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Labor Share Decline and Intellectual Property Products Capital*

Dongya Koh
University of Arkansas

Raül Santaeulàlia-Llopis
Washington University in St. Louis
Universitat de València
CEMFI

Yu Zheng
City University of Hong Kong
European University Institute

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Abstract

We study the behavior of the US labor share over the past 65 years. We find that intellectual property products (IPP) capital entirely accounts for the observed decline of the US labor share, which otherwise is secularly constant for structures and equipment capital. The decline of the labor share reflects that the US is undergoing a transition to a more IPP capital-intensive economy. This result has essential implications for the US macroeconomic model.

Keywords: Labor Share, Intellectual Property Products, Capital, 1999- and 2013-BEA Revisions
JEL Classification: E01, E22, E25

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1 Introduction

The constancy of the labor share (LS), one of the great fantasies of contemporary macroeconomics, is finally gone: The LS declines. With the most recent national income and product accounts (NIPA) data after the 2013 Bureau of Economic Analysis (BEA) comprehensive revision, the US aggregate LS decreases from 0.68 in 1947 to 0.60 in 2013 (panel (a) of Figure 1). Compared with the LS implied by the pre-revision data (Elsby, Hobijn, and Sahin, 2013, Karabarbounis and Neiman, 2014a, Piketty and Zucman, 2014), the up-to-date LS shows a prolonged secular decline that starts much earlier in (at least) the late 1940s, doubles the size of the decline of the pre-revision LS from roughly 4 to 8 LS points, and still continues (panel (b) of Figure 1). These findings shatter the alleged constancy of the LS (Kaldor, 1957, Prescott, 1986), which is nothing short of "a bit of a miracle" in Keynes' colorful language.

After carefully analyzing the national income and fixed assets data from the recent 1999 and 2013 BEA revisions that capitalize intellectual property products (IPP), we show that the prolonged secular decline of the LS is driven by IPP capital. In particular, IPP capital accelerates the measured capital formation and depreciation, barely affecting the time series of the price of investment. Removing, in an accounting sense, the effects from IPP on aggregate capital accumulation, depreciation and the price of investment in a parsimonious investment model, we recover a LS that is trendless from 1947 to the present. That is, the shift in the speed at which aggregate capital accumulates and depreciates due to the increasing importance of IPP capital in the US economy fully accounts for the observed decline of the LS.

The introduction of IPP capital in national accounts is a substantial improvement on the measurement of aggregate capital and output. While IPP is (and has always been) part of the US economy (Corrado, Haltiwanger, and Sichel, 2005a, Akcigit, Celik, and Greenwood, 2013), it is only after the changes in the BEA accounting rules with the expansion of the definition of capital that the effects of IPP capital on the LS emerge from hideout. The 11th comprehensive revision of the NIPA in 1999 recognizes business and government expenditures for software as fixed investment. More recently, after the 14th comprehensive revision in 2013, the BEA now treats expenditures by business, government and nonprofit institutions serving households (NPISH) for R&D and expenditures by private enterprises for the creation of entertainment, literary and artistic originals (henceforth, artistic originals) as investments in various forms of durable capital and no longer, as previously done, as expenditures in intermediate nondurable goods (for the private sector) or as final consumption (for the government sector).[1] These two newly recognized forms

[1] Other components of the US Economic Accounts, such as the fixed assets tables (FAT) and the industry accounts, are also revised to recognize the newly capitalized IPP. We use the revised data in FAT and the industry

of investment (R&D and artistic originals), combined with software (recognized since 1999), form a class of intangible assets, the so-called IPP. This re-classification of capital implies an upward revision of all previous estimates of the private sector GDP which, as we show, mostly reflects the increase in the consumption of fixed capital generated by the higher depreciation of these new assets.[2] Overall, these revisions capture the increasingly important role of IPP in the US economy: The share of IPP in aggregate investment has increased from 8% in 1947 to 26% in 2013 (Figure 2); see also McGrattan and Prescott (2014).[3]

To investigate the effects of IPP capital on the LS dynamics, we turn to a simple one-sector investment model that isolates the effects of IPP capital on the gross rate of return to capital, the capital stock, and output — i.e., the elements of the capital share (and the LS). First, we construct from the revised fixed assets table (FAT) the value of the investment flows, the price of investment, and the depreciation rate of aggregate capital, which can be measured either with or without IPP capital directly from the data. Then, we compute two distinct measures of the capital stock, with and without IPP, by using two separate investment equations that differ in the investment flow, the price of investment, and the depreciation rate. Second, assuming that the net rate of return is the same across capital goods,[4] we construct two measures of the gross rate of return to capital (i.e., a function of the net rate of return, the price of investment, and the depreciation rate) with and without IPP. Third, with these distinct measures for the gross rate of return to capital, the capital stock, and output we construct a counterfactual LS that, within the context of the model, is net of all effects from IPP capital. This yields the main result of our paper.

The increase in IPP capital income over time accounts for — for any practical purpose — the entire secular decline in the LS that has started in the late 1940s. That is, the decline in the LS reflects an ongoing shift to a more IPP capital-intensive economy. The increasing investment in IPP significantly enhances aggregate capital depreciation — a combination of the new flow

accounts in this paper.

[2]Net IPP capital income was already incorporated in national accounts prior to these BEA revisions; that is, the measured output from proprietors and corporate firms using IPP capital (e.g., software or higher-quality and newer inputs developed through R&D) already included the net returns from the use of IPP (Fraumeni and Okubo, 2005). For example, Amazon's software engineers are constantly finding a more efficient way to organize production: what to order, at which price to sell and where to ship. The increase in sales and revenue from using newer versions of the in-house software is already present in the measured profit (BLS, 1989).

[3]This shift in aggregate investment toward IPP is of considerable size and does not show signs of deceleration. Excluding residential investment accentuates this shift: The investment in IPP grows from 11% of nonresidential aggregate investment by 1947 to 32% by 2013.

[4]The assumption of equal net return across capital goods has been previously used in Cooley and Prescott (1995) when they construct measures of the LS that included the capitalization of government capital and consumer durables. This assumption is innocuous for exploring the effects of IPP on LS as we find that the net return from the pre-1999 BEA revision data (i.e., without IPP capital) is very similar to the net return from the post-2013 revision data (i.e., with IPP capital).

of IPP capital and its higher depreciation rate — that accounts for almost two-thirds of the LS decline, while the net IPP capital income accounts for the remaining one-third of the LS decline. Further, the change in the price of investment accounted for by IPP capital is minor, and hence the direct effect of the price of investment on the US LS is negligible.[5] This finding is consistent with the IPP-free frameworks in Greenwood, Hercowitz, and Krusell (1997) and Krusell, Ohanian, Ríos-Rull, and Violante (2000) where a fall in the price of investment coexists with a trendless LS. In further decompositions, we find that while R&D capital is the largest contributor to the LS decline, the effects of software capital are significant and increasing since the late 1970s. In this direction, we show that the LS decline that starts in the late 1970s using the pre-2013 revision data, which has been the focus of the recent heated debate about the US LS decline, can be fully explained by the rise in software capital.

Our results are robust to the definition of the LS, in particular to restricting the analysis of the LS to the corporate sector which abstracts from the capital-labor partition of ambiguous income (e.g., proprietors' income). Further, by focusing on the corporate LS, we largely mitigate the concerns raised in Gomme and Rupert (2004, 2007) related to the measurement of the housing and government sectors. In the corporate sector, the LS starts declining only in the late 1970s, although at a faster rate than the aggregate LS, falling from 0.65 in 1980 to 0.56 in 2013; values that coincide with the updated data made available online by Karabarbounis and Neiman (2014a). Again, applying to the corporate sector the same methodology we have implemented on the entire economy, we find that IPP capital completely accounts for the decline in the corporate LS.[6]

At the industry level, there is also a strong and negative correlation between the LS and IPP capital intensity. Of the three industries whose output is expanding relative to the rest of the economy, the service and information industry, which combined account for 35% of total output in 2013, have experienced a substantial decline in LS and an increase in IPP capital intensity. In addition, the four major industries whose output share declines (i.e., manufacturing of durable and nondurable goods, retail trade and wholesale trade) also display a decline in LS and an increase in IPP capital intensity. In particular, for both durable and nondurable manufacturing,

[5] Importantly, while our result for the minor role of the price of investment in explaining the LS decline is strictly based on the US economy, Karabarbounis and Neiman (2014a) use cross-country variation in the LS dynamics and show that about half of the total global LS decline can be attributed to the fall in the price of investment. It is likely that these two mechanisms are complementary. The reason is that most countries (if not all) in the sample of these authors have a lower presence of IPP capital than the US and possibly even larger declines in LS than the US (e.g., Australia and Korea) suggesting that a combination of mechanisms (e.g., IPP capital and the price of investment) is likely to be needed in order to account for the full LS declines observed in a wide range of countries.

[6] Perhaps not surprisingly, our results for the entire economy when we explicitly exclude the housing and government sectors are largely consistent with the results for the corporate sector. The reason for this is the large increase in the time series of IPP capital income relative to housing and government capital income, see section 5.

which have experienced the largest declines in LS, the decline is largely due to the increase in IPP investment. Manufacturing would not have experienced any decline since the mid-1980s in the absence of IPP capital.

The rest of the paper is organized as follows. We introduce our definition of LS and discuss its behavior in the post- and pre-revision data in section 2. In section 3, we investigate the implications of IPP capital on the aggregate LS through its effects on investment, its price, and the depreciation rate, in the context of a one-sector investment model. Further, we study the separate role of the private and government sectors in section 4, explore the corporate LS in section 5, and present industry-level evidence in section 6. In section 7, we discuss implications of our results for the US model. We conclude in section 8.

2 The US Labor Share, 1947-2014

In this section, we construct the US LS and discuss its behavior. The LS is defined as one minus the ratio of capital income to output. The difference in alternative definitions of LS hinges on the way ambiguous income is treated – that is, income that cannot be unambiguously allocated to capital or labor (mainly, proprietors' income).[7]

2.1 Benchmark Labor Share

We use the standard definition of LS in growth and business cycle modeling from Cooley and Prescott (1995) which corresponds to the "economy-wide basis" measure proposed in Kravis (1959) and recently discussed in Elsby, Hobijn, and Sahin (2013). This way, to deal with the entries of income for which the attribution to either capital or labor is ambiguous, we attribute to capital income the same proportion of the ambiguous income as the proportion of unambiguous capital income to unambiguous income.[8] We apply this definition to the entire economy as a natural benchmark to study the factor distribution of income of the US aggregate economy.[9] More precisely, we define

[7] See Gollin (2002) for a comprehensive discussion of this issue, which is well known and needs no further belaboring on our part.

[8] This definition of LS is also used in Gomme and Rupert (2004, 2007) and in Ríos-Rull and Santaeulàlia-Llopis (2010). As in Ríos-Rull and Santaeulàlia-Llopis (2010), we do not include land, which we regard as inaccurately measured. Further, the flow of funds accounts, the original source for land capital and its rents, no longer publish the series, as also noted by Gomme and Rupert (2007). We can, however, add consumer durable goods to the computation of the LS, under the assumption of the same net rate of return to consumer durables as to othe forms of capital (see Cooley and Prescott (1995)). The results of our exercise do not change with this addition.

[9] Our choice of the LS for the entire economy is guided by the fact that this is the most widely used definition of LS in standard applications in macroeconomics, e.g., growth accounting, development accounting, and business cycle accounting. We study the behavior of the corporate LS in section 5.

1. Unambiguous Capital Income (UCI) = Rental Income + Corporate Profits + Net Interest + Current Surplus Government Enterprises
2. Unambiguous Income (UI) = UCI + Depreciation (DEP) + Compensation of Employees (CE)[10]
3. Proportion of Unambiguous Capital Income To Unambiguous Income: $\theta = \frac{\text{UCI+DEP}}{\text{UI}}$.
4. Ambiguous Income (AI) = Proprietors' Income + Taxes on Production − Subsidies + Business Current Transfers Payments + Statistical Discrepancy
5. Ambiguous Capital Income (ACI) = $\theta\times$ AI.

Then, capital income, Y_K, is computed as

$$Y_K = \text{UCI} + \text{DEP} + \text{ACI},$$

which we use to construct our benchmark LS as

$$\text{Labor Share} = 1 - \text{Capital Share} = 1 - \frac{Y_K}{Y},$$

where aggregate output, Y, is the gross national product (GNP), that is, the sum of total unambiguous and ambiguous income, i.e., $Y = \text{UCI} + \text{DEP} + \text{CE} + \text{AI} \equiv \text{GNP}$.

Panel (a) in Figure 1 shows the time series of the LS constructed from the post-2013 revision data. Clearly, it exhibits a relentless secular decline starting in the late 1940s. The LS begins at 0.678 in 1947 and reaches a historical low at 0.604 in 2013, implying a decline by 11% over the past 67 years.[11]

It is important to emphasize that the recent debate about the secular decline of the LS (e.g., Elsby, Hobijn, and Sahin (2013), Karabarbounis and Neiman (2014a), and Piketty and Zucman (2014)) has been motivated by pre-2013 revision data.[12] To assess the impact of the 2013 BEA

[10]While aggregate depreciation shows up as the consumption of fixed capital (CFC) in NIPA, our subsequent analysis is based on the depreciation of fixed assets (DEP) from FAT. We choose to do so, since FAT allow us to disaggregate depreciation by types of capital (i.e., structures, equipment, and IPP), which is important for the subsequent analysis. We have verified that the CFC from NIPA and DEP from FAT are almost identical. Moreover, an additional advantage of FAT data over NIPA is that the FAT provide industry-level series under the North American Industry Classification System (NAICS) throughout the entire sample period, whereas NIPA data split into the Standard Industrial Classification (SIC) and NAICS within the sample period. We return to this point in section 6.

[11]Our time-series LS data are available in this permanent link: US Factor Shares from KSZ.

[12]There are several remarks to be noted. First, Elsby, Hobijn, and Sahin (2013) focus on LS constructs provided by the Bureau of Labor Statistics (BLS), which we discuss in Appendix H. Second, Karabarbounis and Neiman

revision on the behavior of LS, we present our benchmark LS together with a measure of LS constructed using the pre-2013 revision data in panel (b) of Figure 1. Both of these measures of LS follow the same definition and, hence, the difference in their behaviors is entirely driven by the difference in the data inputs: our benchmark uses current post-2013 revision data while the alternative uses pre-2013 revision data.

Not surprisingly, the pre-2013 revision data deliver a LS similar to the "economy-wide basis" version studied in Elsby, Hobijn, and Sahin (2013) which shows a decline starting in the late 1970s. Comparing the pre- and post-revision LS, we first notice that the 2013 BEA revision shifts the LS down and brings forward the decline from the late 1970s to the late 1940s. Second, our benchmark LS exhibits a much stronger decline than its pre-revision equivalent. Precisely, with post-2013 revision data the LS declines from 0.678 in 1947 to 0.604 in 2013, while with pre-2013 revision data the LS declines from 0.685 in 1947 to 0.637 in 2013. Similarly, simply fitting a linear time trend to our post-2013 LS yields a secular decline of 7.2 percentage points, while this figure is 4.4 percentage points using pre-2013 revision data. That is, the post-2013 revision data imply a LS decline that almost doubles the decline previously studied in the literature.

2.2 The Effects of IPP Depreciation on Labor Share

We have seen in the last section that the BEA has recently revised the data in a way that produces a much prolonged decline in the LS. Going through each of the components of national income before and after the 2013 revision — panels (a), (b) and (c) of Figure 3, we find that the effect of the revision has been concentrated on one single entry, the aggregate depreciation. As a matter of fact, the upward revision of the aggregate depreciation is almost as much as the upward revision the GNP received.[13]

This suggests a simple two-step exercise. First, if we could remove from the aggregate depreciation the part coming from R&D and artistical originals added by the 2013 revision (and this implies removing this depreciation from both capital income and output in the computation of the LS), then we should be able to construct a LS similar to that implied in the pre-revision

(2014a) focus on the corporate LS — see our discussion in section 5 — although these authors also provide estimates for the aggregate economy using national income data and Penn World Tables data. Third, while our analysis, as in Elsby, Hobijn, and Sahin (2013) and Karabarbounis and Neiman (2014a), focuses on the gross LS, Piketty and Zucman (2014) study the decline of the net LS. Piketty and Zucman (2014) construct a LS for the US that starts at the level of 0.80 in 1974 and decreases to 0.71 in 2010. For that sample period, our benchmark LS declines from 0.67 to 0.61. The larger LS decline found by these authors is most likely due to the difference in the data sources, in particular, as argued in Bonnet, Bono, Chapelle, and Wasmer (2014), to the use of market prices for housing capital. Instead, our LS construct is strictly based on BEA national income data.

[13] See also online Appendix B for the item-by-item effects on the LS due to each component of national income before and after the 2013 BEA revision.

data. Second, if we further remove the part of aggregate depreciation coming from the software, we should have a first glimpse of how the recognition of the IPP capital has impacted the LS measure. Thanks to the FAT, we are able to carry out this exercise using the disaggregated depreciation data by types of capital. The FAT provides the depreciation of the IPP as well as that of each of its components: software, R&D, and artistic originals.[14] We simply subtract the depreciation from the relevant type of IPP from the post-revision aggregate depreciation and revise the GNP down by an equal amount in computing the counterfactual LS.

Indeed, a simple removal of the depreciation from R&D and artistic originals almost reproduces the pre-revision LS (i.e. the magenta line labeled "Without Non-Software IPP Dep." in Figure 4).[15] Figure 4 further shows the LS after removing the full IPP depreciation (i.e. the orange line labeled "Without IPP Depreciation"). The magnitude of the decline of the LS is greatly reduced. While the benchmark LS shows a linear decline of 7.3 percentage points, the LS without IPP depreciation registers a decline of 3.3 percentage points, or a 55% reduction of decline over the entire sample period.

The merit of doing this exercise is that we can directly use national income data, i.e., depreciation by type of capital, provided by the BEA to net out the effects of IPP on the LS through IPP depreciation. However, IPP capital has further effects, in addition to those from depreciation, that come through net capital income (e.g., the increases in profitability from the improvements in organizational efficiency due to the use of a specific software). These effects of IPP on net capital income are and were already present in national accounts before the 1999 and the 2013 revisions (see Fraumeni and Okubo (2005)). That is, the BEA revisions that capitalize IPP mainly correct upward the measure of capital income through the incorporation of IPP capital depreciation in national accounts. Unfortunately, BEA does not provide a separate IPP account that we can use to disentangle how much of the net capital income is generated by IPP capital. To this end, in the next section we provide an alternative methodology to assess the full effects of IPP capital on the LS using a standard investment model as an accounting device in which IPP capital directly affects the gross rate of return, the capital-output ratio, and hence the LS.

3 The Effects of IPP Capital on the Labor Share

While IPP depreciation alone goes a long way in explaining the LS decline, there are further effects of IPP capital that come through net capital income (e.g., the increase in output derived from IPP use). To study this, we introduce a simple one-sector model and decompose the total

[14] See Table 2.4 in FAT for private fixed assets and Table 7.3 for government fixed assets.

[15] From 1975 to 2013, the LS without non-software IPP depreciation declines by 4.85 percentage points, while the pre-revision LS declines by 5.05 percentage points.

effect of IPP capital on the LS into several channels: the price of investment, the depreciation rate, and the investment flows. We are able to separately identify the effect of IPP capital on these variables directly from the data thanks to the investment, its price, depreciation, and the capital stock by types of capital available from the FAT.

3.1 A One-Sector Investment Model

Consider a competitive-markets environment with one sector and one good produced with an aggregate production function with two inputs, capital k_t and labor l_t: $f(k_t, l_t; \Omega_t)$.[16] The production function is assumed to be constant returns to scale (CRS), and Ω_t are possibly time-varying technological parameters. Note that we do not impose restrictions on the elasticity of substitution between capital and labor, although in order to capture LS dynamics we require f to move away from a Cobb-Douglas form with constant coefficients.The investment i_t, measured in consumption good units, can be converted via a linear technology into a capital good x_t usable in production,

$$x_t = v_t i_t, \tag{1}$$

where the investment-specific technical change (ISTC) – that is, v_t – is the inverse of the relative price of investment, $p_t = \frac{1}{v_t}$.[17] Both i_t and v_t capture changes in the composition of structures, equipment, and IPP investment. The law of motion of capital, in efficiency units k_t^x, is then

$$k_{t+1}^x = x_t + (1 - \delta_t) k_t^x, \tag{2}$$

where δ_t is the depreciation rate of k_t^x for the composite of structures, equipment, and IPP capital. Aggregate capital, k_t^x, therefore, depends on the investment flow, i_t, its relative price, $\frac{1}{v_t}$, and the depreciation rate, δ_t. Note that the depreciation rate is allowed to change with time because the composition of aggregate capital also changes, particularly between IPP and non-IPP capital.

Let the net return to capital, or the interest rate, be denoted as r_t and the gross return to capital, or the marginal product of capital, be denoted as R_t. The intertemporal investment

[16] We provide an analogous three-sector model in online Appendix F where structures, equipment, and IPP capital are treated as separate capital goods. Our results under that framework are similar to those obtained with the one-sector model studied in this section.

[17] As in Greenwood, Hercowitz, and Krusell (1997) and Fisher (2006), we identify ISTC as the inverse of the relative price of investment. Under competitive markets, the relative price of investment in terms of consumption is $\frac{1}{v_t}$; that is, the price reflects quality. Under noncompetitive markets, however, the price will reflect both quality and sources of inefficiency such as markups or barriers to technology (or, more generally, investment wedges); see Restuccia and Urrutia (2001), Hsieh and Klenow (2007) and McGrattan and Prescott (2010). Even though here we do not distinguish ISTC from investment wedges, if the effects of IPP capital on LS via the relative price of investment are minor, as we find is the case, so will be the effects via ISTC and investment wedges.

decision of the firm implies that[18]

$$R_{t+1} \equiv \frac{\partial f(k_{t+1}, l_{t+1})}{\partial k} = \frac{1}{v_t}(1 + r_{t+1}) - \frac{1}{v_{t+1}}(1 - \delta_{t+1}). \tag{3}$$

Under the assumption that the net return to capital is identical across IPP and non-IPP capital goods, the effects of IPP capital on the gross return to capital, R_t, come through v_t and δ_t.

The effects of IPP capital on the LS,

$$LS_t = 1 - \frac{R_t k_t^x}{y_t}, \tag{4}$$

are due to its effects on the following:

1. The price of investment, $\frac{1}{v_t}$, that affects the LS indirectly through the accumulation of capital, k_t^x, in (2) and directly through the rate of return, R_t, in (3).
2. The depreciation rate, δ_t, that affects the LS indirectly through the accumulation of capital, k_t^x, in (2), and directly through the rate of return, R_t, in (3).
3. Investment, i_t, that affects the LS through its effects on capital accumulation, k_t^x, in (2).

Finally, every change in capital income, $R_t k_t^x$, implies an identical change in output, y_t.

This model allows us to do two things. First, we can measure the full effects of IPP capital on the LS through its effects on v_t, δ_t, and i_t. Second, we can decompose the effects of IPP capital in two different ways: by exploring each of the three determinants (v_t, δ_t, and i_t) in isolation or by exploring the gross rate of return, R_t, and the capital-output ratio separately.

3.2 The Effects of IPP on Aggregate Investment, Its Price, and Depreciation Rate

In this section, we describe the construction of the three determinants of the LS, v_t, δ_t. and i_t, separately with and without IPP capital.

3.2.1 The Price of Investment

First, we construct a time series for the price of aggregate capital accounting for the differences in the price of investment in structures, equipment, and IPP.

[18] Writing the Bellman equation of the firm as $V(k) = \max_{k',l} f(k,l) - wl - \frac{k'-(1-\delta')k}{v} + \frac{1}{1+r'}V(k')$, then the first order condition (FOC) implies that $\frac{1}{v} = \frac{1}{1+r'}V'(k')$. By taking the derivative of the value function with respect to k, updating one period, and combining it with the FOC, we obtain (3).

The construction of the price of investment, P_t^I, closely follows Ríos-Rull, Schorfheide, Fuentes-Albero, Kryshko, and Santaeulàlia-Llopis (2012). P_t^I is built as a Törnqvist aggregate of the price index of structures (ST), equipment (EQ), and IPP investment with the shares of each type defined as[19]

$$s_t^j = \frac{P_t^{I,j} Inv_t^j}{\sum_j P_t^{I,j} Inv_t^j}, \text{ where } j = ST, EQ, IPP, \tag{6}$$

where our measure of aggregate investment includes private and government accounts and both residential and nonresidential investment.[20] Panel (a) of Figure 5 plots the series i_t with and without IPP investment together with their ratio. The series with IPP grows faster than the one without IPP. The two series start at similar levels in the late 1940s but by the end of the sample period, the one with IPP is about 36% higher than the one without IPP.

To compute the investment price growth let $\lambda(x_t) = \frac{x_t}{x_{t-1}} - 1$. Then,

$$\lambda(P_t^I) = \left(\frac{s_t^{ST} + s_{t-1}^{ST}}{2}\right)\lambda(P_t^{I,ST}) + \left(\frac{s_t^{EQ} + s_{t-1}^{EQ}}{2}\right)\lambda(P_t^{I,EQ}) + \left(\frac{s_t^{IPP} + s_{t-1}^{IPP}}{2}\right)\lambda(P_t^{I,IPP}).$$

The level of the price index for total investment can be recovered recursively,

$$P_t^I = P_{t-1}^I[1 + \lambda(P_t^I)],$$

with P_0^I=1. Let the price index of consumption be P_t^C.[21] The relative price of investment is then defined as

$$p_t = \frac{P_t^I}{P_t^C},$$

[19]The Törnqvist price index specifies, for a variety of components indexed by j,

$$\frac{P_t^I}{P_{t-1}^I} = \Pi_j \left(\frac{P_t^{I,j}}{P_{t-1}^{I,j}}\right)^{\frac{1}{2}\left[s_t^j + s_{t-1}^j\right]}, \tag{5}$$

where s_t^j is the share of the value of the variety j.

[20]The construction of Inv_t^j and $P_t^{I,j}$ for $j = ST, EQ, IPP$ is described in online Appendix A.1.5 including a description of the subcategories of investment that structures, equipment and IPP incorporate. As previously discussed, the 1999 BEA revision already incorporated software into equipment capital. Indeed, under such capital taxonomy, Cummins and Violante (2002) correct the series for the price of investment provided by BEA in order to adjust for the quality of capital. Here, instead, we use the post 2013 BEA revision data that separately measures the software prices and the prices of other IPP components; see further details on data sources in online Appendix A and description of these inputs in online Appendix C.

[21]The construction of P_t^C is discussed in online Appendix A.1.5. Note that to make the model consistent with the data, we set the price of structures, $P_t^{I,ST}$, to be equal to the price of consumption, P_t^C.

whose inverse, $p_t = \frac{1}{v_t}$, is ISTC.

We compare the price series p_t that accounts for the three kinds of capital with the series that includes only structures and equipment. They are shown, together with their ratio, in panel (b) of Figure 5. Both series have declined since the 1950s, dropping from an initial level of 1.00 in 1947 to about 0.60 in 2013. The relative price of investment with IPP is slightly lower than the one without IPP. The ratio between the former and the latter is around 0.995 in the 1960s and between 0.97 and 0.98 since the late 1980s. Altogether, the effect of IPP capital on the price of investment seems rather minor compared with the effect of IPP capital on aggregate investment. In other words, the fall in the price of investment is largely driven by investment in equipment and not in IPP.[22]

3.2.2 Depreciation Rate

We compute the aggregate capital depreciation rate with IPP as $\delta = s_{K_{ST}}\delta_{ST} + s_{K_{EQ}}\delta_{EQ} + s_{K_{IPP}}\delta_{IPP}$, where $\delta_j = \frac{DEP_{K_j}}{K_j}$ and $s_{K_j} = \frac{K_j}{\sum_j K_j}$. The depreciation rate without IPP is computed similarly excluding δ_{IPP}.[23] The difference between depreciation rates with and without IPP is shown in panel (c) of Figure 5. The series with IPP is uniformly higher than the series without IPP and visibly accelerates in the 1980s. The series with IPP starts at 4% in 1947 and ends at 5.2% in 2013, compared with an increase from 3.7% to 3.9% for the series without IPP.

The depreciation rate in capital structures averages 2.2% per year during our sample period. The depreciation rate of equipment is around 12% per year from 1947 to 1982 and rises slightly to 13% per year by the end of the period. The depreciation rate of IPP is much higher and grows over time. It starts at 15% per year and grows to 21.4%.[24] The high depreciation rate of IPP reflects the higher rate at which IPP capital becomes obsolete.

[22] For further analysis see the discussion of panels (a) and (b) of Figure C-1 in online Appendix C.

[23] The net capital stock by types of capital is from FAT 1.1 and the depreciation of fixed assets by types of capital is from FAT 1.3. See online Appendix A.1.3.

[24] See panel (a) of Figure C-2 in the online Appendix. Clearly, software is the IPP capital with the largest depreciation rate, starting around 0.30 in the early 1960s and reaching to an average of 0.34 in the 2000s. R&D capital depreciation is roughly around 0.17 since the 1970s. The lowest depreciation rate is for artistic originals capital with an average around 0.14 since the 1970s; see panel (b) of Figure C-2 in the online Appendix. Further, note that while R&D accounts for around 80% of total IPP investment in the early 1960s, this share declines to a steady 50% in the 2000s; see panel (a) of Figure C-3 in the online Appendix. In contrast, the share of software investment in IPP increases from an average of 4% in the 1960s to a steady average of 40% since the 2000s. Artistic originals account for about 10% throughout the entire sample. That is, it is the increasing importance of software capital that causes the upward trend in IPP depreciation.

3.3 The Total Effects of IPP Capital on the Labor Share

In this section, we use our one-sector model to compute the full effects of IPP capital on the LS. To measure the full effects of IPP capital on the LS we use the definition in (4) and construct a counterfactual LS without IPP capital from our one-sector model. First, from the post-revision data, we construct the aggregate investment, the price of investment, and the depreciation rate as detailed in section 3.2. With this in hand, we use the law of motion of capital in (1) and (2) to build the aggregate capital series, k_t^x. Then, given the LS computed in section 2 using post-revision data, we recover the gross return R_t from (4) and the net return r_t as the only unknown in (3). The net return to capital r_t is set to be the same across all types of capital, an assumption that we maintain throughout.[25,26] Second, we construct the IPP-free gross return by combining v_t without IPP, δ_t without IPP, and investment without IPP.[27] Then, we build the aggregate capital stock net of IPP by using the perpetual inventory method as for the one with IPP. The product of IPP-free gross return and capital is our measure of capital income without IPP. Finally, to construct the counterfactual LS without IPP capital, we further adjust total output by the absolute change in capital income due to IPP.

Our main result is shown in Figure 6. There we plot LS with IPP capital – that is, our benchmark LS from the post-revision data described in section 2 – and the counterfactual LS without IPP capital computed here. In striking contrast to the post-revision LS (blue line), the LS without IPP (orange line) is basically trendless over the past 65 years; the respective linear trends plotted in Figure 6 are for the 1947-2010 period. If we fit a linear trend to the LS without IPP from 1947 to any endpoint between 2008 and 2012, the estimated trend is not significantly different from zero.[28] By adding the value for 2013, the year in which LS reaches its minimum, the estimated trend remains quantitatively negligible.[29,30]

To assess the evolution of capital intensity, we decompose the capital share of income into that generated by structures, by equipment, and by IPP in Figure 7. Consistently with our main

[25] Given that k_t^x, v_t, and δ_t are constructed with post-revision data and with IPP, then the computed LS from equation (4) must be, by construction, identical to the post-revision LS in section 2.1.

[26] As a matter of fact, the net rate of return, r_t, that we infer from (3) is remarkably invariant to whether we use the pre-1999 BEA revision data (which does not include IPP capital), or the pre-2013 revision data (which does not include non-software IPP capital) or the post-2013 revision data (which includes IPP capital). Thus, the assumption of constant r_t across capital types seems innocuous.

[27] We use the same initial value for both aggregate composites of capital with and without IPP.

[28] Precisely, a linear trend from 1947 to 2008, at the onset of the Great Recession, yields a nonsignificant slope of -0.000401; a linear trend from 1947 to 2012 yields a negative but nonsignificant slope of -0.001454.

[29] The estimated linear trend from 1947 to 2013 is -0.0018 with a standard error of 0.00084 in 10-year averages. This implies an estimated value of 0.685 in 1947 and 0.673 in 2013, that is, merely a 1 LS point decline.

[30] In Appendix E, we extend our analysis to the historical sample period 1929-2013 for which national income data are available and reach the very same result that removing IPP capital generates a trendless LS.

result, the capital share of IPP is the one that explains the secular rise in the capital share of income by linearly increasing from 1% in the late 1940s to 8% in 2013. That is, the US economy is becoming increasingly more IPP capital-intensive over time.[31] In contrast, the capital share of equipment remains steady at 10%, and the capital share of structures remains relatively trendless at 21% through the entire sample period with a slight rebound up by 4-5 LS percentage points in the 2000s — which helps explain the acceleration of the LS decline in the last fifteen years.

To externally validate our counterfactual exercise, in panel (a) of Figure 8 we plot the above LS without IPP against the LS computed from the vintage BEA data released in 1998 (i.e., before IPP investment made it to national accounts) available at the Archives Library of the St. Louis FED, and the LS computed in Gomme and Greenwood (1995) who also implemented a definition of LS similar to ours using data before software entered the national accounts as investment.[32] The results are straightforward. Our counterfactual LS that removes IPP capital from the current BEA data aligns very well with the LS series from vintage data that do not incorporate IPP capital. All three series without IPP capital suggest a trendless LS, pointing to IPP as the main source of the decline of the LS.

Finally, to put our analysis in the context of the most recent debate of the decline, which is motivated by the pre-2013 revision data, we ask if incorporating software capital alone accounts for the decline of US LS in the pre-2013 revision data. The answer is yes. To see this, we start from the series of investment, price of investment and depreciation rate, all net of IPP, which we used to make our main argument, and add to them the effect from including software capital. This produces the green line in panel (b) of Figure 8 and note that this green line is virtually identical to the actual LS implied by the pre-2013 revision data (i.e. the magenta line in panel (b) of Figure 8). Analogously, if we took the pre-2013 revision data — invariably used in previous literature to document and explain the decline of the US LS — and removed the effects from software capital in those data, we would obtain a trendless LS (i.e. the orange line that purges national income from IPP capital).

To summarize, using a simple investment model we have shown strong evidence that the observed decline of the LS is driven by IPP capital. That is, the US economy grows more IPP capital-intensive over time and this generates the LS decline.[33]

[31] Our time-series data of the capital share attributed to each type of capital are available in this permanent link: US Factor Shares from KSZ.

[32] We would like to thank Paul Gomme for sharing their vintage data with us.

[33] We further note that large and persistent cyclical fluctuations of LS, however, survive our scrutiny of IPP capital and call for a theory. That is, simple visual inspection of Figure 6 suggests that IPP capital does not change the cyclical properties of the LS. Hence, while IPP capital can explain the secular decline of LS, the cyclical behavior of LS does not seem much altered by it and remains unexplained; see a recent discussion in Koh and Santaeulàlia-Llopis (2014).

3.4 A Decomposition of Total Effects: Prices, Depreciation, and Investment

For a further investigation of the effects of IPP on LS, we also provide decomposition exercises through v_t, δ_t, and capital accumulation. We describe several decomposition exercises in Figure 9. The first exercise aims at reproducing the findings of section 2.2, where we remove the IPP depreciation, within our accounting framework. Note that from (3), we can express the capital income $R_t k_t^x$ as

$$R_t k_t^x = \left(\frac{1+r_t}{v_{t-1}} - \frac{1}{v_t} \right) k_t^x + \frac{1}{v_t} \delta_t k_t^x = \left(\frac{1+r_t}{v_{t-1}} - \frac{1}{v_t} \right) k_t^x + DEP.$$

where $\left(\frac{1+r_t}{v_{t-1}} - \frac{1}{v_t} \right) k_t^x$ is net capital income and DEP is depreciation. We use the post-revision data to compute $\frac{1}{v_t} \delta_t k_t^x$ without IPP. That is we replace DEP in the above equation with the aggregate depreciation without IPP and keep all other components at their post-revision values. The resulting LS is shown as the green line in panel (a) of Figure 9. The trend of this LS accounts for roughly two-thirds of the total decline, a magnitude comparable to the effect of removing the effect of IPP depreciation on the decline of the LS shown in section 2.2 (see Figure 4). The remaining one-third of the decline is accounted for by the IPP capital income net of depreciation.

In the second experiment, we begin with the trendless LS without IPP and cumulatively add back the effects of IPP on the price of investment, the depreciation rate and the investment flow (panel (b) of Figure 9). If we replace the price of investment without IPP with the price of investment with IPP in the construction of the IPP-free LS, the resulting LS largely overlaps with the IPP-free LS (see the purple line label "+ Inv. Price with IPP"). This implies that the changes in the price of investment induced by the IPP capital, and hence also the fall in the price of investment that is largely driven by equipment (see section 3.2.1), play a minor role in accounting for the LS decline, a result that resembles that of Elsby, Hobijn, and Sahin (2013) for the US.[34] If we further replace the depreciation rate without IPP by the depreciation rate with IPP, we obtain the green line labeled "+ Dep. Rate with IPP". The effect of IPP capital through the depreciation rate is also quite limited. Finally, we replace the investment series without IPP by the aggregate investment with IPP. This brings us back to the LS with the full impact of IPP as computed from the post-revision data. That is, it is the increase in aggregate investment due to the incorporation of IPP that generates the LS decline.

In the theoretical derivation of section 3.1, we identify a direct and indirect channel through which the price of investment and the depreciation rate incorporating IPP can affect the LS (panel

[34] Without restricting the analysis to the US, the fall in the price of investment can have important implications in explaining the global decline of the LS, see Karabarbounis and Neiman (2014a).

(c) and (d) of Figure 9). Panel (c) of Figure 9 shows that the price of investment incorporating IPP has almost no effect on the LS, either directly, through the gross rate of return or, indirectly, through capital accumulation. Surprisingly, panel (d) of Figure 9 shows a small effect of the depreciation rate with IPP on the LS as well. This result masks two competing effects: (i) A higher depreciation rate increases the gross rate of return, R_t, which tends to increase capital income for a given capital stock, hence reducing the LS (see the purple line labeled "+ Dep. Rate with IPP (Through R)"). (ii) A higher depreciation rate also reduces the accumulation of capital, which decreases capital income for a given rate of return, thereby increasing the LS (see the green line labeled "+Dep. Rate with IPP (Through Cap. Accum.)"). The two effects turn out to be offsetting, leaving the LS only slightly increased, if changed at all, from the reference level.

We have shown that, overall, the increased rate of capital accumulation due to IPP investment is the dominating force behind the LS decline, while the increased rate of depreciation or the reduced price of investment plays lesser roles.[35] To highlight the contribution of IPP to aggregate capital accumulation, Figure 10 plots three ratios: the capital stock with IPP to the one without IPP,[36] the output with IPP to the one without IPP, and the capital-output ratio with IPP to the one without IPP, normalizing all ratios to 1 in 1947. Between 1947 and 2013, IPP capital raises the aggregate capital stock by 12% and the capital-output ratio by 8% by 2013, which explains the LS decline – that is, IPP capital implies an increased aggregate capital that is roughly three times larger than the implied increase in output. That is, the LS decline simply reflects the fact that the US is undergoing a process of IPP capital-deepening and the revised data take this into account. We discuss this assessment further in section 7.

3.5 The Role of Software, R&D, and Artistic Originals Capital on Labor Share

Here, we further examine the components of IPP in the BEA accounts: software, R&D, and artistic originals. The investment share in IPP associated with R&D has decreased from 84% in the early 1960s to 50% in the late 1990s, while the investment share associated with software started to increase from null in the early 1960s to 40% in the late 1990s (see panel (a) of Figure 11). Interestingly, since the late 1990s the shares of R&D and software have remained steady throughout the 2000s. The remaining 10% of IPP investment is attributed to artistic originals.

The contribution of each of these three categories of capital to the LS decline is illustrated

[35] As the effects of IPP capital on the gross rate of return, R_t, work through the the depreciation rate and the the price of investment, we find that IPP does not change R_t in a significant manner – precisely, only a 2% increase from 1947 to 2013.

[36] This capital series are divided by v_t so that capital and output are in the same consumption good units.

in panel (b) of Figure 11.[37] Starting from the LS without IPP (the orange line), we replace the time series of investment, its price, and depreciation rate without IPP with their counterparts including only artistic originals. This produces the purple line labeled "+ artistic originals". The inclusion of the artistic originals component has little effect on the behavior of LS. However, including R&D in a similar fashion produces a larger decline in LS (the green line in the same figure), which accounts for about two-thirds of the total decline by 2013. The gap between the green line and the post-revision blue line is accounted for by adding the software component of the IPP.

Panel (c) of Figure 11 plots the change in LS upon the inclusion of each component separately. The total decline in the LS due to IPP capital is depicted by a continuous downward trend that registers a drop of about 5 LS points by 2010 (see the magenta line in panel (c) of Figure 11). Of the three IPP components, the effect from the capital of R&D is the largest. R&D alone generates 87% of the total LS decline generated by IPP capital until 1965. After that year, the role of R&D slowly diminishes and is gradually replaced by that of software: R&D accounts for 73% of the decline in the 1970s, 71% in the 1980s, 65% in the 1990s, and 57% of the decline in the 2000s. Meanwhile, due to the acceleration of the investment share of software since the 1960s, the share of the LS decline accounted for by software has increased to almost 30% in the 2000s.

4 The Effects of Government IPP Capital on Labor Share

This section examines the role of the private and government sectors separately. We start by showing the importance of private and government IPP in aggregate investment in panel (a) of Figure 12. Both private and government IPP investments slowly rise from the late 1940s to the mid-1960s, although this share always remains below 10% for both sectors. However, since the mid-1980s, the private IPP investment accelerates to reach 20% of aggregate investment by 2013, while the government IPP investment remains somewhat steady around 6%.[38]

[37] To conduct this exercise, note that the private fixed investment by type of IPP is available from NIPA Table 5.3.5 and the government investment from NIPA Table 3.9.5. The price of investment by type of IPP is from NIPA Table 5.3.4. Net stock of capital and the depreciation of fixed assets by type of IPP are available from Table 2.1 and 2.4 for private sector and 7.1 and 7.3 for government in FAT.

[38] That is, while the private and government sector show roughly an equal share of IPP investment until the late 1960s, the share of IPP investment in the private sector is 3.3 times larger than in the government sector by 2013. However, note that within sectors IPP contributes to 25% of total private investment and 32% of total government investment. The increase in the private IPP share of aggregate investment is due to a continuous increase in private R&D and a fast increase in private software, both reaching around 9% of aggregate investment by 2013 (panel (a) of Figure C-5 in the online Appendix). Instead, the government R&D share of aggregate investment decreases from 8% in mid-1960s to 5% in the early 2010s and the government software still remains below 1.2%.

As shown in panel (b) of Figure 12, removing the IPP capital in the private sector (analogous to section 3.3 for the entire economy), we find that the LS decline is largely alleviated. That is, the reduction in the LS that comes from the private sector only is given by the distance between the blue line and the green line in that panel. We present this reduction as a percentage of the total decline in the LS in panel (c) of Figure 12. The capital of private IPP investment accounts for an increasingly large fraction of the decline in the LS since the mid-1960s. In 2000, about 73% of the decline in LS is due to the capital of the private sector IPP alone.

5 The Corporate Sector

There are at least two motivations for investigating the LS in the corporate sector only.[39] Firstly, by focusing on the corporate sector, we purge ambiguous income from the computation of the LS (i.e., there is no proprietors' income), see the discussion in Karabarbounis and Neiman (2014a).[40] Secondly, the corporate sector does not include either the housing sector or the government sector, where the measurement of LS is subject to criticism (Gomme and Rupert, 2004, 2007).[41]

The corporate LS is shown in panel (a) of Figure 13.[42,43] This LS remains steady around a value of 0.63 from the late 1940s to the late 1970s and, as noted by Karabarbounis and Neiman (2014a), it exhibits a decline from 0.63 in 1975 to 0.56 in 2013, with an accelerated decline starting in the early 2000s.[44] Further, analogous to section 2.2, removing IPP depreciation also removes about 43% of the LS decline that occurred between 1975 and 2013. Note that the corporate sector fixed investment consists of private nonresidential fixed investment and assets.[45]

Panel (b) of Figure 13 shows the investment share of structures, equipment, and IPP in the corporate sector. The share of investment in structures declines from around 35% in the late

[39]The corporate sector represents 55% of GNI in 1948 and 65% in 2013. It increases to 71% in the early 1980s and decreases to 65% in the 2000s.

[40]See also earlier treatments of the corporate LS in Boldrin and Peralta-Alva (2009) (among others).

[41]See Appendix G for an analysis of the housing and government sectors for the entire economy.

[42]We compute the corporate LS by dividing the compensation of employees (i.e., the income accruing to employees, such as wages, salaries, employers' contributions for social insurance, and other labor income) by the gross value added, which consists of the consumption of fixed capital, compensation of employees, taxes on production and imports less subsidies, and net operating surplus, and, in turn, net operating surplus consists of net interest and miscellaneous payments, business current transfer payments, and corporate profits.

[43]Here we focus on the joint LS behavior of financial and nonfinancial corporate businesses. See online Appendix A.3 for data sources and construction. The LS behavior of the entire corporate sector and the nonfinancial corporate sector are similar because the financial corporate sector is relatively small. The gross value added of the financial corporate sector accounts for 4% of the corporate gross value added; this proportion slowly increases to 12% toward the end of the sample.

[44]Our corporate LS is identical to the updated LS data supplied by Karabarbounis and Neiman (2014a) for the subperiod 1975 to 2012 (i.e., the green line in panel (a) of Figure 13).

[45]That is, the corporate sector does not include components associated with residential investment and/or government investment. It also excludes non-corporate private investment.

1940s to a somewhat steady 20% since the late 1990s. Equipment investment accounts for a steady 53% of total investment until the late 1990s, after which it starts to decline, reaching 46% in 2013. This change is explained by an increase in the share of IPP investment from 9% in the late 1940s to 27% in the late 1990s, reaching 33% in 2013. The IPP figures are larger for the corporate sector than for the entire economy, suggesting a larger IPP capital intensity in the corporate sector.[46]

The FAT decompose the fixed assets (and their depreciation) of the corporate sector into structures, equipment, and IPP (see online Appendix A.3). This allows us to assess the effects of IPP capital on corporate sector LS in a one-sector model analogous to section 3.3. The investment prices are those for the entire economy already computed in section 3.2. The results from the counterfactual exercise of removing IPP capital are shown in panel (c) of Figure 13. The IPP capital completely explains the LS decline in the corporate sector. The counterfactual LS (orange line in panel (c) of Figure 13) without IPP capital displays no visible trend after 1975.[47]

To summarize, as for the entire economy, the decline of the corporate sector LS is accounted for by IPP capital.[48] Further, a decomposition analogous to section 3.4 reveals that the flow of IPP investment plays the major quantitative role, while the price of investment and the depreciation rate do not contribute much to the LS decline in Corporate America (panel (d) of Figure 13).

Interestingly, although perhaps not surprisingly, the behavior of the corporate LS resembles the 'asset-basis' LS measure from the Major Sector Multifactor Productivity division at the BLS. This is due to the fact that the BLS uses the return to capital from the corporate sector to impute the capital income attributed to the ambiguous entries of national income.[49] In this context, our results suggest that the nature of the acceleration of the decline of the corporate (or the 'asset-basis') LS since the early 2000s (Elsby, Hobijn, and Sahin, 2013) is not secular. This recent decline does not represent a break from a secular trend as the corporate LS is secularly trendless without IPP.[50] Instead, without IPP the corporate LS peaked (above its secular average) in 2001, and its decline thereafter is more likely to be of cyclical (or medium-run) nature.

[46] Part of the reason of this observation is that the corporate sector does not include residential investment. See Figure C-4 in the online Appendix for a decomposition of investment shares for the aggregate economy without residential investment.

[47] If at all, LS seems to slightly increase by 2 LS points from the late 1940s to the mid-1970s.

[48] We also decompose the capital share in structures, equipment and IPP for the corporate sector in online Appendix D. Consistent with our results for the aggregate economy, while capital share of structures in the corporate sector decreases from 24% in 1947 to 13% in 2000, it also rebounds up by 5 LS percentage points from the beginning of the 2000s, which contributes to accelerate the LS decline in the 2000s.

[49] The time series of the 'asset-basis' LS from BLS practically overlaps with the corporate LS from BEA, see Appendix H.

[50] Formally, we have computed standard Bai-Perron tests and found that they do not pick any sign of structural change for the counterfactual LS without IPP capital from 1975 to 2013.

6 IPP Capital and Labor Share by Industry

In this section, we investigate which industries are becoming more intense in IPP capital and whether the decline of LS at the industry level can be explained by industry-wide IPP capital intensity.

To start, we plot the output shares of 12 main industries from 1947 to 2013 in Figure 14.[51] Of all industries, only services, information, and FIRE (finance, insurance, real estate, rental and leasing) are growing relative to other industries, so their output shares increase, see panel (a) of Figure 14. The fastest-growing industry is services which starts at 13.1% of the total output in 1947 and grows to 30%, almost a threefold factor, by 2013. FIRE also shows an important increase in output share from around 12% in 1947 to 22.6%, almost a twofold factor, in 2013. Information starts low, around 3.2% and increases by about a 1.5-fold reaching an output share that is still small, 5.5%, compared with the other growing industries. The output shares of industries that stagnate or decline are found in panel (b) of Figure 14. The industry with the largest decline is clearly manufacturing. The durable goods manufacturing share of output drops from nearly 18% in the early 1950s to 7.6% in 2013, and the nondurable goods manufacturing share of output drops from 14.3% in 1947 to 6.9% in 2013. In relative terms, it is also important to note the drop in the agricultural share of output from 9.3% in 1947 to 1.4% in 2013. In short, output is moving to services, FIRE and information, and the industries with stagnant or decreasing output shares by 2013 that still represent a large share of output are manufacturing (in durables and nondurables), retail trade, and wholesale trade.

We start by showing the evolution of structures, equipment and IPP investment shares for 12 main (i.e., 2 digit NAICS) industries. Figure 15 shows the industries with high IPP investment. Information and (durables and nondurables) manufacturing are the industries with the largest shares of IPP investment. For these industries, the IPP investment accounts for 60% of the industry-specific aggregate investment in 2013, representing the largest type of investment. For the information industry, the IPP investment starts at 30% of total investment in the late 1940s and remains steady until the mid-1970s, after which it starts to linearly increase to 60% in 2013. The IPP share in the investment of durables manufacturing starts at 20% in the late 1940s and

[51] We recognize 12 main industries, 11 of which correspond to the 2-digit North American Industry Classification System (NAICS) codes: agricultural, forestry, fishing and hunting, mining, utilities, construction, durable goods manufacturing, nondurable goods manufacturing, wholesale trade, retail trade, transportation and warehousing, information, and finance, insurance, real estate, rental and leasing. We additionally construct services as the twelfth industry, which includes the following set of 2-digit NAICS code industries: professional and business services, educational services, health care and social assistance, arts, artistic originals and recreation, accommodation and food services, and other services. In online Appendix A.2, we further describe the source and sample periods of industry data and some adjustment methods that we apply to the value added data by industry.

linearly increases to 30% in the early 1960s and further 60% in the early 2010s. The IPP share in the investment of nondurables manufacturing is somewhat lower than that of durables, starting around 10% in the late 1940s and increases to reach a plateau around 20% in the 1960s and the 1970s and then linearly increases from the early 1980s to reach roughly 60% in 2013. The IPP investment share in services is slightly below 10% before the 1970s, and it rises from the 1980s to reach roughly 40% in 2013. The IPP investment in wholesale trade remains nil until the 1970s, after which it shows an extraordinary growth that reaches 40% of investment by 2013. The trend of the IPP share of investment in retail trade resembles that in wholesale trade. The growth in the IPP share in the investment in retail trade starts only in the mid-1970s and it increases to around 20% in the 2010s. From these high IPP industries, we observe (i) declines in the share of structures except in wholesale trade and (ii) declines in equipment investment, except in information and services where equipment tends to remain steady and in retail trade where it slightly increases.

Next, we use additional industry-level data of investment, price of investment, and depreciation from the FAT to construct industry LS using equation (4) from section 3.1.[52] We apply that formula separately to each industry under the assumption that the net return to capital is identical across NAICS industries. The main reason to use this LS construct, in addition to ensure consistent industry classification under NAICS throughout the 1947-2013 period, is that it allows us to study the effects of IPP capital on the LS at the industry level, in the same manner that we explored these effects at the aggregate level in section 3.3.[53] At the same time, we construct the industry IPP capital intensity by dividing the IPP capital stock by the total capital stock in each industry. We investigate the relationship between LS and the IPP capital intensity by industry for two subsample periods, 1947-1999 and 2000-2012 in panel (a) in Figure 16.[54] This exercise explores whether industries that have grown more in IPP capital intensity have also experienced a decline in LS.

There are three observations to highlight. First, in terms of IPP capital intensity, the industries

[52]A nice feature of the FAT is that, unlike NIPA, they consistently use NAICS codes from 1947 to 2013. The change in the industry classification in NIPA makes the construction of a consistent measure of LS over time from NIPA alone unfeasible for some industries, for lack of disaggregated subindustry data.

[53]For the subperiod 1998-2012 we also construct the NAICS industry LS computed directly from the national income components in NIPA according to section 2.1; this is not feasible for the pre-1997 years because the NIPA industry classification for those years is based on the Standard Industrial Classification (SIC). We plot industry-level LS constructed from the FAT data against industry-level LS computed from NIPA in Figure I-3 in online Appendix I. By and large, the two constructs of LS correspond well. Since our model is frictionless, the difference of the model-based LS and the data-based LS is an indicator of frictions beyond what is factored into the price series of investment.

[54]The point break of 2000 is motivated by the fact that, since the ealry 2000s, we find IPP investment has reached a steady structure of its components, that is, the share of software, R&D, and artistic originals in total IPP investment has remained relatively stable after year 2000; see the discussion in online Appendix C.

with the highest intensity are also those that experience larger growth in IPP capital intensity in the 2000s. In addition, these industries consist of six of the seven industries with the highest output share in 2013.[55] These industries include information and services—that is, two of the three growing industries identified in Figure 14—that respectively grow by about 0.05 and 0.06 IPP capital intensity points from the first to the second subperiod, nondurables and durables manufacturing which respectively grow by 0.166 and 0.088 IPP capital intensity points, and wholesale and retail trade, which respectively grow by 0.080 and 0.030 IPP capital intensity points. Some of these industries, such as nondurables and durables manufacturing and information, have a relatively high level of IPP capital intensity above 0.10 before 2000, and others such as wholesale trade and services start from IPP capital intensity below 0.06 before 2000. Second, in terms of LS, the largest decline occurs in durables manufacturing by 0.15 LS points, in nondurables manufacturing by 0.08 LS points, in both information and retail trade by 0.07 LS points, and in wholesale trade by 0.04 LS points from the first to the second subperiod. These results represent the first direct empirical evidence of the relationship between the largest growth in IPP capital intensity and the largest declines in LS at the industry level. The largest increases in IPP capital intensity and declines in the LS occur for industries with large initial LS values. Instead, industries with relatively low LS such as agriculture, FIRE, and utilities, barely experience an increase in IPP capital and declines in the LS. Finally, only two of the 12 main industries exhibit a positive relationship between IPP capital intensity and LS, transportation and mining.

We also disaggregate the 12 main industries into 46 subindustries (3 and 4-digits NAICS) for the period 1947-2013.[56] For each of these subindustries, panel (b) in Figure 16 reports on the vertical axis the difference (i.e., changes in levels) in LS between the pre- and post-2000 years and on the horizontal axis the difference in IPP capital intensity between the pre- and post-2000 years. Our sample largely populates the bottom-right quadrant of that panel suggesting that most subindustries display a decline in their LS associated with an increase in their IPP capital intensity, with very few industries showing a decline in IPP capital intensity and/or an increase in LS (e.g., petroleum and coal products (Sub-24)). For example, chemical products (Sub-25) shows an increase in IPP capital intensity by .26 points and a decline in LS by .06 points and computer and electronic products (Sub-13) shows an increase in IPP capital intensity by .15 points and a decline in LS by .17 points. The general pattern is that increases in IPP capital intensity go hand in hand with decreases in LS at the subindustry level; a simple regression weighted by subindustries output shares implies that for a .100 points increase in IPP capital intensity, LS declines by .020 points. In all, even with a finer industry classification, we find a

[55] Only FIRE is missing with a high output share but low IPP capital intensity.

[56] See Table I-1 in online Appendix I for industry codes and names. Our sample increases to 57 subindustries if we restrict the attention to the post-1970 years, without providing additional insights in our results.

negative relationship between LS and IPP capital intensity that is consistent with that for 2-digit NAICS industries.

When IPP capital for each industry is removed in the same fashion as described in section 3.3, we confirm that the LS of industries that invest in IPP flattens out. These results are shown in Figure 17 for the main industries that invest in IPP—that is, information, services, nondurable and durable goods manufacturing, wholesale trade and retail trade.[57] The effects of IPP on LS are largest for the manufacturing sector. Using the post-revision data, the LS of nondurable goods manufacturing and that of durable goods manufacturing declines by, respectively, 0.20 and 0.25 LS points from 1947 to 2013, representing the two largest LS declines in all industries. Further, at the same time, these two industries have also invested heavily in IPP, especially in the post-2000 period, suggesting a potential relationship between IPP capital and LS. Removing the effects from IPP capital largely mitigates the decline in LS. For nondurables manufacturing, the LS without IPP decreases by 15 percentage points from 1947 to 1984, but it actually increases by 5 percentage points from 1985 to 2013, netting a 10% decline over the entire sample. For durable goods manufacturing, LS without IPP declines by 10 percentage points from 1947 to 1983 and thereafter remains constant until the end of the sample. IPP capital drives the LS of the manufacturing industries down.

Finally, the effects of IPP capital on the LS in information industry are also large. With IPP capital, the LS in information declines from 0.68 in 1947 to 0.50 in 2013, a drop of 0.18 LS points. After removing IPP capital, the LS drop in information reduces to 0.06 LS points from 0.71 in 1947 to 0.65 in 2013, and LS displays an increase from 0.60 in the mid-1980s to 0.65 in 2013. For the services industry the LS starts at 0.86 in 1947. With IPP capital, the LS in services falls to 0.82; without IPP capital, LS remains essentially flat and ends at the same 0.86 in 2013. We find similar effects of IPP capital on the LS in wholesale trade and retail trade.

7 Implications for the U.S. Model

We believe the finding that IPP capital generates the observed decline in the US LS has profound implications for the US macroeconomic model.

The incorporation of IPP capital to national accounts through the 1999 and 2013 BEA revisions represents a substantial improvement in the measurement of capital (and its income). These revisions help national accounts capture a more accurate picture of the US economy. With these new data we have shown that the decline in the LS should be seen as the effect of a shift — a process of structural transformation — toward a larger IPP economy. It is such ongoing

[57] For industries that do not invest in IPP the effects of removing IPP capital are, obviously, negligible.

shift to a more IPP capital-intensive economy and its implications on income distribution across sectors and factors of production that should be modeled.[58]

7.1 The Aggregate Production Function and Future Directions

The answer to finding the macroeconomic model that fits the new facts is likely not to be unique.[59] Since the influential work of Karabarbounis and Neiman (2014a), there has been an interesting debate on the shape of the aggregate production that captures the LS decline. In this section, we relate this debate to the new data. It is however worth reiterating that our main empirical finding on the effects of IPP on LS has not required specific assumptions on the shape of the production function (see section 3.1).

The recent debate has centered on the role of the long-run elasticity of substitution between aggregate capital and labor. In this context, we explore how IPP capital — a new form of capital deepening — affects the long-run elasticity of substitution. As in Karabarbounis and Neiman (2014a), we focus on the first order condition of capital from an aggregate invesment model with a constant elasticity of substitution (CES) production function. That is, we recover the elasticity σ from the equation $\Delta \ln(1 - LS) = \frac{\sigma-1}{\sigma} \Delta \ln \frac{K}{Y}$ where the increment Δ is the estimated linear trend for the associated logged variable and sample period.[60] The results are in Table 1.

The elasticity implied from the most updated data that contains IPP capital (and income) is large and significantly different from one, 1.866, see column (1) in panel (a) of Table 1. This large elasticity is the result of a significant increase in the trend of 1-LS and an even larger increase in the capital-to-output ratio. To study the effects of IPP capital on the implied elasticity, we compare column (1) with the elasticity obtained from our main counterfactual in which the LS, capital, and output are purged of IPP, as described in section 3.3. Without IPP and, hence, with a trendless LS, we find the elasticity is much smaller, 1.087, see column (2) in panel (a). In fact,

[58] Alternatively, practitioners can in principle opt out from IPP capital, as the vast majority of dynamic stochastic general equilibrium (DSGE) models currently do. In that world without IPP, our results imply that it is reasonable to assume a trendless LS where what remains to be explained are the cyclical fluctuations of the LS. The important caveat behind the choice of modeling the US without IPP is that one is knowingly ignoring a large and growing piece of aggregate investment.

[59] While a large set of mechanisms have been explored to understand the cyclical behavior of LS (see a recent review in Koh and Santaeulàlia-Llopis (2014)), previous studies on endogenous LS dynamics do not incorporate — to the best of our knowledge — an explicit IPP channel which we regard, as per our results, as necessary to account for the trend of the LS.

[60] Karabarbounis and Neiman (2014a) use additional cross-country variation to pin down σ. Instead, our focus on the US economy implies that to obtain σ we simply resolve the one-equation one-unknown problem posed by first order condition of capital, 1-LS $= \alpha \left(\frac{K}{Y}\right)^{\frac{\sigma-1}{\sigma}}$, evaluated in the long run. That is, to solve for the the long-run elasticity we use estimated deterministic linear trends for the logged 1-LS and the logged capital-to-output ratio. Note that linear trends of logged variables are growth rates and, hence, the constant α drops from the analysis.

without IPP we cannot significantly distinguish the elasticity from one, i.e., from a Cobb-Douglas production function. We repeat the same exercise for a shorter sample from 1975 to 2010. The effects of IPP are analogous to the full sample, although with a lower elasticity with IPP, 1.210, that is also significantly different from one, see column (1) in panel (b). Again, without IPP capital the elasticity is smaller, 1.039, and not significantly different from one, see column (2) in panel (b). When we sequentially add the effects of IPP on the aggregate price of investment and depreciation rate to the IPP-free LS, the estimated elasticity changes only marginally (see columns (3) and (4) in Table 1). The main driver of the high elasticity is the flow of IPP investment (see column (5) in Table 1). This is directly related to the fact that IPP investment is the main driver of the decline of the LS (see section 3.4).[61]

To sum up, the elasticity between capital and labor is large and significantly above one. This elasticity can be fully accounted for by IPP capital: Without IPP capital, i.e., with a trendless LS, we cannot reject the possibility of a Cobb-Douglas form for the long-run production function.

While our results echo those in Karabarbounis and Neiman (2014a), our analysis suggests a different capital-deepening mechanism for the US. In a cross-country analysis, these authors find that capital deepening generated by a fall in the price of investment implies that, everything else equal, the elasticity of substitution between capital and labor must be larger than one in order to explain the decline in LS. In contrast, for the specific case of the US, our results show that capital deepening in the form of IPP is behind the larger-than-one elasticity. This restates the result in section 3.3 that the decline of the price of investment — driven by the price of equipment and not IPP (see section 3.2.1) — plays no quantitative role in the decline of the US LS. This result is also confirmed by the pre-1999 BEA revision data, where a trendless LS coexists with a falling price of investment. Furthermore, it is also consistent with the modeling choices in Greenwood, Hercowitz, and Krusell (1997) and Krusell, Ohanian, Ríos-Rull, and Violante (2000) that use IPP-free frameworks motivated by those data.

As per our results, a theory for why the elasticity of substitution is larger than one must be linked to the rise in IPP capital and the subsequent decline of the LS. However, the aggregate production function does not clarify the mechanisms that drive the elasticity of substitution up in the presence of more IPP capital. In particular, at the aggregate level the denitions of capital and labor inputs fail to recognize the asymmetric interaction that IPP capital might have on dierent types of labor, e.g., skilled versus unskilled. For example, a large body of research that examines the increase in wage inequality suggests that the equipment capital-skilled labor complementarity is an important dimension behind skill-biased technical change (Krusell, Ohanian, Ríos-Rull, and

[61] Note that the decomposition of the IPP effects via the price of investment, depreciation, and investment flow in Table 1 is analogous to that carried out in panel (b) of Figure 9 and described in section 3.4.

Violante (2000)). In this context, it is likely that equipment (e.g., computers) and IPP capital (e.g., software) are related with some degree of complementarity. Then, if we consider IPP capital as potentially more complementary to skilled work — or to the composite of skilled work and equipment capital — than to unskilled work, then both "IPP capital deepening" and "skill deepening" can be concurrently in process and behind the larger substitutability between capital and labor, in particular, with respect to unskilled labor. Yet, these effects are not trivial and hinge critically on the cross-elasticities of substitution between traditional capital, IPP capital, skilled work, and unskilled work, an area of investigation that remains unexplored and that we believe is a fruitful avenue for future research.

7.2 Further Challenges

Two further challenges arise from current data limitations. The first challenge is that BEA is likely to fall short in accounting for the entire set of IPP capital. While BEA investment accounts incorporate software, R&D, artistic originals, they leave out other recognized sources of IPP such as brand equity and organizational capital (Corrado, Hulten, and Sichel, 2005b, 2009). Under the direct data used by BEA to measure IPP, there are good reasons for such choice because the capital of these additional IPP components requires series of investment and depreciation rates that are either not readily available (or do not exist) as not all IPP items are marketed.

The literature has explored alternatives to get around this limitation. McGrattan and Prescott (2005, 2010) recover aggregate IPP capital as a latent variable in their model.[62,63] Their exercise gives us a unique opportunity to compute how much BEA currently captures of total IPP using a measure of total IPP obtained with an entirely different methodology. If we focus on the corporate sector, we find that BEA IPP capital represents 11.0% of total capital in the late 1990s, while this figure is 29.4% in McGrattan and Prescott (2005). In terms of capital income shares, we find that BEA IPP capital accounts for 5.7% of total income in the 2000s, while this figure is 7.6% in McGrattan and Prescott (2010). These comparisons confirm the notion that BEA captures a fraction, i.e., roughly 60% of total IPP.

To address this issue, at least partially, we extend the BEA accounts to incorporate advertising capital, an important dimension of brand equity.[64] In an earlier setting, at a time where only

[62]These authors use the structure of their economic model to recover series of aggregate IPP capital (as a latent variable in their setting) such that other model moments—that do not directly involve IPP—are consistent with their observable counterparts.

[63]Alternatively, Hall (2000) uses stock market data to estimate intangible capital stock.

[64]This exercise is described in detail in online Appendix J. Of the set of IPP components currently omitted by BEA, advertising is perhaps the IPP component for which there are, till some extent, more available measures of investment and depreciation, see Bagwell (2007), McGrattan and Prescott (2014) and Hall (2014).

software investment was part of national accounts, Corrado, Hulten, and Sichel (2009) incorporate a wider set of IPP components to national accounts than what BEA currently does.[65] Here, we partially follow their same strategy by adding advertising capital to the current BEA measures of capital and output. To do so, we use the investment series for advertising largely based on the work by Douglas Galbi; see Hall (2014).[66] We find that advertising accounts for a relatively constant 9% of aggregate investment from 1947 to 2010. The share of advertising in aggregate investment is the largest of all IPP components until the mid-1950s and still at least as large as software and slightly below R&D by 2010.[67] Assuming a depreciation rate of .5, the median in the set of estimates in Bagwell (2007), we recover advertising capital. Incorporating advertising capital in an exercise similar to that in section 3.5 shifts the LS down by around 0.015-0.017 LS points from 1947 to 2010 but does not strengthen (or alleviate) the decline of LS.

The second challenge is the provision of direct measures of output and factor income shares of the IPP sector that we cannot identify in the current data. One option is to use the Input-Output Tables in a manner similar to Valentinyi and Herrendorf (2008), classify commodities into a new IPP sector and compute the capital and LS for each dollar of IPP output. Alternatively, the BEA has already contemplated the possibility of creating an R&D industry in the US industry accounts.[68] In preparing for the 2013 NIPA revision, the BEA has built a R&D satellite account that provides detailed statistics on the nominal and real R&D investment (i.e., R&D output), the R&D capital stock, the rate of return, and the depreciation rate of R&D capital.[69] Using the performer-based data of the National Science Foundation surveys, from which the R&D satellite account itself draws heavily, it should be possible to combine wages and compensations of R&D personnel to form the basis of a measure of labor income in the R&D sector.[70] If the BEA could

[65] A close look to the Figure 3 in Corrado, Hulten, and Sichel (2009) suggests that a LS that extends the pre-2013 BEA revision capital with a large set of IPP capital (e.g., R&D, brand equity, organizational capital, and human capital) remains fairly constant from the early 1950s to the early 1980s, and declines roughly about 5% LS points from 1980 to 2005.

[66] These series consist of aggregate advertising expenditures in newspapers, other periodicals, magazines, direct mail, farm publications, business papers, billboards, out of home yellow pages, radio, television, broadcast TV, cable and Internet. They are available at purplemotes.net, `http://www.galbithink.org/cs-ad-dataset.xls` (as of January 2014). Alternatively, Corrado, Hulten, and Sichel (2005b) and Corrado, Hulten, and Sichel (2009) estimate the investment in brand equity as roughly 60% of the expenditures on advertising and market search. The "60%" adjustment is motivated by research in the marketing literature that indicates only a portion of advertising has a service life of more than one year. Our estimates of advertising investment are consistently about 50% to 60% higher than those in Corrado, Hulten, and Sichel (2009) throughout the common sample period from 1950 to 2003. This implies that replacing our estimates with theirs in our accounting exercise only changes the level of our LS with ad investment but not its trend. See Appendix J for our accounting exercise incorporating advertising.

[67] McGrattan and Prescott (2014) show similar findings using Compustat data.

[68] See Section V of "R&D Satellite account: Preliminary Estimates" (on page 62 of Okubo, Robbins, Moylan, Silker, Schultz, and Mataloni (2006)).

[69] For a detailed summary of the BEA's methodology of estimating the output, its price, and the depreciation of R&D, see online Appendix A.4.

[70] These expenditure data are used in the BEA's construction of an input-cost price index of R&D output, which

expand such effort on the R&D satellite account to all components of IPP, we would be able to construct the LS for the IPP sector the same way we construct the LS at the industry level. We call for an effort from the statistical agencies to consolidate the production of IPP into an integral account that differentiates the IPP sector from the rest of the economy. The potential gain from such cleaner IPP accounting framework in understanding the current US economic model could be huge.

7.3 Links to the Labor Market and Globalization

The behavior of LS can be further related to observations in the US labor market, in particular, the effects of globalization (Autor, Dorn, and Hanson (2013)). Specifically, the observed decline in the US LS since the 1980s could also reveal cumulative effects of outsourcing US manufacturing as argued in Elsby, Hobijn, and Sahin (2013). In this direction, we have found that manufacturing shows the largest increases in IPP and the largest declines in LS (see our discussion in section 6). This way, from our perspective, it seems natural to interpret globalization as a source generating incentives for IPP investment. That is, firms outsource the routine process of their production, which allows them to focus on the innovation process. For example, Bloom, Draca, and Reenen (2014) show Chinese import competition led to increased innovation within EU firms and reallocated employment between firms toward more technologically advanced firms.[71] Under this interpretation, one channel through which the relocation of production units to countries with low labor costs can affect the US LS is through increases in the US IPP capital intensity, particularly, in the manufacturing industry; although we acknowledge that this argument deserves further exploration.

8 Conclusion

Two main findings stand out from our analysis. First, the labor share decline is a phenomenon that starts in the late 1940s and doubles the size of previous estimates. The length and size of this decline wrecks the balanced growth path hypothesis (or Kaldor facts). Second, IPP capital fully accounts for the decline in the labor share. These empirical findings emerge from recent improvements of the measurement of aggregate capital (and its income) in national accounts. That is, it is all in the measurement. While the Kaldor facts are based on measures of traditional capital, the recent capitalization of IPP — gradually incorporated by the 1999 and 2013 BEA revisions — provides a better and a more accurate picture of the US economy, one in which IPP

later gave way to an alternative output price index believed to better capture the productivity increase of R&D.

[71] Petri Böckerman and Mika Maliranta (2012) find similar effects of globalization on employment that shift employment from firms with high LS toward firms with low LS in a panel of Finnish firms.

capital deepening generates a secular decline of the labor share. We reach this conclusion by constructing a counterfactual labor share that is purged of IPP capital using a simple investment model as an accounting device and show that this labor share with solely traditional capital is absolutely trendless.

We believe that these results have essential implications for the US macroeconomic model. The decline of the labor share should be seen as the result of a shift toward a more IPP capital-intensive economy, a shift induced by continuing innovation and technological change. It is such innovation and its implications on income distribution across sectors and factors of production that should be modeled. We call for macroeconomic frameworks that recognize this nonbalanced growth originated from IPP capital deepening and its role in explaining the secular decline of the LS.[72]

Looking ahead, while we have focused on the secular behavior of US data and across its industries, multi-country analysis poses interesting challenges for future research. For example, exporting IPP capital to China is likely to shift the technological structure to be more capital-intensive in China and reduce the Chinese labor share. Further, we also confirmed the presence of large and persistent cyclical fluctuations in factor shares that are not altered by IPP capital and that, hence, still beg for an explanation. Finally, while we have not attempted to link labor share and economic inequality (see recent discussions in Bridgman (2014), Krusell and Smith (2014) and Karabarbounis and Neiman (2014b)), our result that IPP capital is behind the US labor share decline suggests that theories that aim at jointly explaining the labor share decline and the increase in individual inequality should explicitly consider innovators and entrepeneurial activities that generate IPP. This leads to our final remark. Considering that IPP is not only an important source of growth (Jones, 2005, Lucas, 2009) but also, as per our results, a main driver of the labor share decline, implies that welfare assessments of labor share decline should incorporate a growth-inequality tradeoff that has been overlooked by previous studies (e.g., Piketty (2014)).

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[72] For example, to the best of our knowledge, current frameworks that feature IPP capital (e.g., McGrattan and Prescott (2005, 2010)) or nonbalanced growth (e.g., Acemoglu and Guerrieri (2008)) do not study the decline of the labor share, but they could easily address it.

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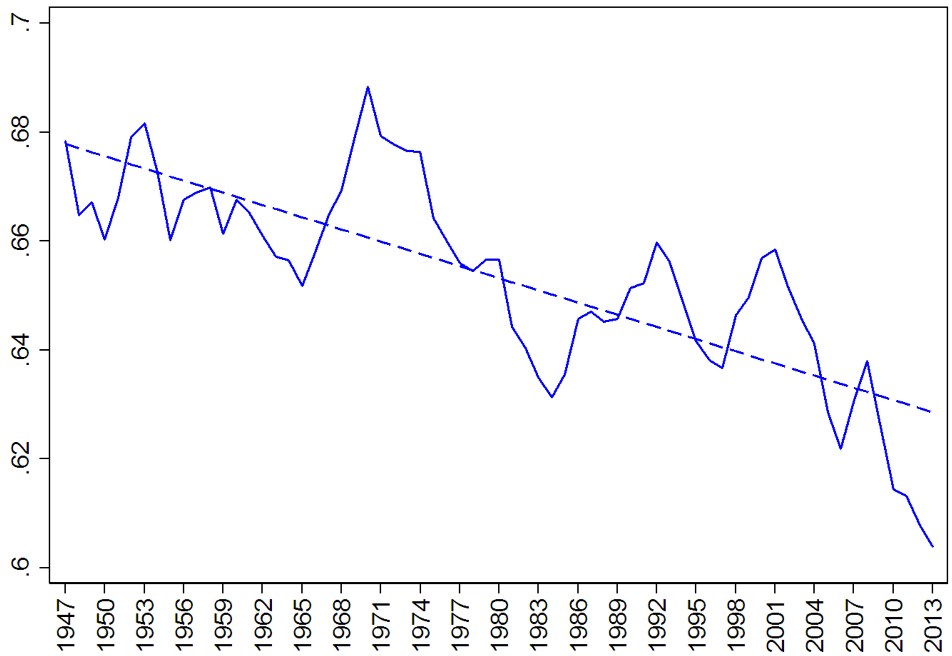
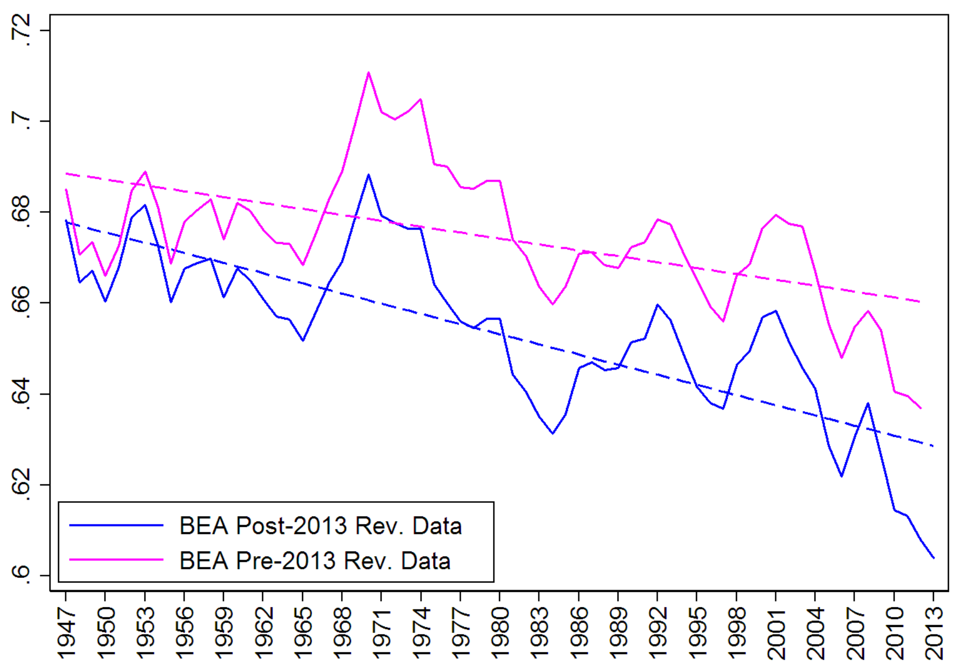
Figure 1: US Labor Share, BEA 1947-2013

(a) Post-2013 BEA Revision

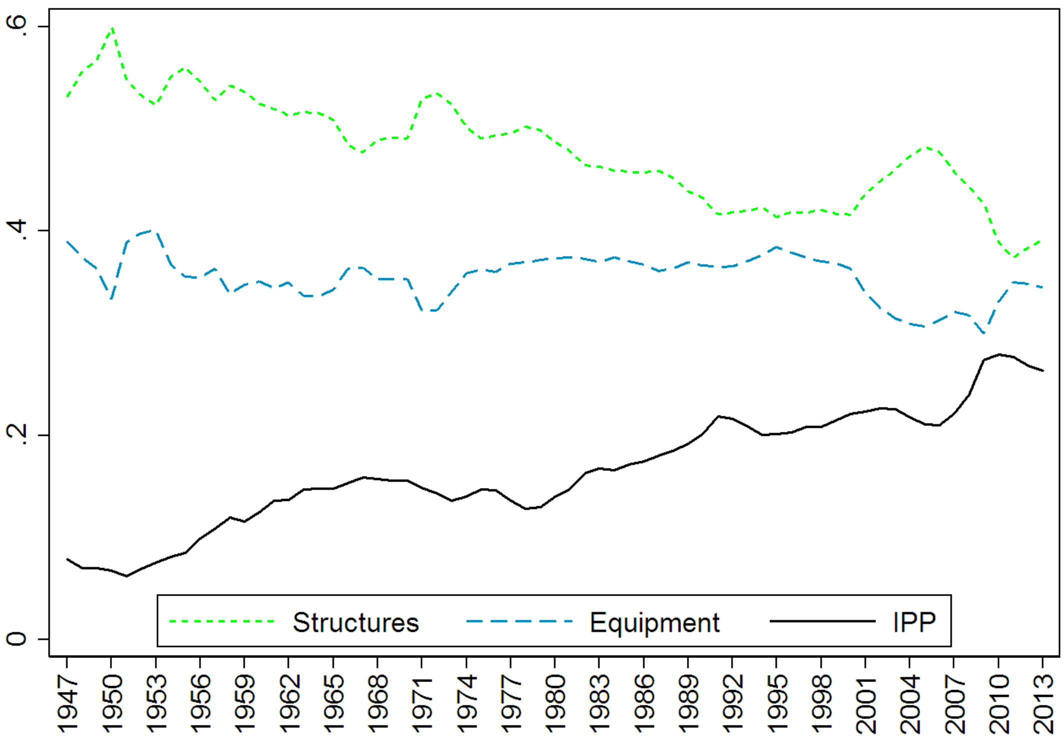


(b) Pre- and Post-2013 BEA Revision



Notes: In panel (a), the labor share of income refers to the benchmark definition described in section 2.1 and uses only post-2013 BEA revision data. In panel (b), we plot our benchmark LS together with the LS constructed under the same definition but using the data released before the July 2013 BEA comprehensive revision. The dashed lines are fitted linear trends with an absolute decline of 4.4 percentage points from 1947 to 2013 using pre-2013 revision data and 7.2 percentage points using post-2013 revision data. All variables used in computations are in nominal terms.

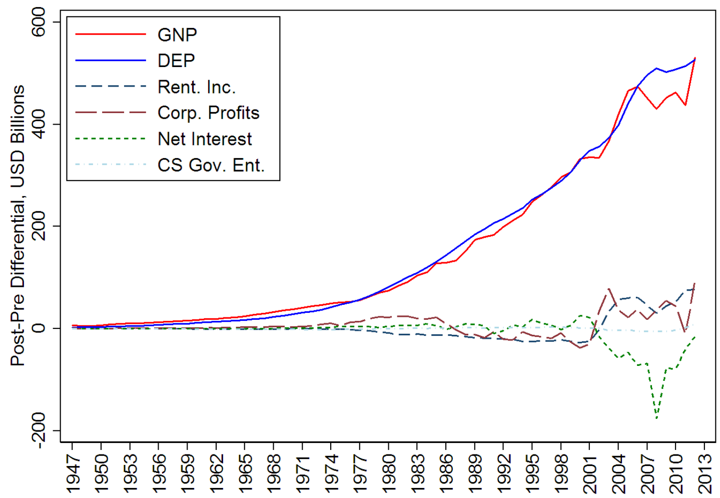
Figure 2: Structures, Equipment and IPP Investment Shares, BEA 1947-2013



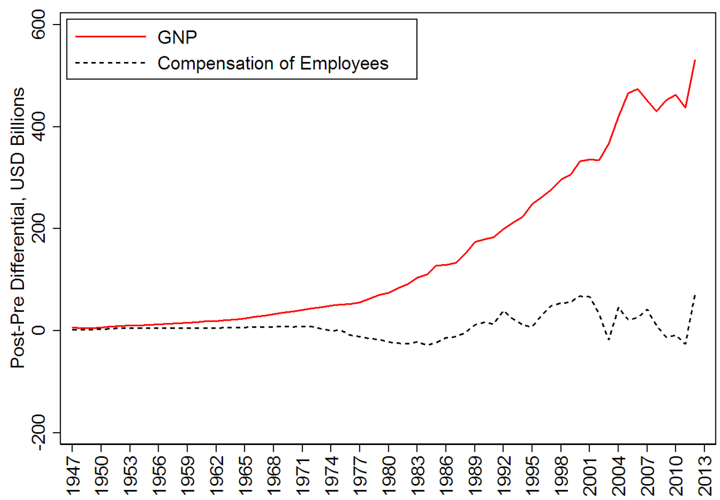
Notes: The investment shares are in terms of aggregate investment that includes both private and government investment and both residential and nonresidential investment. See data construction details in section 3.2.

Figure 3: Pre- vs. Post-2013 BEA Revision Data: Labor Share Components

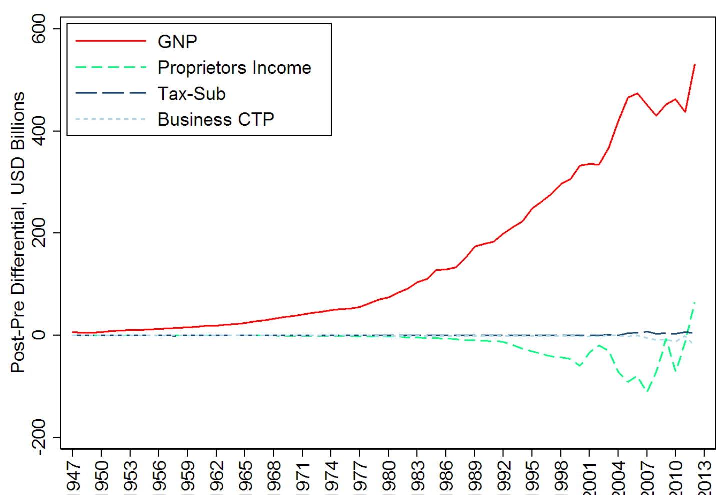
(a) Output, Capital Income and Depreciation



(b) Output and Labor Income

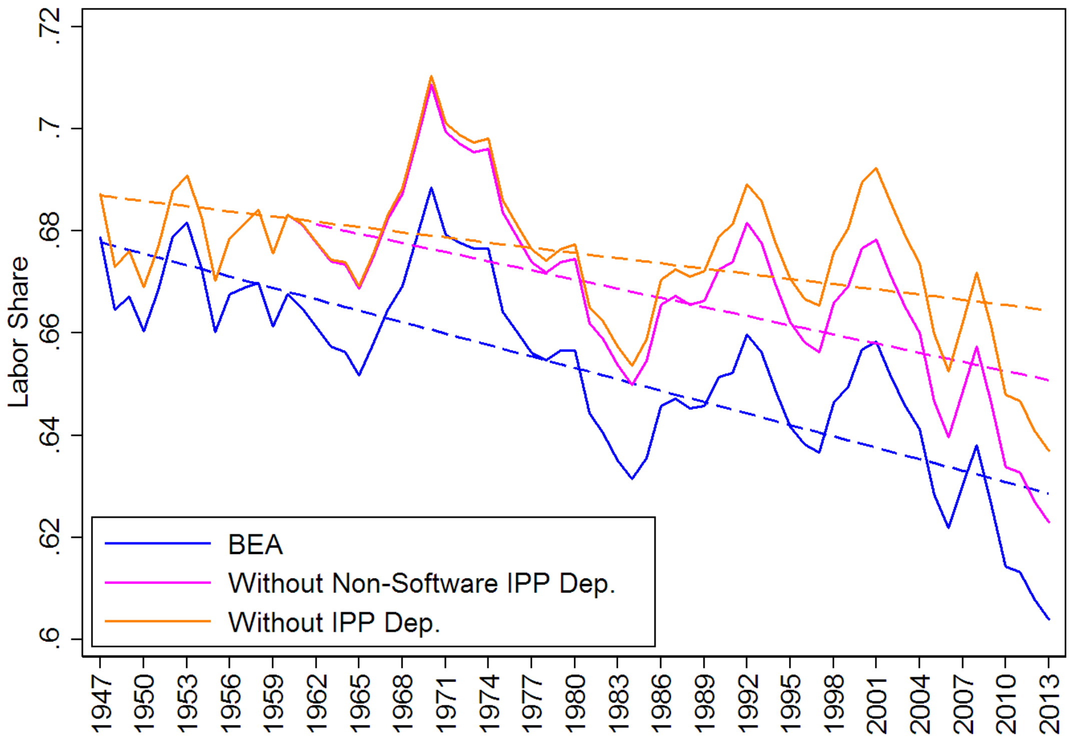


(c) Output and Ambiguous Factor Income



Notes: The 'Pre-Post Differential' reported in panel (a), (b) and (c) are defined as post-2013 BEA revision data minus pre-2013 BEA revision data, in USD Billions. All variables are in nominal terms.

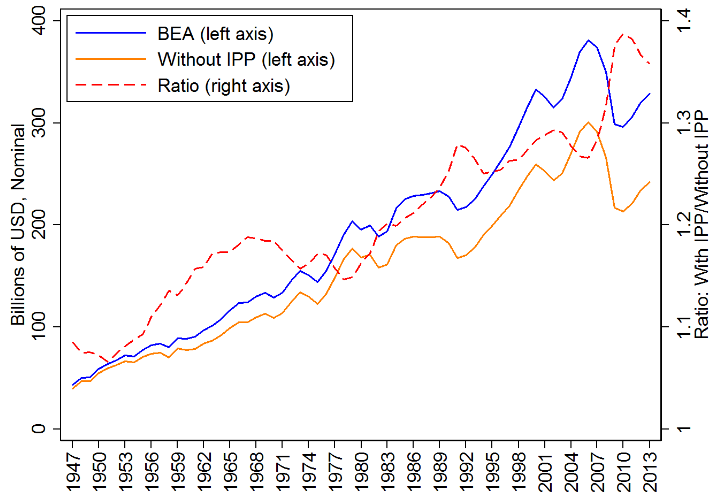
Figure 4: IPP Depreciation and Labor Share, BEA 1947-2013



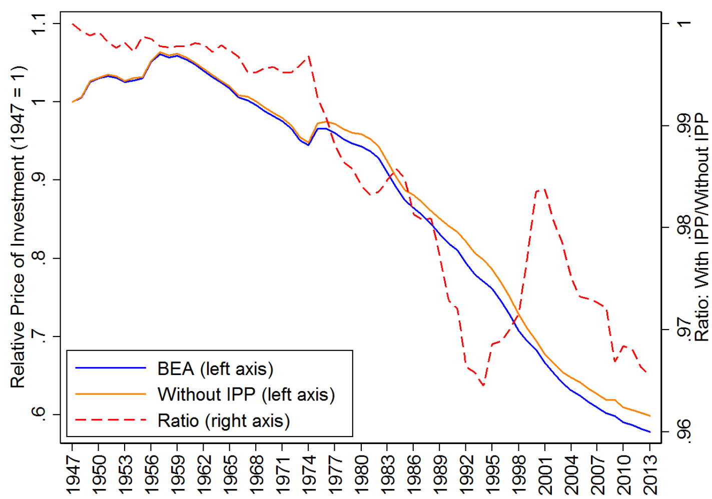
Notes: Benchmark labor share is defined in section 2.1. Labor share without IPP depreciation uses post-2013 revision FAT data to remove, from capital income and from GNP, the increase in depreciation solely generated by IPP, see section 2.2. Analogously, labor share without non-software IPP depreciation we solely remove non-software IPP depreciation from the computation of labor share, see section 2.2.

Figure 5: Effects of IPP Capital on Aggregate Investment, Its Price and Depreciation Rate

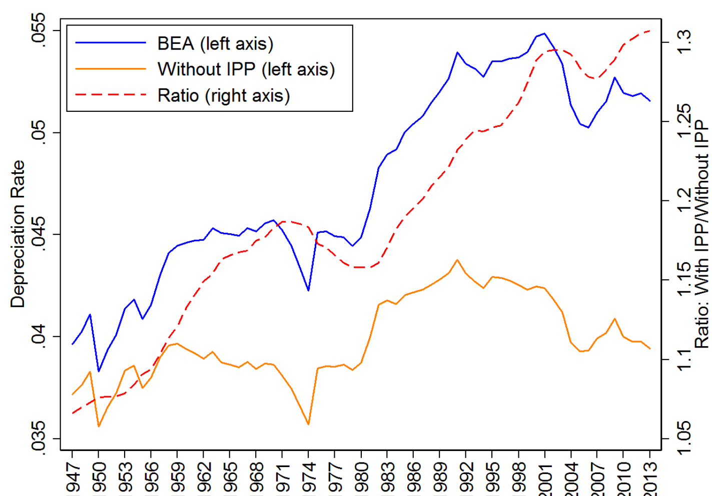
(a) Aggregate Investment With and Without IPP



(b) Relative Price of Investment With and Without IPP

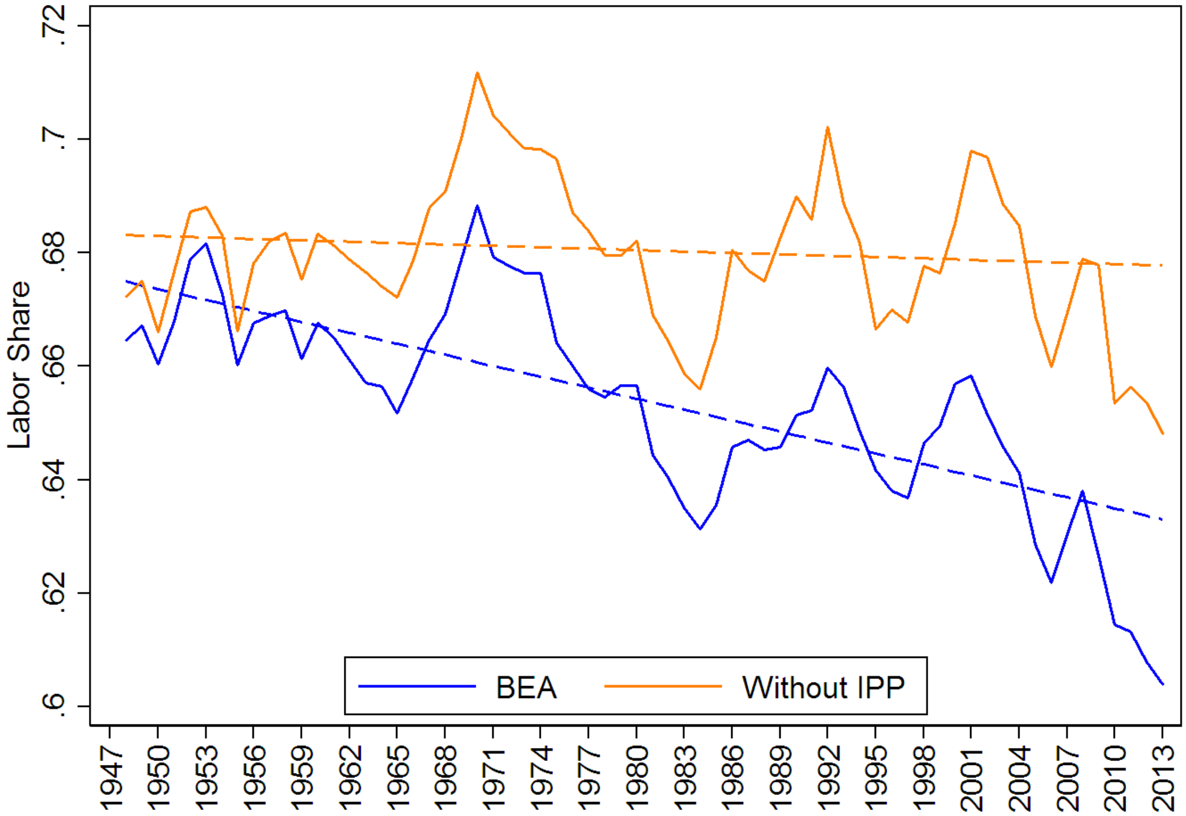


(c) Depreciation Rate With and Without IPP



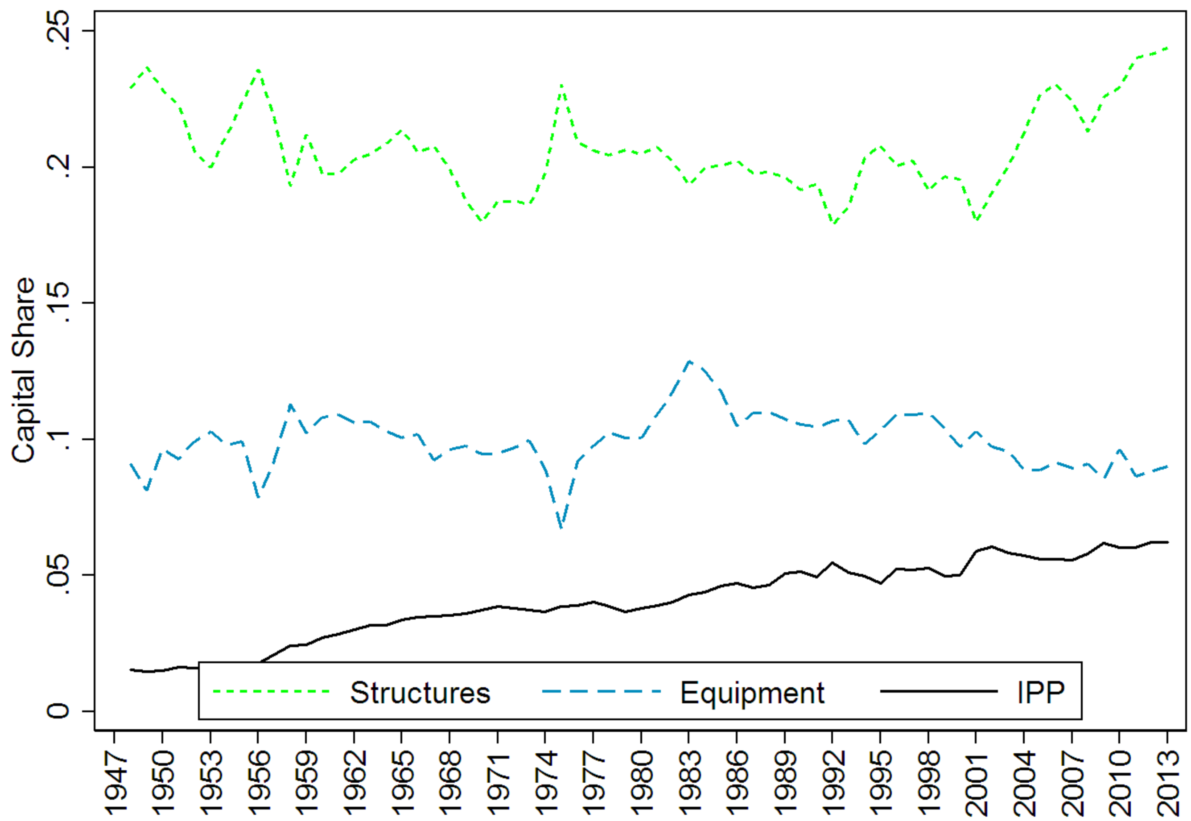
Notes: The construction of aggregate investment, investment price, and depreciation rate for, respectively, panel (a), (b) and (c), is discussed in detail in section 3.2.

Figure 6: Effects of IPP Capital on Labor Share, US 1947-2013



Notes: The labor share labeled as "BEA" refers to the benchmark definition described in section 2.1 and uses only post-2013 BEA revision data (also depicted in panel (a) of Figure 1). The labor share without IPP refers to the counterfactual labor share that results from entirely removing IPP capital by setting v, δ and investment to their values without IPP in the computation of labor share, see section 3. The underlying linear trend for labor share without IPP is not significantly different from zero from 1947 to 2012; the plotted dashed line refers to 1947-2010.

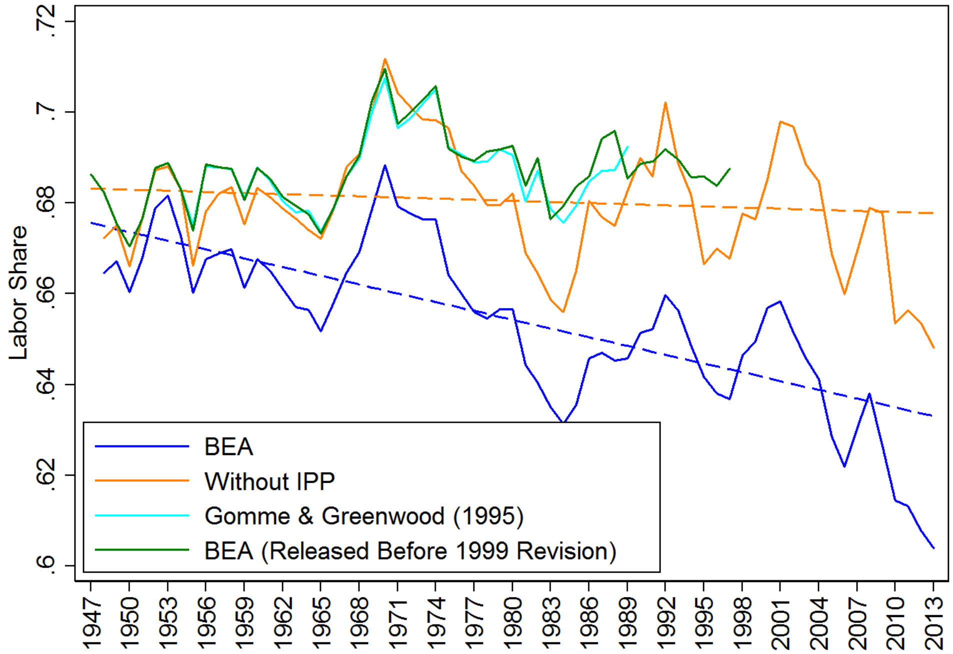
Figure 7: The Capital Share of Income: Structures, Equipment and IPP, US 1947-2013



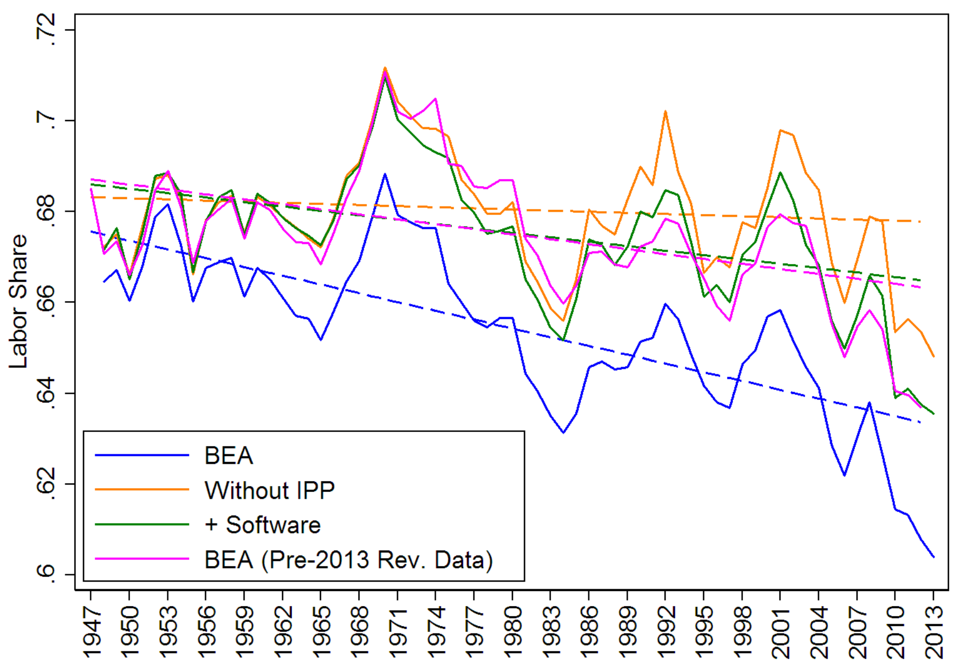
Notes: The capital share of structures, equipment and IPP are computed using the same methodology described in section 3.3 to remove IPP from capital income. The sum of these three capital shares by type of capital adds up to one minus the benchmark labor share computed in panel (a) of Figure 1. The sum of the capital share of structures and equipment adds up to one minus the the counterfactual LS "Without IPP" (orange line) plotted in Figure 6.

Figure 8: Vintage Labor Share

(a) When IPP Was Not Capitalized, Pre-1999 BEA Era



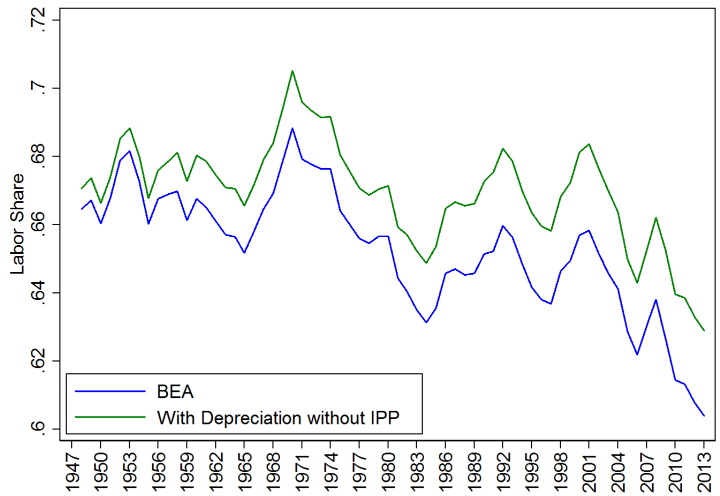
(b) Effects of Software Capital on Labor Share with Pre-2013 Revision Data



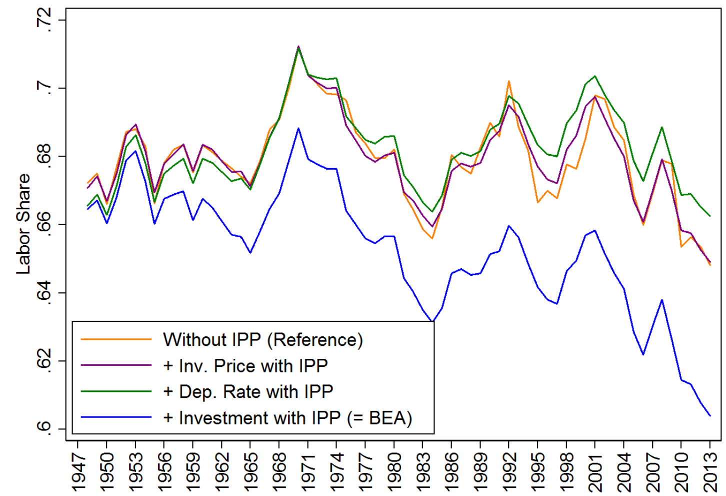
Notes: In panel (a), the labor share labeled as "BEA" refers to the benchmark definition described in section 2.1 and uses only post-2013 BEA revision data (also depicted in panel (a) of Figure 1). The labor share labeled "Without IPP" refers to the counterfactual labor share that results from entirely removing IPP capital, see section 3. The labor share labeled as "BEA Released Before 1999 Revision" is computed using data released by BEA in 1998 and available at the Archives Library of the St. Louis FED. The labor share constructed in Gomme and Greenwood (1995) using data before software entered the national accounts as investment is also reported. To avoid differences in levels, we normalize the mean of the last two series of labor share to the mean of our counterfactual labor share. In panel (b), the series labeled "+ Software" takes the labor share series without IPP as reference and adds software capital. The series labeled as "BEA (Pre-2013 Rev. Data)" refers to labor share computed using pre-2013 revision data from BEA which include capitalized software but not other forms of IPP capital. The underlying linear trend for labor share series "+ Software" and "BEA (Pre-2013 Rev. Data)" are not significantly different from each other. See section 3.3 for a discussion.

Figure 9: A Decomposition of the Effects of IPP capital on Labor Share: It is All in Capital Accumulation

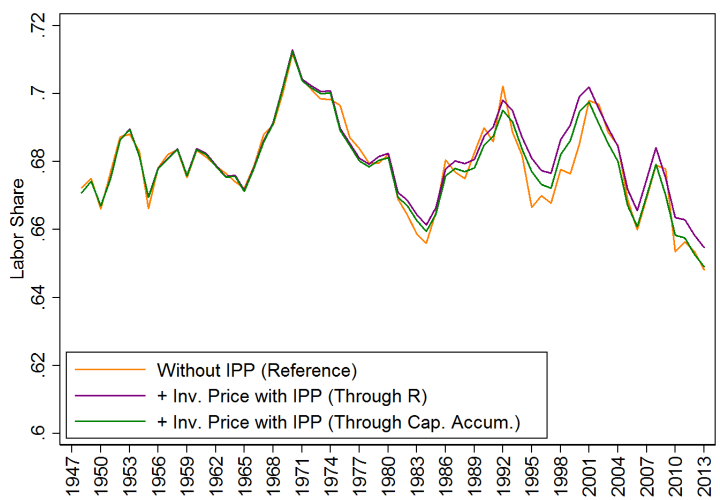
(a) Depreciation, $\delta_t k_t^x / v_t$



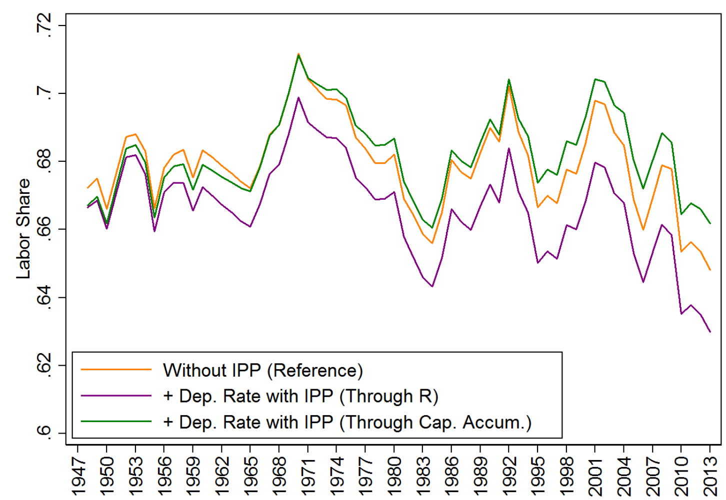
(b) Investment, Its Price and Depreciation Rate



(c) Price of Investment Through R_t & Capital Accumulation

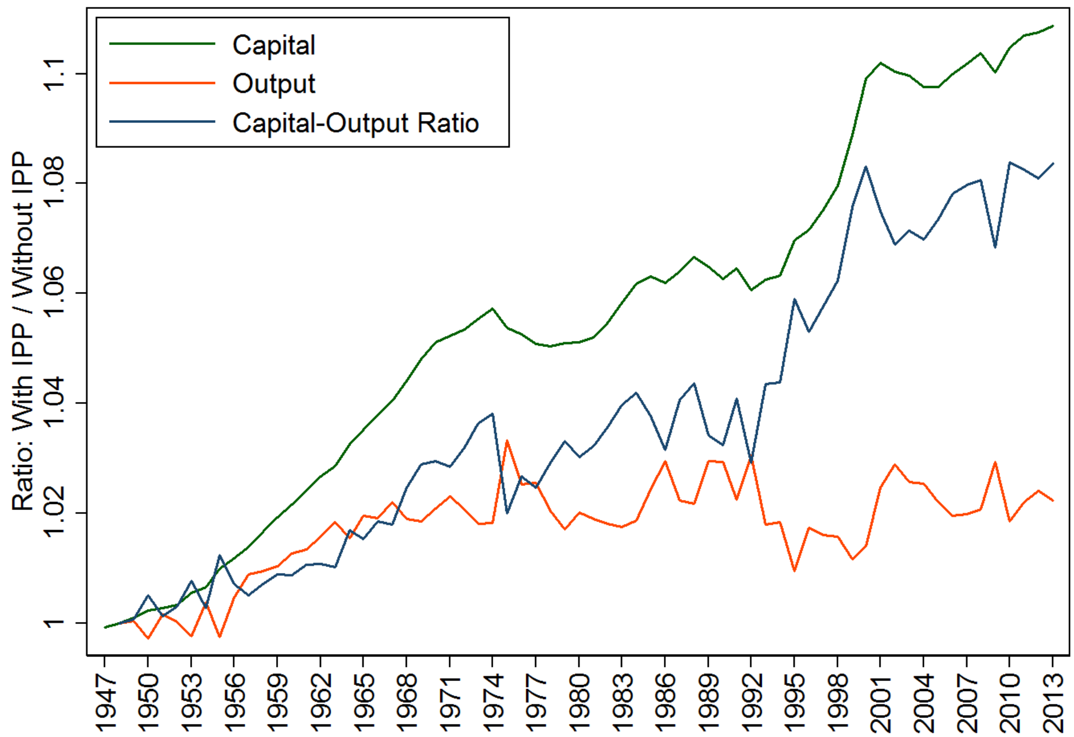


(d) Depreciation Rate Through R_t & Capital Accumulation



Notes: In panel (a) the reference scenario is the benchmark labor share with IPP and the counterfactual labor share results from imposing capital depreciation, $\delta_t k_t^x / v_t$, without IPP to the reference scenario. In panel (b) the reference scenario is benchmark labor share without IPP and the counterfactual experiment consists of sequentially adding to the reference scenario the investment price with IPP, the depreciation rate with IPP, and investment with IPP such that we end up recovering benchmark labor share with IPP. The last two panels take the benchmark labor share without IPP as reference scenario and compute the counterfactual labor shares that results from adding, respectively, the price of investment (in panel (c)) and depreciation rate (in panel (d)) with IPP to the reference scenario separately revealing their effects through R_t and through capital accumulation.

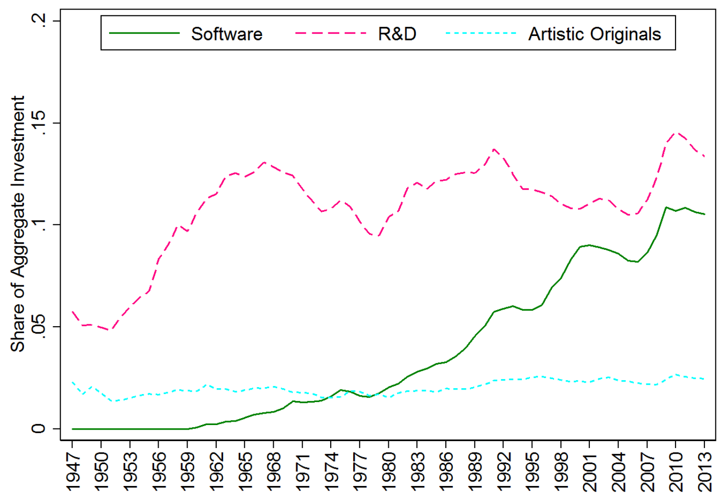
Figure 10: The Effects of IPP Capital on Aggregate Capital



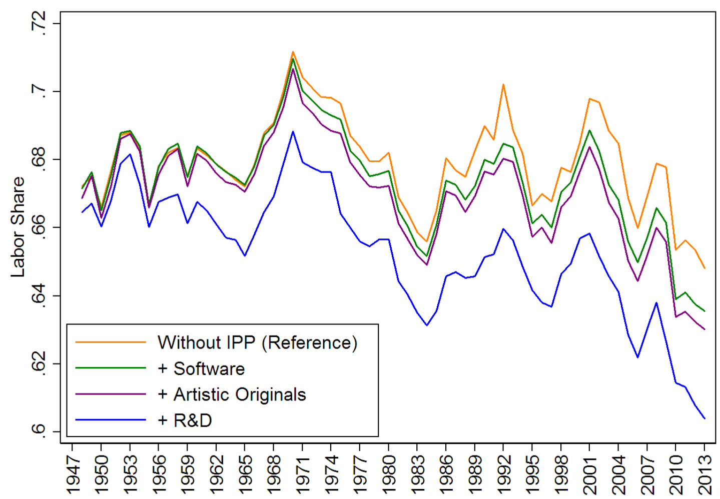
Notes: The effects of IPP capital on aggregate capital, output and the capital-output ratio refer to the ratio between each of these variables with IPP to without IPP.

Figure 11: Effects of Software, R&D and Artistic Originals capital on Labor Share

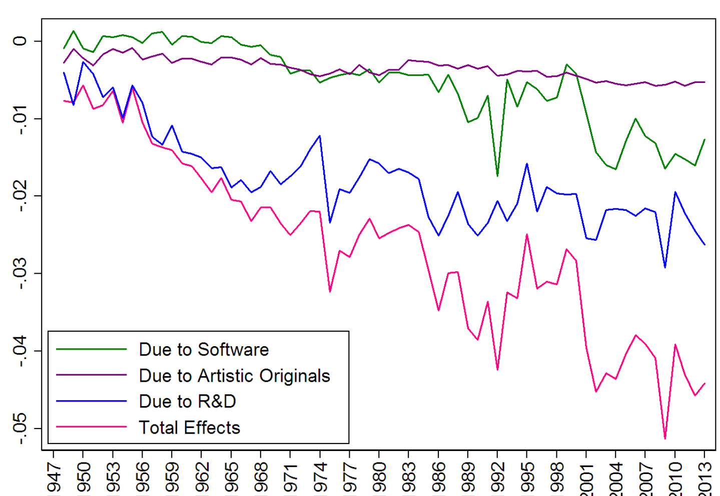
(a) Software, R&D and Artistic Originals Investment Shares, BEA



(b) Effects of IPP Capital on Labor Share: By Type of IPP



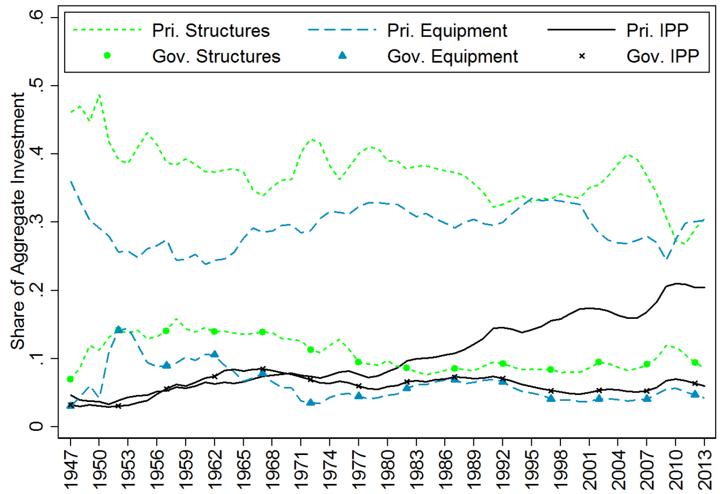
(c) Labor Share Decline Decomposition: By Type of IPP



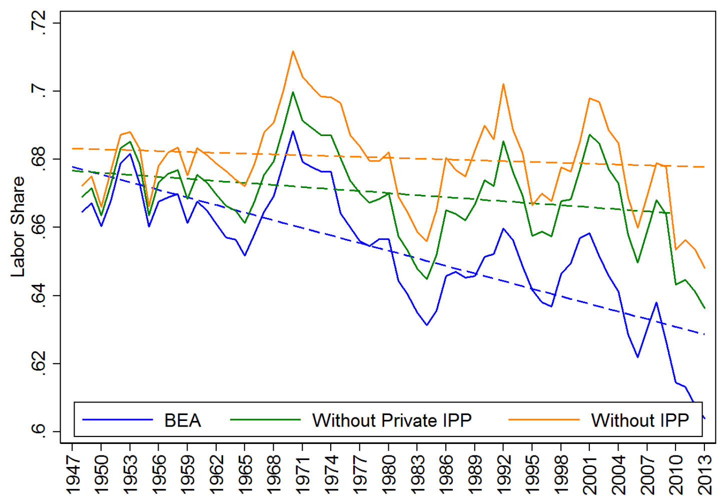
Notes: Panel (a) shows the IPP components shares of aggregate IPP investment. In panel (b) the reference scenario is benchmark labor share without IPP and the counterfactual labor share consists of sequentially adding artistic originals, R&D and sofware capital. Panel (c) shows the amount of labor share decline separately generated by each type of IPP capital.

Figure 12: Effects of Private and Government IPP Capital on Labor Share

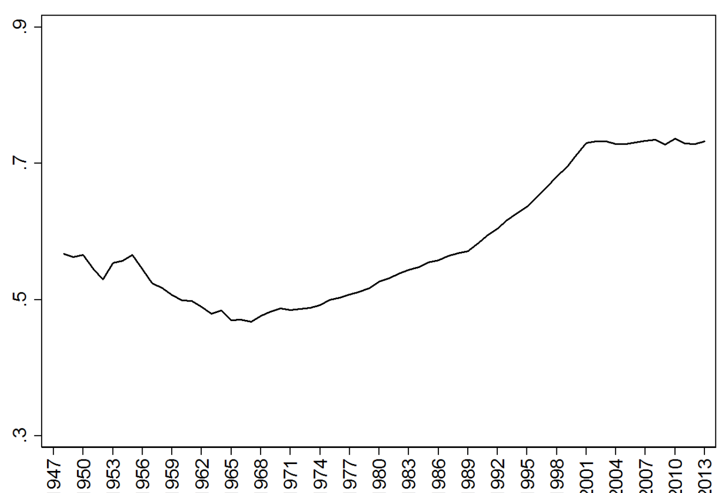
(a) Structures, Equipment and IPP Investment Shares, BEA



(b) Effects of Private and Government IPP Capital on LS

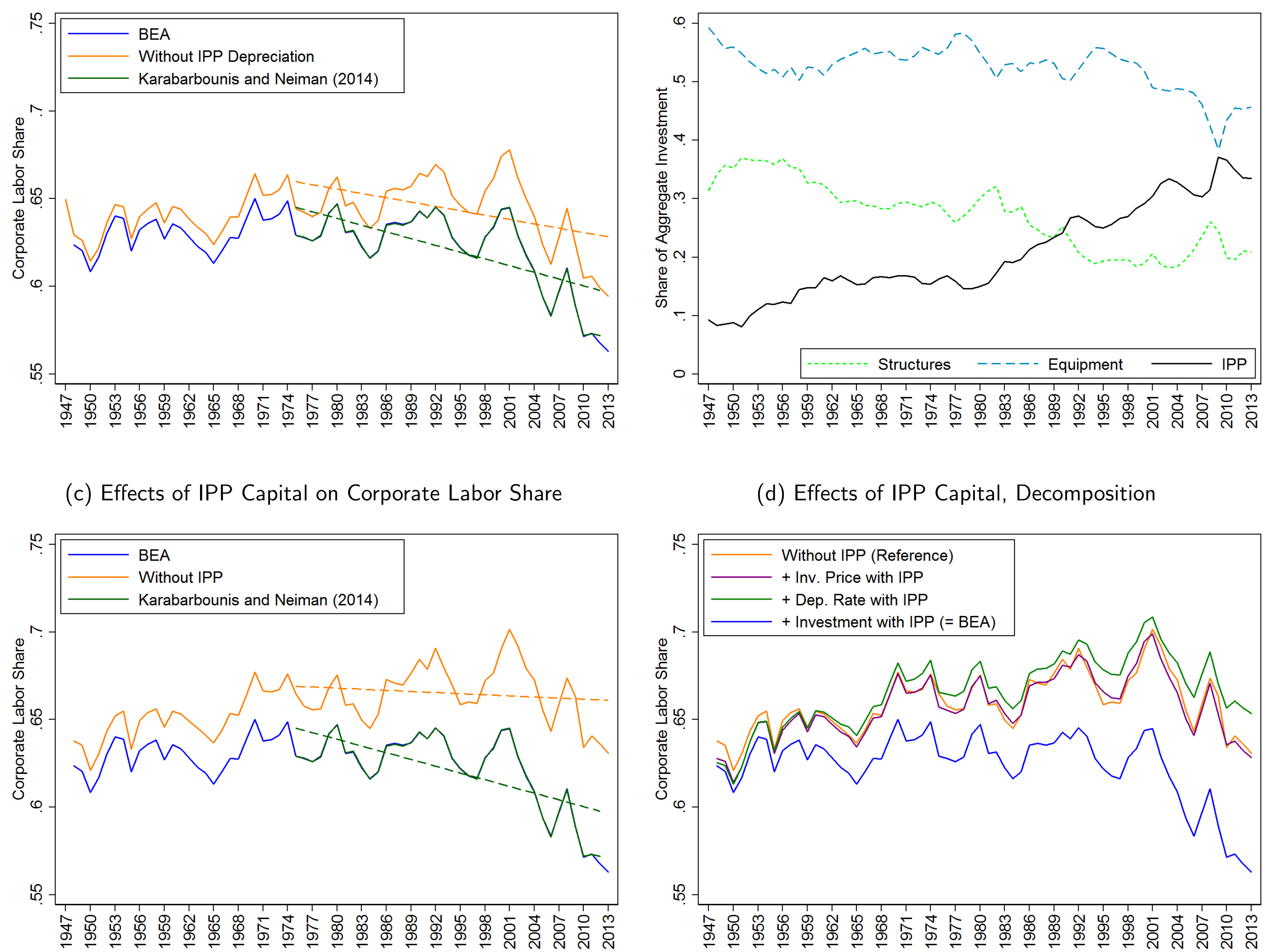


(c) Percentage of LS Decline Due to Private IPP Capital



Notes: Panel (a) shows the evolution of each type (i.e., structures, equipment and IPP) of private and government investment as share of aggregate investment. Panel (b) shows the effect on the labor share from private and government IPP capital separately. The reference scenario is benchmark labor share with IPP capital. Panel (c) shows the reduction in labor share generated by the capital of private IPP as a percentage of the total labor share decline. See section 4 for a discussion.

Figure 13: Effects of IPP Capital on Corporate Labor Share



(a) Corporate Labor Share, BEA 1947-2013

(b) Struct., Equip. and IPP Inv. Shares, Corporate Sector, BEA

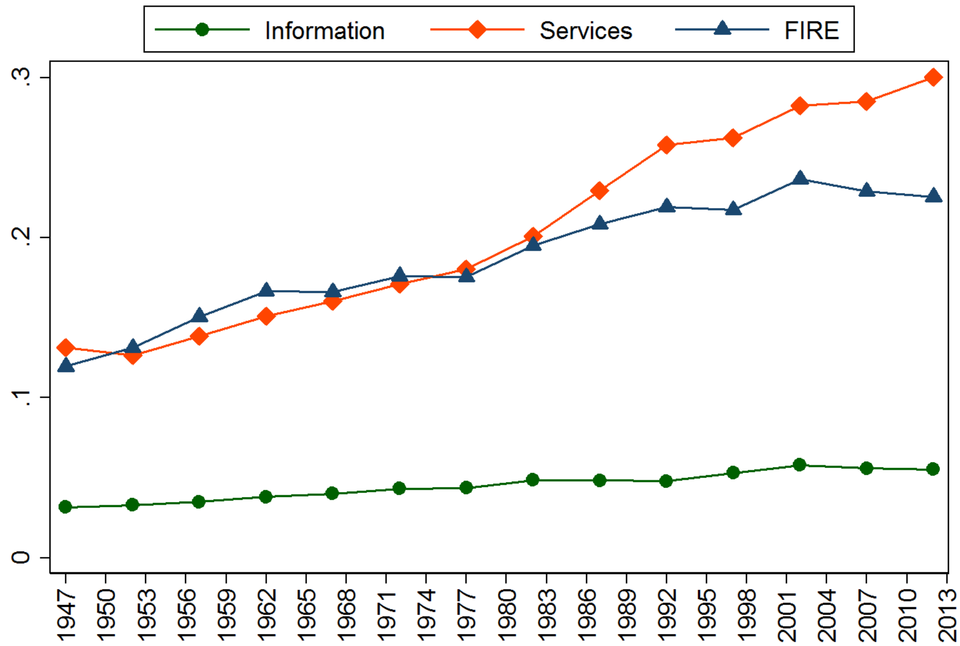
(c) Effects of IPP Capital on Corporate Labor Share

(d) Effects of IPP Capital, Decomposition

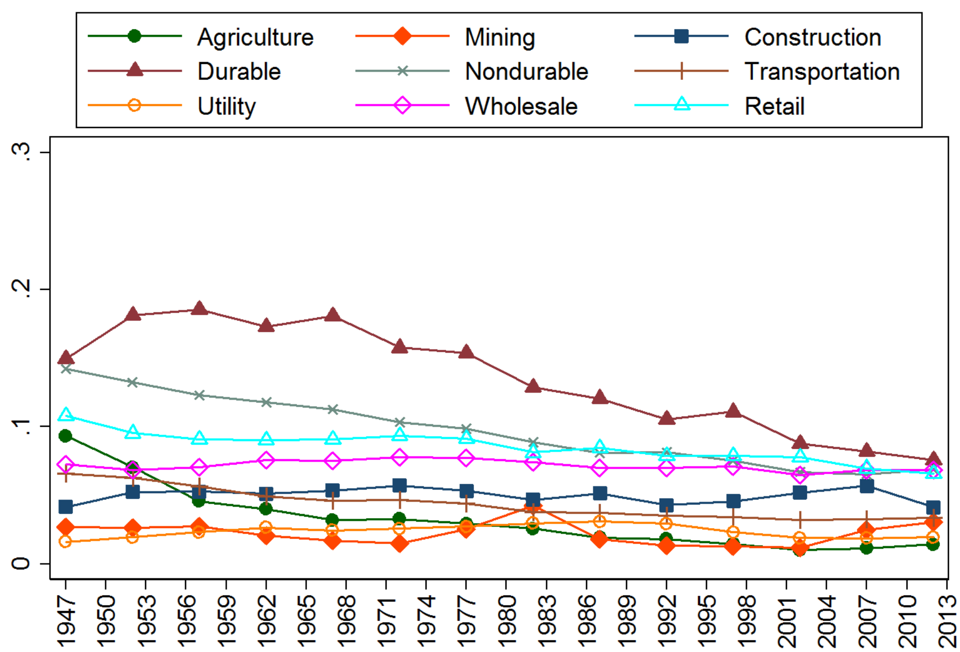
Notes: In panel (a) the reference scenario is the benchmark labor share for the corporate sector from the post-revision data (i.e. the blue line). This measure of labor share is identical to the updated labor share data supplied by Karabarbounis and Neiman (2014a) for the subperiod 1975 to 2012 (i.e. the green line). This panel shows the effects of removing IPP depreciation (i.e., the orange line). Panel (b) shows the share of nominal investment by type of assets. In panel (c), we remove the entire effect from IPP capital (i.e. the orange line). In panel (d), we decompose the effects of IPP capital by sequentially adding to the sans-IPP scenario, the effects from the price of IPP investment, the depreciation rate of IPP and the IPP investment.

Figure 14: US Output Shares by Industry, BEA 1947-2013

(a) Growing Industries



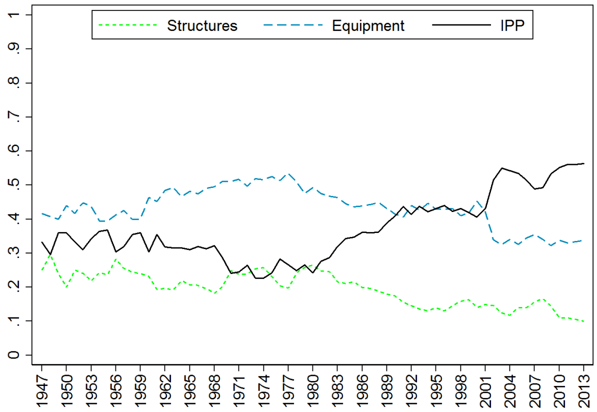
(b) Declining Industries



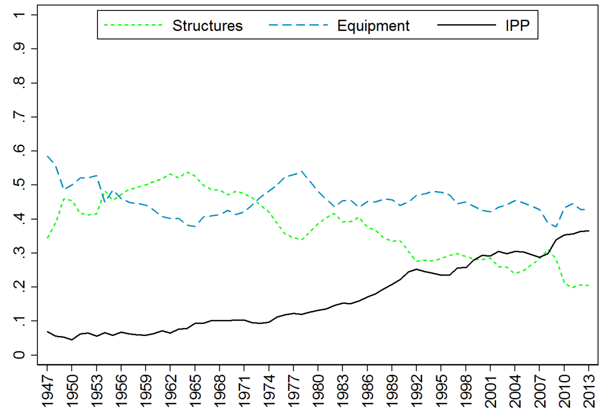
Notes: The output shares by industry are computed using NAICS classification as described in section 6.

Figure 15: Structures, Equipment and IPP Investment Shares, High IPP Industries

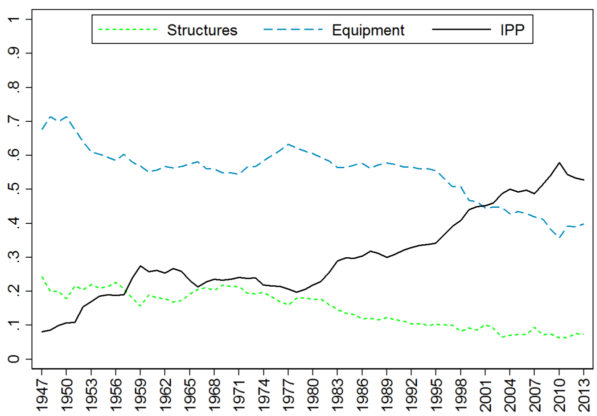
(a) Information



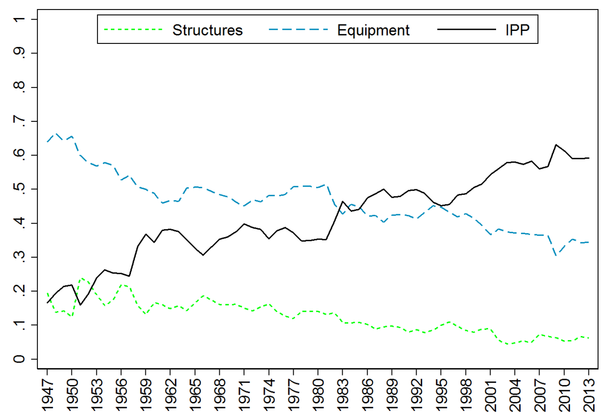
(b) Services



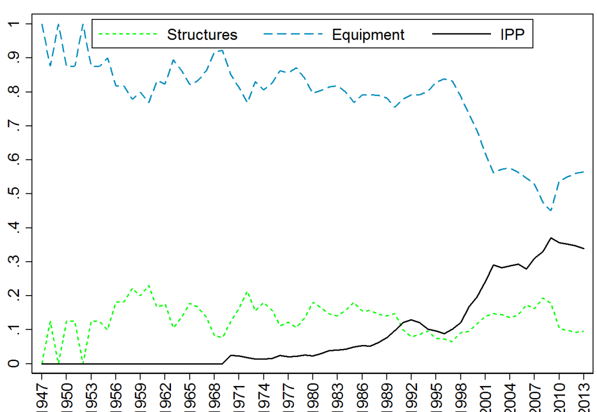
(c) Manufacturing: Nondurable goods



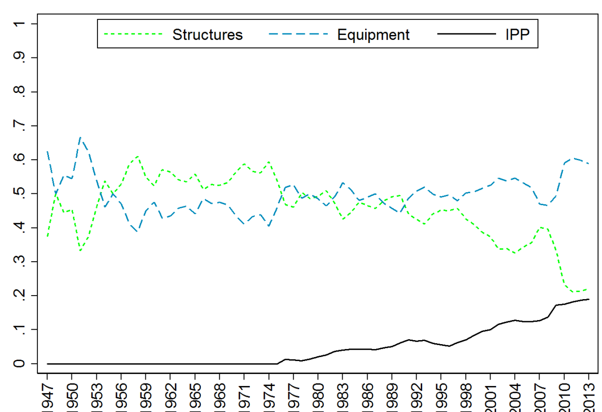
(d) Manufacturing: Durable goods



(e) Wholesale Trade



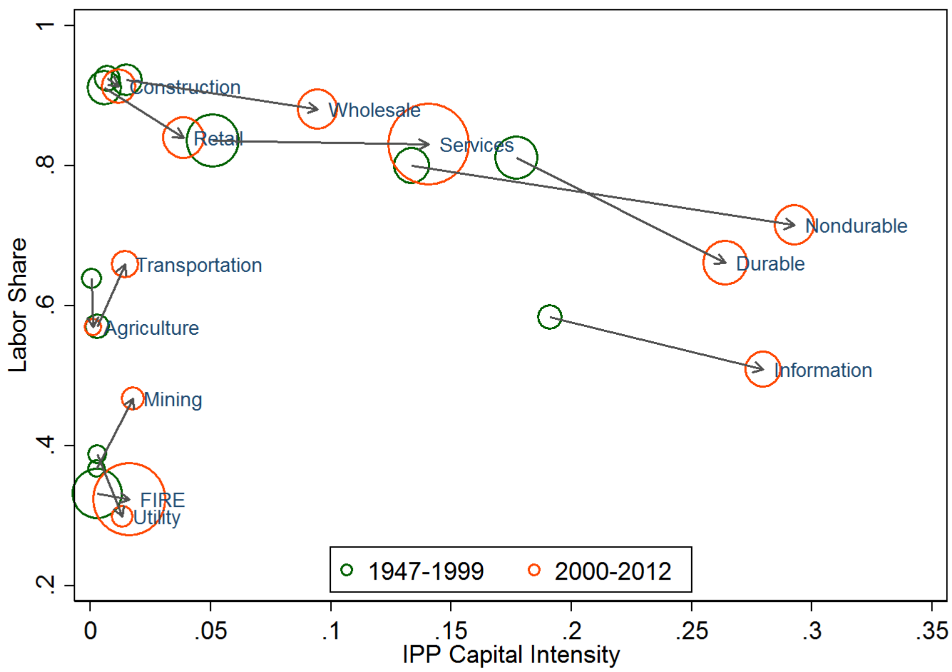
(f) Retail Trade



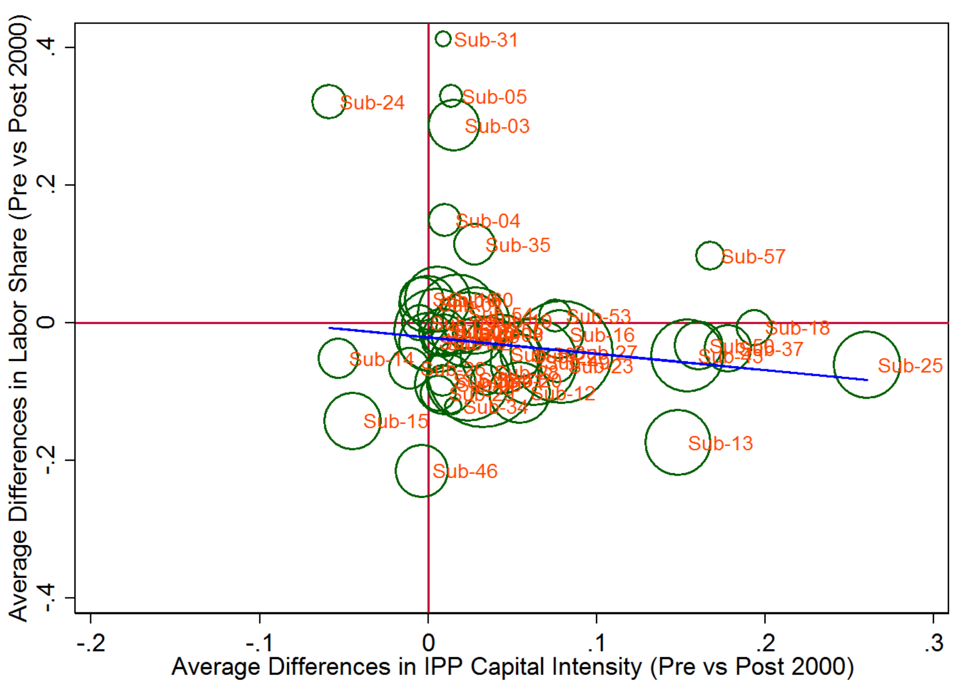
Notes: In each panel we plot the structures, equipment and IPP investment shares of industry-specific aggregate investment for 2-digit NAICS industries that we categorize as having high IPP investment.

Figure 16: Labor Share and IPP Capital Intensity by Industry: Pre- and Post-2000s

(a) Main Industries



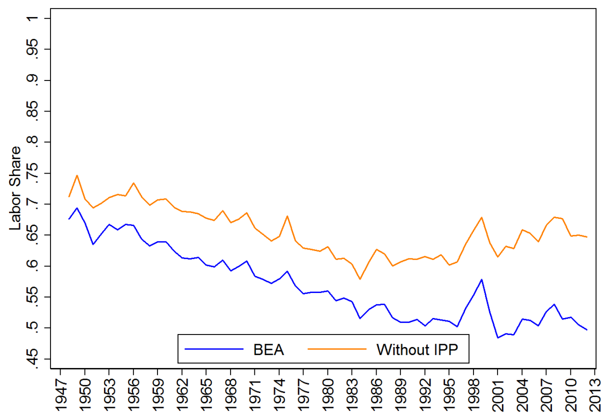
(b) Sub-Industries



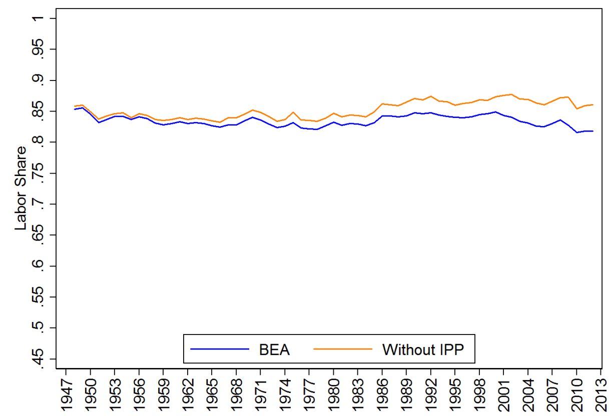
Notes: Labor share is computed by industry using NAICS classification. IPP capital intensity is the share of IPP capital in total capital by industry (or subindustry). The size of the points refers to the industry-specific share of output in the aggregate economy. See a discussion in section 6.

Figure 17: The Effects of IPP Capital on Labor Share By Industry

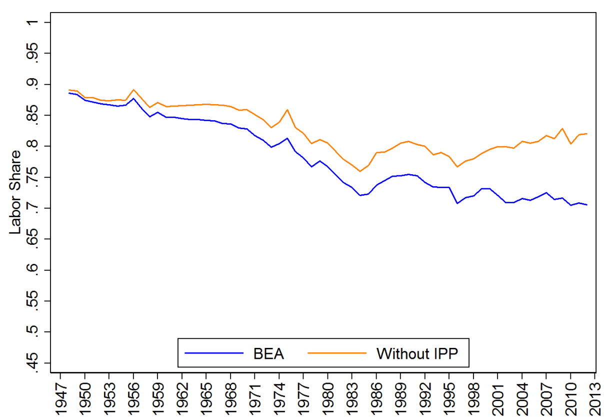
(a) Information



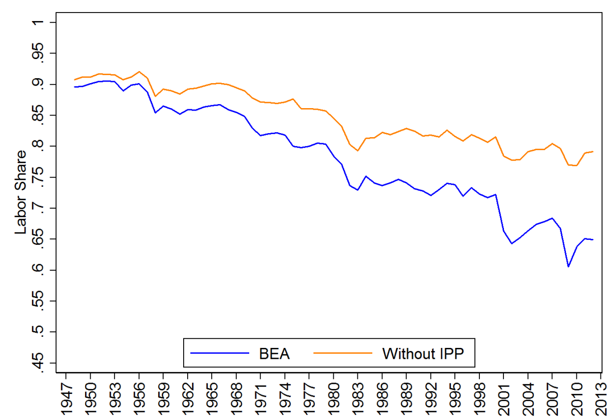
(b) Services



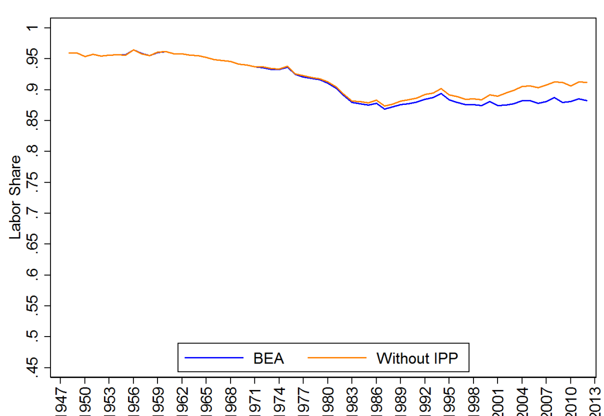
(c) Manufacturing: Nondurable goods



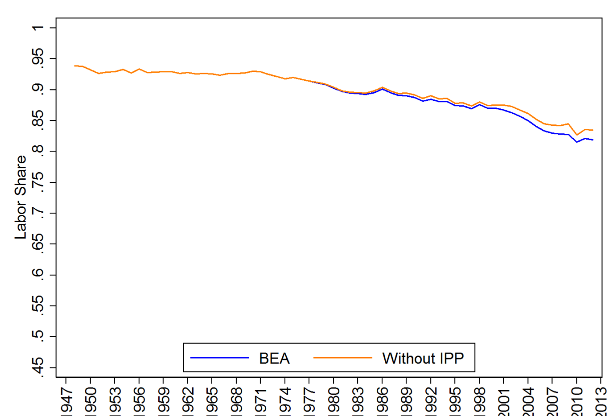
(d) Manufacturing: Durable goods



(e) Wholesale Trade



(f) Retail Trade



Notes: In each panel, the blue lines labeled "BEA" are the labor shares for the six industries which invest appreciably in IPP capital. The orange lines labeled "Without IPP" are the counterfactual labor share constructed by removing the full effects of IPP capital on the price of investment, the investment flow and the depreciation rate. See section 6 for a discussion.

Table 1: IPP Capital and the Long-Run Elasticity of Substitution Between Capital and Labor, US 1947-2013

	BEA Data		Counterfactuals		
	Post-2013 Rev. (1)	Without IPP (2)	+ IPP Price (3)	+ IPP δ (4)	+ IPP Inv. (5)
(a) Full Sample:					
Elasticity, σ	1.866***	1.087	1.058	0.768**	1.866***
$\cdot\ \Delta \ln$ (1-LS)	0.185***	0.024	0.019	-0.057**	0.185***
$\cdot\ \Delta \ln \frac{K}{Y}$	0.399***	0.308***	0.354***	0.191***	0.399***
(b) 1975-2010:					
Elasticity, σ	1.210***	1.039	1.016	0.937	1.210***
$\cdot\ \Delta \ln$ (1-LS)	0.170***	0.033	0.014	-0.050	0.170
$\cdot\ \Delta \ln \frac{K}{Y}$	0.982***	0.846***	0.919***	0.760***	0.982***

Notes: Panel (a) reports the implied long-run elasticity inferred from the ratio $\frac{\sigma-1}{\sigma} = \frac{\Delta \ln (\text{1-LS})}{\Delta \ln K/Y}$ where the increment Δ is a linear trend for our full sample. The increments are multiplied by 100, i.e., expressed in percentages. Column (1) refers to the most updated BEA data that incorporates IPP capital. Columns (2) to (5) refer to the accounting counterfactuals reported in panel (b) of Figure 9 discussed in section 3.4: Column (2) refers to our benchmark accounting conterfactual without IPP capital; column (3) introduces to the previous counterfactual the aggregate price of investment that incorporates the IPP price; column (4) introduces to the previous counterfactual the aggregate depreciation rate that incorporates the IPP depreciation rate; and column (5) introduces to the previous counterfactual the aggregate investment that incorporates IPP investment. By construction, column (1) and (5) are identical. In Panel (b) we reproduce our results for panel (a) but for the sample years in Karabarbounis and Neiman (2014a), i.e., from 1975 to 2010. We denote significance level at 10 percent with (*), 5 percent with (**) and 1 percent with (***). For the elasticity σ we report significance with respect to a value of one, that is, we explore whether the long-run aggregate production function is significantly different from Cobb-Douglas, while for $\Delta \ln$ (1-LS) and $\Delta \ln \frac{K}{Y}$ we report significance with respect to a value zero.