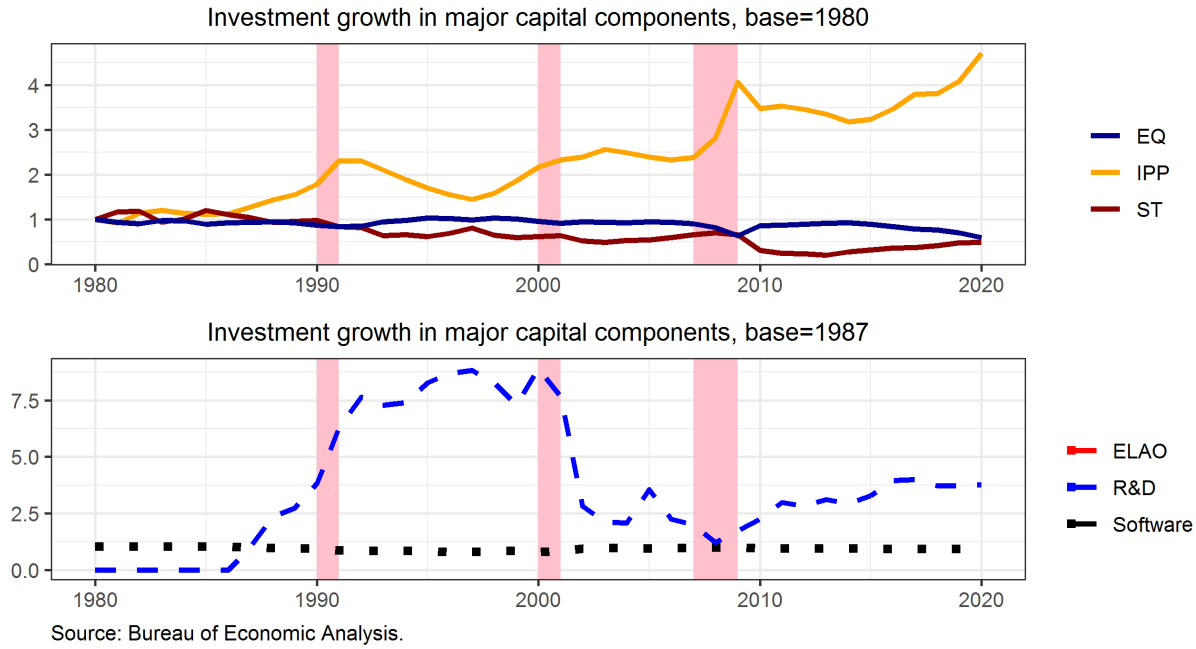
	IPP	Software	R&D	ELAO	IPP share	Soft share	R&D share	ELAO share
6	4,986	4,988	0	0	0.02	1	0	0
5	23,2213	195,266	36,946	0	0.15	0.84	0.16	0

In 1980, out of every $100 of investment, $65 went into into equipment, $25 went into structures, and only $10 went into investment in IPP. However, as the top panel of Figure 12 shows, investment in equipment and structures stagnated or slightly decreased from 1980 to 2020, while investment in IPP skyrocketed.

Inside IPP, by 1980 all investment was going into software, and it wasn't until 1987 that the first R&D investment is recorded in this sector. The bottom panel of Figure 12 illustrates that investment in software consistently remained at the 1980 levels, while the investment pattern for R&D was quite volatile; first, R&D investment increased a lot until 2000, but fell quickly after the high tech bust, leading up to the Great Recession. After that, R&D investment partially recovered and remained around its current level, such that by 2020, the R&D share of capital inside IPP was 16 percent and the software share was 84 percent.

Also, remember that this uneven increase in R&D investment happened even with the increase in its price shown previously in Figure 5.

Figure 12. Finance and Insurance Sector



Source: Bureau of Economic Analysis.

10. Management of Companies and Enterprises Sector

This sector (NAICS 55) comprises establishments that hold securities or equity interests of other companies for the purpose of controlling or influencing management decisions and establishments that administer, oversee, and manage strategic or organizational planning and decision-making of companies. Establishments in this sector perform activities that are often undertaken in-house by establishments in many other sectors of the economy.

Government establishments engaged in administering, overseeing, and managing governmental programs are not included in this sector, and are classified in the Public Administration (NAICS 92). Other establishments primarily engaged in providing a range of day-to-day office administrative services, such as financial planning, billing and record keeping, personnel, and physical distribution and logistics, are classified as Office Administrative Services (NAICS 56111).

As Table 14 shows, this sector did not have very much IPP capital in 1980. In contrast, by 2020,

IPP capital amounted to 19% of total capital. In 1980, the IPP capital consisted of software and the prominence of software had increased even more by 2020.

Table 14. Evolution of Real Intangibles Capital Stock and Capital Shares 1980-2020

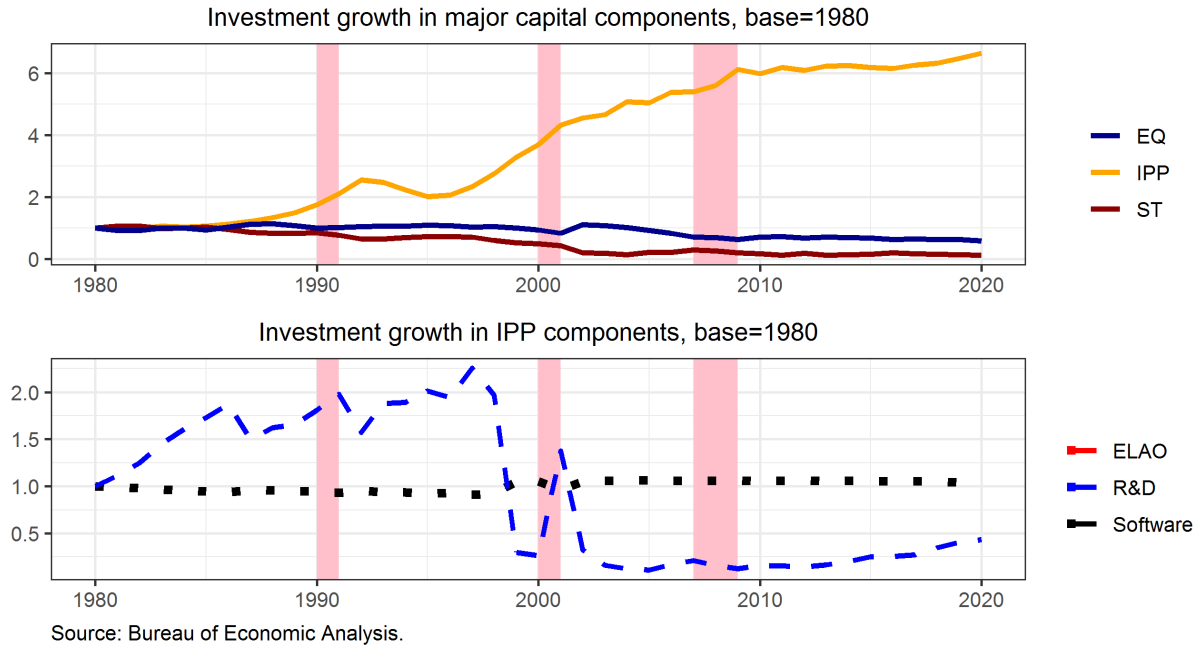
	IPP	Software	R&D	ELAO	IPP share	Soft share	R&D share	ELAO share
8	2,196	1,799	397	0	0.01	0.82	0.18	0
7	71,026	68,273	2,753	0	0.19	0.96	0.04	0

In this sector, the initial shares of the investment allocated among structures, equipment, and IPP in 1980 were 52, 37, and 11 percent.

The upper panel of Figure 13 shows how investment in IPP increased timidly until 1995, and took off after that.

At the beginning of our sample, 93 percent of IPP investment was spent in software, while the remaining 7 percent went into R&D.

Figure 13. Management of Companies Sector



Source: Bureau of Economic Analysis.

The bottom panel of Figure 13 shows that investment in R&D grew faster than investment in software

until the end of the 1990s, but slower after that, effectively washing out the importance of R&D capital inside IPP capital. As Table 14 shows, the share of R&D capital inside IPP decreased from 18 to 4 percent between 1980 and 2020, in favor of software. The prices of software fell consistently during this period.

11. Summary and Conclusions

Discussions of intangible capital generally look at aggregates, and focus at how our difficulty measuring intangibles accurately affects measures of total investment, GDP, and especially different measures of productivity.

Instead of focusing on what intangibles we could be missing, in this paper, we have taken a different approach: closely looking at the disaggregated components of intangible capital that are already being measured in the NIPAs, in some key sectors in the U.S. economy, together with the comovements among these components and their counterparts of tangible capital, structures, and equipment.

Our analysis shows that the use of the most expensive and bulky capital in production, that of nonresidential structures, has been eroding consistently since 1980 among all the sectors studied in the paper, but to different degrees. This erosion has been closely followed by another in equipment capital. In their place, a new type of capital has appeared: IPP capital.

We have used BEA's decomposition of intellectual property products to show that capital and investment in intellectual property products is an aggregation of sometimes very different trends in the components: R&D, Software, and Entertainment, literary and artistic originals.

Our descriptive analysis examines seven key sectors: Manufacturing (durable and nondurable); Healthcare; Finance and insurance; Consumer services; Management of companies and enterprises; Professional, scientific, and technical services; and Information.

We have shown that there is a lot of heterogeneity in the type of IPP capital different sectors can use to produce and deliver goods and services, and we think that the evolution of prices of these three types of IPP capital has played an important role in the pace of investment and transformation in these sectors.

Sectors like Information, Finance and insurance, or Management of companies and enterprises are very amenable to software capital, while other sectors like Manufacturing (durable and nondurable) and

Professional, scientific, and technical services have only been able to incorporate software capital in their production to a lesser extent, while continuing to invest heavily in the relatively more expensive R&D capital, as they had been doing since the 1980s.

Lastly, Consumer services and Healthcare have also increased their investments in a balanced mix of software and R&D capital but at much more modest levels compared to the rest of capital intensive sectors analyzed in this paper. Both sectors continued to be heavily invested in expensive nonresidential structures.

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