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Recent Declines in Labor's Share in US Income: A Preliminary Neoclassical Account

Robert Z. Lawrence

Abstract

As shown in the 1930s by Hicks and Robinson, the elasticity of substitution (σ) is a key parameter that captures whether capital and labor are gross complements or substitutes. Establishing the magnitude of σ is vital, not only for explaining changes in the distribution of income between factors but also for undertaking policy measures to influence it. Several papers have explained the recent decline in labor's share in income by claiming that σ is greater than 1 and that there has been capital deepening. This paper presents evidence that refutes these claims. It shows that despite a rise in measured capital-labor ratios, labor-augmenting technical change in the United States has been sufficiently rapid that effective capital-labor ratios have actually fallen in the sectors and industries that account for the largest portion of the declining labor share in income since 1980. In combination with estimates that corroborate the consensus in the literature that σ is less than 1, these declines in the effective capital-labor ratio can account for much of the recent fall in labor's share in US income at both the aggregate and industry level. Paradoxically, these results also suggest that increased capital formation, ideally achieved through a progressive consumption tax, would raise labor's share in income.

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Robert Z. Lawrence is senior fellow at the Peterson Institute for International Economics and Albert L. Williams Professor of International Trade and Investment at the Harvard Kennedy School.

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Peterson
Institute for
International
Economics

1750 Massachusetts Avenue, NW Washington, DC 20036-1903
Tel: (202) 328-9000 Fax: (202) 659-3225 www.piie.com

Over the past decade, in addition to its poor employment performance, the US economy has been plagued by sluggish wage growth and rising income inequality. The debate over inequality in the 1980s and 1990s focused on the growing disparity between the earnings of skilled and unskilled workers and the earnings of the super-rich (Lawrence 2008). Growing income inequality between capital and labor income has now been added to these concerns.

Remarkably, the growth in real GDP per worker over the decade of the 2000s, which averaged 1.7 percent annually, was actually more rapid than in the 1970s, 1980s, or 1990s, yet in the 2000s workers saw almost no increase in their take-home pay. Consistent with this gap between labor productivity and wage growth was a pronounced decline in the share of US national income earned by workers.

This development is unusual. For much of the past century, the long-run shares of national income earned by capital and labor in the United States have been fairly stable.[1] As figure 1 shows, since the late 1960s, the share of labor compensation (a measure that includes wages and benefits) in national income cycled between 64 and 67 percent. However, since 2008 that share has fallen considerably below this cyclical variation.[2] The counterpart to the declining labor share has been a rise in the share of capital, which has been especially concentrated in corporate profits. As profits are far less equally distributed than wages, this increase has contributed to rising income inequality.

There are several plausible reasons for this development—globalization, automation, weak bargaining power of labor, political capture, higher markups—but the natural starting point for explaining factor income shares is the neoclassical theory of the functional distribution of income enumerated by John Hicks and Joan Robinson in the 1930s.[3] This theory highlights the role played in allocating income between capital (K) and labor (L) by the ease with which they can be substituted. When there are constant returns to scale, competitive conditions, and a production function where output $Y = F(K,L)$ the magnitude of these responses can be summarized with a single parameter—the elasticity of substitution—commonly depicted by σ and defined as $d \log (K/L)/d \log (F_K/ F_L)$. If factors are paid their marginal products, R the rental rate = F_K and W the wage rate = F_L. This implies that the ratio of factor income shares is $\frac{RK}{WL} = \frac{R}{W} * \frac{K}{L}$. The components of this ratio will generally change in opposite directions.

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[1] See, for example, Cobb and Douglas (1928), Keynes (1939), Kaldor (1961), Dew-Becker and Gordon (2005), Mankiw (2007), and Lawrence (2008). The "stability" of shares is quite sensitive to how they are measured. It makes a difference whether labor compensation is measured relative to net or gross capital income and relative to the entire economy or just the corporate sector. For an early skeptical view of what exactly one means by a constant share, see Solow (1958). For a recent discussion, see Kraemer (2010). For a skeptical view that labor's share has recently fallen to all-time lows emphasizing the difference between net and gross income, see Bridgman (2014).

[2] With the exception of the United Kingdom, the European experience has been different. There was a rise in the labor share in the 1970s, but thereafter the labor share declined in many European countries and Ireland (Bertoli and Farina 2007, 12). See also (O. Blanchard 1997, O. Blanchard 2006).

[3] See Hicks (1963) and Robinson (1932). For a comprehensive review of the evidence and theories of labor's share, see Schneider (2011).

Thus for labor's share to fall, *RK* must rise by more than *WL*. When $\sigma = 1$, the components will change proportionally and the factor income ratio (*RK/WL*) will remain constant.[4] When σ is > 1, the factors are gross substitutes. A given percentage rise in *K/L* will give rise to a smaller percentage fall in R/W and labor's share will fall; conversely, if $\sigma < 1$, the factors are gross complements. A given percentage rise in *K/L* will be more than offset by a fall in *R/W*, and labor's share will rise.[5] As Elsby, Hobjin, and Sahin (2013) show, the relationship between changes in the labor share in income (*L*s) and the capital-labor ratio will be captured by equation (1):

$$d \ln L\mathrm{s} = -(1 - L\mathrm{s})\frac{\sigma-1}{\sigma}\, d \ln K/L \tag{1}$$

In this framework, σ can also be used to relate changes in factor shares to changes in the capital-output ratio (*K/Y*).[6] Where *K*s is the share of capital, for example, the relationship between *K*s and changes in *K/Y* is:

$$d \log K\mathrm{s} = (1 - \frac{1}{\sigma})\, d\, (\log (K/Y). \tag{2}$$

In this specification, an increase in the capital-output ratio will be associated with a rising share of capital in income if $\sigma > 1$, a declining share of capital if $\sigma < 1$, and no change when $\sigma = 1$.

Determining σ and changes in the quantities of capital and labor used as inputs, however, is not sufficient to explain changes in income distribution when there is technological change. Hicks characterized technical change according to its relative impact on the marginal products of the two factors. He called such a change "capital saving" if it raised the marginal product of labor by more than it raised the marginal product of capital. Following Uzawa (1961), however, I use the more common appellation "labor-augmenting." For a given wage-rental rate, such a change would lead firms to use more labor and less capital to produce a given quantity of output. "Labor-saving" technical change (normally called "capital-augmenting") raises the marginal product of capital by more than the marginal product of labor and leads to higher capital-labor ratios at any given wage-rental ratio. These changes can be captured in a production function by the degree to which each factor is augmented.[7] Assume λ_l and λ_k are measures

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[4] σ is defined here so that it is positive.

[5] Considering extreme cases when *K/L* increases reveals the intuition behind this result. If $\sigma = \infty$ and capital and labor are perfect substitutes, their relative prices do not change; if the supply of capital increases and *W/R* remains fixed, capital's share must rise. Conversely, if it is impossible to substitute capital for labor and $\sigma = 0$, starting from a position in which the capital-labor ratio was equal to the required proportion in which these factors had to be used and thus *W* and *R* are both positive, any increase in capital would be redundant and thus capital's marginal product would decline to zero. The result would be that all income would accrue to labor.

[6] The elasticity of F_k with respect to the capital-output ratio *K/Y* is given by $\frac{-1}{\sigma}$, which implies that the ratio of capital's share in income $K\mathrm{s} = F_k\, K/Y$. Thus $d \log K\mathrm{s} = (1 - \frac{1}{\sigma})\, d\, (\log (K/Y)$. See Rognlie (2014) and Bentolia and Saint-Paul (2003) for derivations.

[7] If technical change raises the marginal product of capital by more than the marginal product of labor. Hicks (op. cit chapter VI, pp. 121–22) defines it as "labor saving." I refer to it here as "capital augmenting." Similarly, technical changes that raise

of labor- and capital-augmenting change, respectively. If $d\lambda_l > d\lambda_k$, there is net labor-augmenting (or capital-saving) technical change; if $d\lambda_l < d\lambda_k$, there is net capital-augmenting (or labor-saving) change.

Once technical change is taken into account, what matters for income distribution is the change in the *effective capital-labor ratio*, $k = (\lambda kK/\lambda lL)$. If $d\lambda_l$ and $d\lambda_k$ are equal, there is so-called Hicks-neutral technological change, and both factors are augmented to an equal degree. With nonneutral change, however, a complete explanation of changes in factor income shares requires determining not only σ and changes in the physical measures of K and L but also how λ_l and λ_k have evolved over time. With technical change, equation (1) becomes

$$d\ln Ls = -(1 - Ls)\frac{\sigma-1}{\sigma}\,d\ln(\lambda_k K/\lambda_l L). \tag{3}$$

In this framework there are two possible explanations for labor's recent declining share. The first is that capital and labor are gross substitutes—that is, that $\sigma > 1$ and there has been a rise in k. The second is that capital and labor are gross complements—i.e., that $\sigma < 1$ and there has been a decline in k. Several recent studies have come down on the side of the first explanation, arguing that $\sigma > 1$ and that an increase in capital deepening is responsible for the fall in labor's share. Elsby, Hobjin, and Sahin (2013, 40) point to increased capital intensity caused by the offshoring of labor-intensive tasks from the United States as the major cause. Karabarbounis and Neiman (2014) point to a global decline in the relative prices of investment goods, which, they argue, has raised capital-labor ratios and reduced labor's share. Piketty (2014) develops a model in which the capital-output ratio is a function of the ratio of s/g—the saving rate over the growth rate. The capital-output ratio rises when g declines and σ remains constant. Piketty and Zucman (2013) use this result and equation (2) to calibrate that $\sigma > 1$ and the decline in labor's share is the result of a higher capital (wealth)-output ratio.

All these claims are at odds with the preponderance of studies that have found that $\sigma < 1$ in the United States. Although there is empirical evidence and a theoretical presumption that technical change has been labor augmenting, these studies all ignore a possible role for changes in the pace of labor-augmenting change in accounting for the change in factor income shares.

This paper puts forward the alternative "gross complements" explanation for the declining US labor share—that $\sigma < 1$ and the effective capital-labor ratio has declined. It shows that labor-augmenting technical change in the United States has been sufficiently rapid, both at the aggregate level and in the sectors that account for the largest portion of the declining labor share, that despite a rise in measured capital-labor ratios, effective capital-labor ratios have fallen. In combination with estimates that $\sigma < 1$, these changes in k can account for the declines in labor's share in GDP since 1980. This is the case for declines in labor's share at the aggregate level; within key sectors, such as manufacturing, mining, and

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information technology (IT); and within the manufacturing industries that have had the largest impact on the declining labor share overall.

The results are compatible with the extensive empirical evidence surveyed by Chirinko (2008) that $\sigma < 1$ and with the critiques of Piketty advanced by Rognlie (2014), Summers (2014), and Acemoglu and Robinson (2014). The results are also consistent with the evidence that on balance US technical change has been labor augmenting (Antras 2004, Wei 2014, Young 2010). In addition, they accord with the fundamental insights of growth theory that when $\sigma < 1$, labor-augmenting technical change is required to maintain a balanced growth path (i.e., a path where capital and output grow at the same rate) in the face of rising capital-labor ratios (Uzawa 1961, Jones and Scrimgeour 2004). They are also supported by the work of Acemoglu (2003, 2002), who explains how endogenous technical change is likely to revert to pure labor-augmenting change.

This paper uses industry and aggregate data to estimate a constant elasticity of substitution (CES) production function assuming that technical change has an exponential functional form. Its conclusions are in line with those of Oberfield and Ravel (2014), who use manufacturing plant data and a different identification strategy based on variations in factor prices across local areas. Despite their different methodology, they also find that σ in US manufacturing is less than 1 and that most of the recent decline in the share of labor in US manufacturing can be accounted for by "changes in the pace of the bias of technical change."[8]

Section I discusses measurement and data issues and explores the timing, magnitude, and sector sources of various measures of recent declines in the US labor share. It uses shift-share analysis to measure the degree to which the overall decline can be attributed to share changes within industries and changes in industrial composition, identifying the sectors that have made the most important contributions to the aggregate change over various periods. Since 2000 these sectors have included the manufacturing, mining, and IT sectors, including industries within manufacturing such as petroleum refining and coal products, chemicals, and computers and electronics.

Section II critiques the studies that claim that capital and labor are gross substitutes, point to capital deepening to account for the decline in labor's share, and fail to evaluate the pace of labor-augmenting technical change. These accounts are contrasted with evidence that $\sigma < 1$; that on balance technical change has been labor augmenting; and that recent growth in investment, especially in US manufacturing, has been unusually weak.

Section III applies the approach developed by Antras (2004) to simultaneously estimate σ and the magnitude of factor-augmenting technical change. These estimates are used to derive measures of changes

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[8] Oberfield and Raval (2014) are agnostic as to the precise source of this bias. They mention automation, offshoring, and the decline of unions as possibilities. This paper places technical change at the heart of the explanation.

in the effective capital-labor ratio (k), which are combined with the estimates of σ to demonstrate that especially in manufacturing, recent changes in labor's share in the aggregate as well as in key sectors and industries can be explained with a reasonable degree of accuracy.

Section IV discusses the implications of the findings for policy measures that affect capital formation, in particular the importance of stimulating capital formation to increase labor's share. It points to alternative methodological approaches and provides suggestions for further research.

I MEASURES AND SECTORAL SOURCES OF THE DECLINE IN LABOR'S INCOME SHARE

The most useful measure of factor shares for discussions of overall US income inequality is the share of labor compensation in national factor income (NFI). This measure includes (1) compensation of employees; (2) the net income earned by capital in various forms (i.e., proprietor's income, rental income, corporate profits, and net interest) after depreciation and inventory valuation adjustments have been taken into account; and (3) net international factor payments. The more comprehensive measure of national income includes taxes on domestic production and imports, but because taxes could be used for a variety of purposes that could benefit either capital or labor, it is appropriate to subtract them from national income when exploring the shares that are relevant for inequality. In practice, as these taxes have been a fairly constant share of national income between 1980 and 2014 (about 8 percent), their inclusion in the aggregate measure of national income is not of great consequence when tracking recent changes in factor shares.

Net domestic income subtracts receipts by US nationals from foreigners and adds payments made by US nationals to foreigners. It thus measures the incomes of factors located in the United States. It is more appropriate as a dependent variable when causation is being ascribed to developments that occur in the United States. For empirical analysis of factor shares, however, equivalent measures on the production side are generally used, and domestic product is thus explained by inputs in the domestic economy. In this case, gross domestic product (GDP), the most commonly used aggregate output measure of value added produced within the United States, includes labor compensation, gross operating surplus, and taxes on production and imports. As with net domestic factor incomes, taxes on production and imports and depreciation should be subtracted for tracking the relative income shares in the domestic economy that are relevant for inequality (Bridgman 2014).

As is apparent from figure 2, which reports labor's share in various income measures since 1929, there is a strong cyclical component to the movement in labor's share. The wage share typically rises with the tightening of the labor market at the end of expansions, remains high at the start of recessions, and falls during the initial phases of recovery. Because of this volatility, it is not easy to distinguish trends from the cycle. Indeed, it is possible to examine the data and to discern a declining trend in the labor share in US

GDP after 1969, after 1980, or after 1990 (consider the peaks in figure 2) or to see no trend at all after 1969 until after 2008, with the share cycling around 65 percent of income. Writing in 2005, for example, Dew-Becker and Gordon (2005, 71) noted that "labor's share was actually higher in 2005Q1 than eight years earlier. Over a longer period going back to 1954, labor's income share has been virtually constant." Writing even later, others, such as Lawrence (2008), still emphasized the long-run constancy of US income shares dating back to the 1980s.[9]

Different measures of labor's share yield somewhat different pictures, but all indicate that labor's share rose between the 1930s and 1970 and has been unusually low since 2008. The measure most consistent with the proposition that the share has been constant over the long run is the share of compensation in GDP (red lower line).

As figure 3 shows, depreciation has constituted a growing share of GDP over the long run; as net domestic product and national income take depreciation into account, the share of labor compensation in these measures actually had a stronger upward trend through the late 1960s than the share in GDP. After 2008, however, because of slow capital formation, depreciation has actually grown more slowly than GDP. In addition, net foreign factor payments have increased, so that labor's share in national income is somewhat lower than in net domestic product. In 2008 the 55 percent share in national income was similar to what it was in the 1950s and even the 1940s. However, from the standpoint of concerns about income equality, labor's share in net factor incomes (the highest purple line) is the most relevant measure. It shows labor's share in 2014 at levels last seen in the late 1940s.

Since 2000 labor's share has fallen by 5.1 percentage points of net national factor income. Had labor compensation per hour simply kept pace with the rise in net national factor income per hour since 2000, worker compensation in 2014 would have been 7.2 percent higher than it was. Moreover, over the past decade take-home pay grew more slowly than labor compensation because of the additional costs of providing benefits, such as more expensive healthcare.[10] Had take-home wages and salaries kept pace with the growth in net factor income between 2000 and 2014, wages in 2014 would have been 9 percent higher than they were. These aggregate labor compensation and wage measures include the earnings of "super-rich" Americans at the very top of the wage distribution. As the highest-paid wage earners increased their share of labor compensation, pressure on the earnings of workers in the middle and lower ends of the wage distribution was even greater.

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[9] Since the 1970s, the international, and especially European, experience has been much more varied. The United Kingdom and the United States maintained fairly constant shares until recently, while countries in continental Europe experienced periods of both rising and falling shares (see Blanchard 1997, Harrison 2005).

[10] According to Burtless (2007), the real average compensation of a full-time worker increased by 5.6 percent between 2000 and 2005, but of this increase 10 percent went to increased social insurance contributions, 24 percent to increased employer pension contributions, and 35 percent to health insurance, leaving less than a third for increased cash wages.

The Business Sector

The conclusion that the behavior of labor's share in the 2000s has been different also emerges from business sector data. As figure 4 shows, the rise in real product compensation matched the rise in gross output per worker between 1969 and 2000 and matched the rise in net output per worker after 1969 until as late as 2008. There has been a larger and growing gap between the rise in both gross and net output per worker and real compensation (i.e., wages deflated by the consumer price index). This gap is sometimes pointed to as indicating that labor is not getting what it deserves, but this gap primarily reflects differences between the mix of goods and services that workers consume and produce (Lawrence 2008). Generally, the prices of the goods and services workers produce have risen more slowly than the prices of the goods and services they consume. On the one hand, there has been relatively rapid growth in productivity in equipment, which workers do not buy. On the other hand, the consumer price index includes housing services, which are not something workers (outside of the construction sector) produce.[11] Had workers chosen to consume the same mix of goods and services they produced, their real (product) wages would have kept pace with (gross) labor productivity growth in 1965–2000 and net labor productivity growth in 1965–2008.

However, as figure 4 indicates, since 2000 growth in real product compensation has fallen behind the growth in real output per worker. This shortfall means that a declining share of gross business sector income has accrued to labor. Moreover, since 2008 the rise in real product compensation has also fallen behind the rise in net value added per worker, implying a growing share in business income for claimants on capital. Nonetheless, around 2000 the share of labor compensation was unusually high, in part because of the activity associated with the dot.com boom. In addition, excluding this period gives rise to somewhat smaller shortfalls between the growth of net value added per worker and the real product wage.

Tracking the shares of labor and capital in national income misses an additional source of growing inequality (figure 5). Income earned by owners of capital takes several forms (corporate profits, net interest income, proprietors' and rental income). Recently, corporate profits have constituted a growing share of capital income. The 5.1 percentage point increase in the share of corporate profits in national income after 2000 is actually greater than the decline in labor's share in income, primarily because of a fall in the share of another component of capital income, net interest. Given that corporate profits accounted for 8.8 percent of national income in 2000, the rise of 5.1 percentage points in the share of corporate profits between 2000 and 2014 represented an increase of 58 percent in the corporate profit share in national income between 2000 and 2014 and a 47 percent increase over the average 9.4 percent of net corporate value added accounted for by corporate profits between 1980 and 2000. Most of this increase

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[11] For a discussion of the role played by housing, see Rognlie (2015).

reflects an increase in the share of corporate profits in domestic income, but national income also includes the foreign earnings of US multinationals; about a quarter of all corporate profits were earned abroad in both 2000 and 2014.[12]

In sum, labor's share in income has fallen by a variety of measures, especially since 2000. The most inclusive measures (for national income) point to declines on the order of 7 percent, with the declines in the gross measures larger than the declines in measures that take depreciation into account. However, these national measures reflect compensation in the government sector as well as measures that impute labor compensation to proprietors. In the corporate sector, the declines in share have been even larger—on the order of 11 percent since 2000. At the same time, the share of corporate profits in national income has increased 57 percent.

Data Selection

When determining the causes of the declining labor share in income, it is helpful to identify the industries that have made the greatest contribution. However, examining changes in income shares in the industries that make up GDP presents challenges because of revisions in the methods used to classify industries and to estimate income. Several industrial classifications have been used (e.g., the Standard Industrial Classification [SIC] for the early periods and the North American Industry Classification System [NAICS] for recent periods). In addition, the Bureau of Economic Analysis recently revised its methodology for estimating value added by industry by changing its treatment of inputs such as research and development (R&D). Previously, spending on R&D, entertainment, and literary and artistic originals were all treated as inputs, which were subtracted from value added. In recent revisions, these items are included as part of value added and investment in fixed assets. These changes have the effect of raising the estimates for value added in R&D–intensive industries, most of which are in manufacturing. As the changes are more important for estimates of gross operating surplus than for labor compensation, the new measures also reduce the share of value added represented by aggregate labor compensation. Combining the unrevised data from before 1997 and the revised data thereafter has the effect of showing a stronger declining trend in the share of labor in general and in the manufacturing sector and R&D–intensive industries in particular.

Unfortunately, the revised data are available only after 1997, whereas data using the previous methodology, which assumes R&D and several other components of firm spending are input costs, are available for 1987–2011. I use the most recent revised data for studying recent changes in order

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[12] In 2014, for example, foreign profits accounted for 25 percent of all US corporate profits, about the same as in 2000. By contrast, net foreign profits constituted 14 percent of profits between 1990 and 1999. Foreign profits contributed 38 percent of corporate profits in the recession year of 2008.

to identify the industries that have played the largest roles in the recent declines in labor share. For longer-run analysis, I use multiple sources.

The data developed by Jorgenson, Ho, and Samuels (2012) are especially useful, because they have developed consistent time series of gross factor incomes using the NAICS. I therefore rely on their measures for analyzing the period 1947–2010 for the economy as a whole as well as for the long-run behavior of labor shares in major sectors such as manufacturing, mining, and posts and telegraphs. To undertake the analysis at a more disaggregated level, I use the (unrevised) NAICS data available for 1987–2011 from the Bureau of Economic Analysis and the Bureau of Labor Statistics. I also use the data developed by the National Bureau of Economic Research in its manufacturing database in an exercise at the six-digit NAICS industry level.

Industry Contributions

The long-run stability of the aggregate labor share in US GDP is surprising given the volatility of labor shares in income within several industries and the changing contributions of industries to overall value added in the economy.[13] Therefore, in explaining the behavior of the overall labor share in value added, it is helpful to distinguish between the impact of changes in sector shares in output and changes in labor shares that occurred within particular sectors. This can be done by decomposing the overall change in labor share (Sl) in gross value-added into changes in sectors output shares (between-industry changes), denoted by W_i, and changes within-industry labor shares, denoted by Sl_i using the following formula:

$$\Delta Sl = \sum i \Delta Wi \; Sl_i + \sum i W_i \Delta Sl_i$$

Change in labor share = between-industry weight changes + within-industry labor share changes

As reported in table 1, although the overall share of labor compensation in GDP fell by about 4 percentage points between 2000 and 2012, the decline was the result of a large number of sectors making negative contributions and just a small number, especially educational services, healthcare, and government, making positive contributions. Over this period the negative impacts were highly concentrated in a few sectors. The between- and within-sector decomposition shows that they account for just 22 percent of GDP declines, whose impact was equal to 82 percent of the overall decline (3.28 of the 3.92 percentage point decline) or, as several sectors made positive contributions, 66 percent of all the absolute changes. Although manufacturing contributed only 15 percent of overall value added in GDP in 2000, the output-weighted declining labor share in manufacturing was equal to 44.4 percent (1.74 percentage points) of the overall economywide drop in labor's share in income. The weighted impact of information services (which had an unusually high share in 2000 because of the dot.com boom, with

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[13] For a theoretical exploration of the relationship between aggregate and sector shares, see Acemoglu and Guerrieri (2008).

many start-ups that were not earning profits and contributed 4.6 percent of GDP) was equal to 21.2 percent of the overall decline; the impact of mining (just 1.1 percent of GDP) was 17.59 percent. Almost all of these changes—3.97 of the 4.0 percentage points—were reflective of changes within these sectors as opposed to changes in the industry shares in value added (i.e. the between-sector changes).

Although these sectors have strongly influenced the aggregate since 2000, in understanding their behavior it is useful to determine when the declines in labor share within these sectors actually began. For this purpose the long-run data of Jorgenson, Ho, and Samuels (2012) are useful. As figure 3 shows, the changes in manufacturing that were evident after 2000 were actually a continuation of a trend that began in the mid-1980s. Before then, labor's share in manufacturing remained fairly constant for a long period: the share of labor in income in manufacturing in 1988 was about the same as it was in 1954. Long-run factor income shares in mining, by contrast, have been volatile over the long run. They remained in the vicinity of 40 percent until 2000 but then experienced a large decline. The IT sector (captured in the Jorgenson, Ho, and Samuels data as posts and telecommunications) experienced a large decline between 1947 and 1960, remained around 60 percent through 1980, and then experienced a declining trend that was interrupted by the rise associated with the dot.com boom around 2000.

This suggests that the behavior of manufacturing and IT warrants attention as far back as the 1980s, whereas study of the behavior of mining should focus mainly on the period after 2000. To explore the impact of these medium-term changes, however, it is necessary to use the unrevised official NAICS data, which are available only after 1987. As reported in table 2, in these data the aggregate decline in labor's share between 1987 and 2011 is relatively small (2.7 percentage points). However, this stability is the result of offsetting changes in individual sectors. In particular, there have been very large declines in the labor income shares in manufacturing (from 68 to 52 percent) and in mining (from 40 to 28 percent) (figure 6). There have been substantial but smaller declines in retail and wholesale trade, transportation, and information and increases in labor's share in agriculture, utilities, professional and business services, education, and healthcare.

The shift-share analysis reported in table 2 breaks down the overall change between changes associated with the relative sizes of the sectors (between-sector changes) and changes within sectors. It suggests that the changes overwhelmingly reflect shifts within rather than between sectors. In 1987 the labor share of income in manufacturing was fairly high. Its shrinkage from 17.4 to 11.5 percent of GDP contributed 0.6 percentage points to the fall in the aggregate share; the contribution of the share changes within manufacturing (1.8 percentage points) was far more important. The 2.4 percentage point impact stemming from manufacturing was equal to 87.9 percent of the overall fall of 2.7 points.

Manufacturing

The decline in the labor share in manufacturing is especially interesting, for three reasons: it began earlier than the aggregate labor share, it made the largest contribution to the aggregate decline after 1987, and manufacturing is heavily involved in international trade. Judged by the share of labor earnings in value added, manufacturing was a relatively labor-intensive sector in 1987. It accounted for more than a quarter of all of the labor compensation in private industry but just 16 percent of both the gross and net operating surplus earned in private industry. By 2011 manufacturing's share of labor compensation in private industry had declined to about 14 percent, about the same as its share in gross operating surplus. In 1987, judged by income shares, the typical manufacturing business was thus more than 50 percent more labor intensive than the rest of private industry. By 2011 labor intensity in manufacturing was about the same as the rest of economy.

In a sector experiencing increasing pressures from international competition, as well as a large decline in employment, one might have expected relatively weak wage growth in manufacturing. However, the drop in labor's share in manufacturing income did not result from a large decline in the relative compensation of manufacturing workers. In fact, the rise in average compensation in manufacturing roughly kept pace with compensation growth in the rest of the economy. Between 2000 and 2012, for example, average compensation per full-time employee rose 64 percent in manufacturing and 61 percent in private industry, according to the Bureau of Economic Analysis.[14]

One possibility is that this wage performance reflected a shift in the employment mix toward more skilled—and thus higher-paid—workers. Indeed, this mix change does explain why manufacturing compensation increased somewhat more rapidly than the rest of private sector.

The employment cost index (ECI) tracks the cost of employing workers with a given set of attributes (skill, education, experience, etc.). It thus gives a better measure of manufacturing wage growth for workers with given skill levels. Between 1987 and 2014, the ECI for manufacturing increased only 2 percent less than the ECI for all civilian workers (and between 2000 and 2012, manufacturing wages grew 1.5 percent more slowly). Thus weak relative wage growth is not a big part of the explanation for labor's declining share in manufacturing compared with the rest of the economy. In addition, as panel a of figure 7 shows, manufacturing's constant share in both the gross and net operating surplus earned in private industry over this period occurred despite a decline in the overall share of the fixed assets devoted to manufacturing. Thus the declining share of labor compensation in manufacturing reflected the combination of a massive drop in manufacturing employment and an increase in overall profitability

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[14] Brock and Dobbelaere (2006) also find that labor's bargaining power was not affected. Kamal, Lovely, and Mitra (2014) find that globalization increased the labor share in China. Ahsan and Mitra (2014) find a similar effect for labor-intensive industries in India.

rather than a decline in the relative pay of manufacturing workers or an increase in the rate of investment. In real terms, manufacturing's share of output has remained roughly constant since 1947.

As panel b of figure 7 shows, rates of return to capital (as indicated by the ratio of the net operating surplus to the value of fixed assets) have remained fairly constant in private industry. However, the returns in manufacturing have increased substantially since 1998, reaching 20 percent in 2012.

A third type of shift-share analysis for the manufacturing sector indicates which three-digit NAICS industries have been the largest contributors to the declining labor share in manufacturing value added. Although 14 of the 18 industries in manufacturing experienced some decline in labor share, the changes with large impacts were concentrated in three industries: petroleum and coal products, chemical products, and computers and electronics. Together these industries, which accounted for just 22.6 percent of value added in manufacturing in 1987, had impacts that amounted to 68 percent of the overall decline in labor's share between 1987 and 2011 (table 3). Changes in industrial composition (between-industry changes in weights) accounted for just over a fifth of the decline; 77.6 percent of the decline reflected the impact of within-industry changes. The drops in labor's share in petroleum refining (from 43.2 to 12.2 percent), chemical products (from 49.6 to 35.2 percent), and computer and electronic products (from 81.7 to 57.7 percent) were particularly dramatic.

A similar result emerges when data for 473 six-digit industries are used in a shift-share analysis. The computation in table 4 indicates that 84 percent of the 13.9 percentage point change between 1980 and 2000 can be ascribed to changes within the six-digit industries. Although the decline is smaller between 2000 and 2009 because of cyclical effects, a similar conclusion—that within-industry changes dominate—emerges from the decomposition of the decline between 2000 and 2009. What is clear, therefore, is that the declining labor share both within the manufacturing sector and the economy as a whole was not caused primarily by the reallocation of resources toward less labor-intensive industries. The bulk of the changes came from changes in shares within industries: 295 of 473 industries, accounting for 76 percent of value added in 2009, experienced within-industry declines in labor share.

In sum, labor's share in income has fallen, especially since 2000, to a degree that appears to be outside the historical norm of cyclical fluctuations. However, even the fairly constant labor share before 2000 was the outcome of offsetting developments across sectors, in particular the rise in labor shares in several service sectors, which offset declines in the IT and manufacturing sectors that began in the 1980s and in the mining sector after 2000. Within manufacturing the changes have been pervasive, but a few industries, especially petroleum refining, chemicals, and computers and electronics, have played key roles in the decline. In the case of petroleum and chemicals, they have done so because both their output shares have increased and labor's shares have declined. However, most of the changes in labor share have reflected changes in factor shares within industries.

The explanation offered later in this paper fits these facts. A fall in the effective capital-labor ratio will raise the marginal product of capital and thus the rental-wage ratio. If the elasticity of substitution is less than 1, this decline will raise the rate of return and the share of capital. At the same time, with sufficiently inelastic demand for labor and rapid labor-augmenting technical change, the labor share and the wage rate could actually fall, despite the rise in the marginal product of labor.

II EXISTING STUDIES

Several recent studies offer explanations for recent declines in the share of labor that rest on claims that σ exceeds unity and there has been increased capital deepening.

Recent Studies

Karabarbounis and Neiman (2014) maintain that the declining labor income share, both in the United States and globally, can be explained by the acceleration in technological progress in the equipment industry and the associated decline in the relative price of capital goods that took place in the early 1980s. They find that, internationally, lower relative prices for investment goods are associated with lower labor shares in income. They use calibration methods based on this international cross-section relationship to estimate that a σ of 1.42 best fits the data. While emphasizing more rapid technical change in the production of equipment, they assume that there is factor-neutral productivity at the aggregate and firm level. As they acknowledge, “The choice of a CES technology with elasticity greater than one rather than a Cobb-Douglas technology (with an elasticity equal to one) is essential [italics added] for producing declines in the labor share in response to declines in the cost of capital relative to the wage because firms increase their capital-labor ratios more than they would with Cobb-Douglas production” (p. 14). In other words, given their assumption of Hicks-neutral technical change, the only way they can explain labor’s declining share in their framework on the basis of a decline in the cost of investment goods is to calibrate a $\sigma > 1$. By assumption, they thus rule out the explanation presented here—that $\sigma < 1$ and that despite the decline in the relative price of capital and associated rise in the capital-labor ratio more rapid labor-augmenting technical change may have resulted in a decline in the effective capital-labor ratio.

In *Capital in the Twenty-First Century*, Thomas Piketty makes the capital-income ratio (K/Y) a function of the saving rate (s) and the growth rate (g); his key equation is $K/Y = s/g$. He argues that with σ unchanged, a decline in g will increase K/Y. If this rise in K/Y is to reduce labor’s income share, σ must be greater than 1, as can be seen from equation (2). Piketty supports his claim that $\sigma > 1$ by citing Piketty and Zucman (2013), who present evidence that both the net income share of capital and the wealth-income ratio rose in seven countries between 1970 and 2010. This association leads them to calibrate that the elasticity of substitution lies between 1.3 and 1.6 (Piketty and Zucman 2013, 35). However, Rognlie (2014) points out that the measure of capital (wealth) that Piketty and Zucman use is the current market value and thus includes capital gains, whereas the equation that relates the capital share to the capital-output ratio using σ (i.e., equation 2) should be specified in real terms. Rognlie shows that removing capital gains from the capital measure to obtain a more appropriate measure of capital radically reduces the capital to income ratio and demonstrates that using book rather than market value (a more appropriate indicator of the impact of capital accumulation generated by saving) suggests that on average the countries in the sample used by Piketty and Zucman actually show a decline in the ratio of capital to income. If a falling capital-output ratio has led to a rising capital share in income, it would actually imply that σ is less than rather than greater than 1, undermining the prediction that increases in the capital-output ratio cause capital's share in income to rise. The estimates provided by Piketty and Zucman appear to rest on faulty data and back-of-the-envelope calculations rather than rigorous econometric analysis. They are also contradicted by the large number of studies that find that $\sigma < 1$.

Elsby, Hobjin, and Sahin (2013) offer no evidence of their own on the magnitude of σ, but the arguments in their paper reflect the assumption that $\sigma > 1$. For example, they observe that in the 2000s, the decline in labor's share in the United States has been associated with a slowdown in the growth of the capital-labor ratio. They argue that as slower growth in the capital-labor ratio should slow rather than accelerate the decline in labor's share (assuming $\sigma > 1$), the neoclassical framework is incapable of explaining the slowdown. Having rejected the framework, they then present evidence that attributes much of the decline in labor's share in income to offshoring by US firms and speculate that the offshoring of more labor-intensive tasks has raised the capital-labor ratio in US industries. In addition, they suggest that with offshoring, σ could rise.[15] However, if σ is actually less than 1, in the face of rapid labor-augmenting technical change a decline in the effective capital-labor ratio could explain labor's declining share (the neoclassical explanation). It is also possible that offshoring might actually have reduced the elasticity of substitution of the production that remains in the United States by making it more intensive in skilled labor (which is more complementary with capital).

The previous section concluded that US manufacturing has played a key role in contributing to the declining labor share in the United States. The behavior of investment in this sector provides little support for the investment boom on which the explanations put forward by these authors rests. If lower prices for investment goods, especially equipment, are at the heart of the explanation, one might expect to see that the net capital stock in manufacturing had increased relatively more rapidly in recent years. However, as figure 8 shows, the average annual growth rate of the net capital stock in fixed assets in manufacturing has actually decelerated, and the share of manufacturing investment devoted to equipment in particular

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[15] Elsby, Hobjin, and Sahin (2013, 40) observe that "if capital is more than unit elastic with respect to labor, Hicks' (1932) result will imply that the US labor share will fall."

has declined. For the periods 1950–80 and 1980–2013, the annual growth rate in the net capital stock in fixed assets in manufacturing declined from 4.3 to 1.9 percent, respectively, and the annual growth rate in the net capital stock in equipment declined from 4.1 to 1.7 percent, respectively. Moreover, since 2000 the overall net stock of fixed assets and the net stock of equipment have averaged just 1.0 and 0.6 percent annual growth, respectively.

Similarly, given the declining share of labor income, applying the argument used by Piketty (that $\sigma > 1$), one would have expected the capital-output ratio in manufacturing to have risen. Yet, as figure 9 shows, between 1980 and 2012 the ratio of the net fixed stock of assets in manufacturing to real manufacturing output actually declined by 33 percent! This decline is also inconsistent with the argument that as a result of offshoring, labor-intensive tasks have been shipped abroad and manufacturing value added in the United States has become more capital intensive in the sense of a higher capital to output ratio. The only evidence that capital deepening has taken place in the United States in recent decades is the increase in the ratios of the net fixed capital stock to full-time equivalent employment that are evident after 1990, especially in manufacturing (figure 10).

However, these increases in capital-labor ratios have been achieved not by additional investment but rather through substantial layoffs of manufacturing workers. Indeed, as figure 11 shows, US nonresidential investment as a share of GDP has been weak since 2000, especially in equipment in general and IT equipment in particular.

Evidence on the Elasticity of Substitution

Although they have gained prominence recently, authors who claim that capital and labor are highly substitutable are in the distinct minority. Many studies that have used a variety of estimation and calibration techniques have overwhelmingly concluded that in both the short and long run $\sigma < 1$. The original study that pioneered the CES function (Arrow et al. 1961) estimated σ at 0.57. Later studies, by David and van de Klundert (1965) and Kalt (1978), estimated elasticities of 0.32 and 0.76, respectively. Hamermesh (1993) surveyed a range of early estimates and find that the results are generally between 0.3 and 0.7. One noteworthy early exception is Berndt (1976), who found support for an elasticity equal to unity. However, Antras (2004) shows that if Berndt's equation were specified to allow for factor-augmenting change, "aggregate elasticity is likely to be considerably less than one and may even be lower than 0.5." Using a variety of methods, Klump, McAdam, and Willman (2007) obtained estimates of the elasticity of substitution of 0.50–0.64. Chirinko (2008) summarizes a large number of studies, finding that "while the estimates range widely, the weight of the evidence suggests a value of (sigma) in the range of 0.40–0.60."[16] Using several estimation techniques, Young (2010) concludes that aggregate US σ is "less

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[16] Ronglie (2014) points out that 31 of the 36 studies cited by Chirinko have elasticities less than one.

than unity and perhaps less than 0.5." He finds that the elasticity is less than unity for the large majority of the 35 individual industries he estimates separately. Wei (2014) uses an international sample of 40 countries and 34 industries. He finds that industry elasticities fall within a range of 0.4–0.9 and that country-level elasticities are typically around 0.62. Mallick (2012) estimates σ for 90 countries and finds that the mean value is 0.34.[17]

It is plausible that over the long run the possibilities of substitution are greater. Indeed, while Fragiadakis et al. (2012) find that short-run elasticities of substitution are typically less than unity, they also find that using a lagged dependent variable implies long-run elasticities greater than unity. Chirinko and Mallick (2014) use time series methods to explicitly measure the long-run elasticity and conclude that over the long run it is still less than 1. Juselius (2008) uses a model that assumes labor and product market imperfections. Using time series analysis on Finnish data, he also concludes that the long-run elasticity is less than 1.

Most of these studies use aggregate time series and stipulate particular functional forms of the aggregate production function and the bias of technological change. Oberfeld and Raval (2014) adopt an approach that allows identification through exogenous variation in factor prices and recover the aggregate elasticity of substitution from plant-level elasticities and estimates of the elasticity of demand. They distinguish changes within and across plants. After aggregating plant data, they find an aggregate elasticity of substitution for US manufacturing of 0.7 that has remained fairly constant over time.

Theory

The traditional workhorse of growth theory is the Cobb-Douglas production function, whose elasticity of substitution is unity. If one accepts that $\sigma < 1$, there are profound implications for growth theory. With Cobb-Douglas it follows that the direction of technical change is irrelevant for income distribution. In the CES world, however, when $\sigma < 1$, a steady state with constant factor income shares and a constant capital-output ratio is possible only if technical progress is purely labor augmenting (see Uzawa 1961 and Jones and Scrimgeour 2004). In a model in which the bias in technological change is endogenous, Acemoglu (2002, 2003) provides an explanation of why technical change will be purely labor augmenting in the long run.

If one accepts that $\sigma < 1$, it must also be the case that for the most part technical change in the United States has been labor augmenting. In the United States, the capital-labor ratio in manufacturing and the economy as a whole has risen steadily, yet for long periods before 1980 for manufacturing and before 2000 for the economy as whole, factor income shares remained fairly constant. This finding implies

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[17] The mean values for the East Asia and Sub-Saharan African countries are 0.737 and 0.275, respectively. For the OECD countries the mean is 0.340.

that the effective capital-labor ratio must have been constant, with labor-augmenting technical change offsetting the rising capital-labor ratio.

Augmenting Change

This reasoning is supported by several empirical studies that have explicitly tried to estimate the direction of US technical change. The pioneering work was undertaken by Antras (2004), who assumes that factor augmentation grows by a fixed percentage annually—an exponential specification. He finds that on balance US technical change has been labor augmenting and that the annual growth in labor-augmenting change has exceeded that of capital-augmenting change by about 3 percent.

Klump, McAdam, and Willman (2007) explore the functional form of labor- and capital-augmenting technical change and confirm that labor-augmenting technical change is best captured by an exponential functional specification. However, they find that the best fit for capital-augmenting change is a functional form that is hyperbolic and tends to disappear over time, a finding that supports the Acemoglu theory.[18]

Wei (2014) adopts the Antras specification. He finds that "at the country level, 35 of the 40 countries exhibit net labor-augmenting technical progress. However, at the industrial level, this is not always true."[19]

In sum, the evidence in support of the capital-deepening explanations based on claims or assumptions that $\sigma > 1$ is weak and inconsistent with recent data for US manufacturing. The literature provides considerable support for the two components of the explanation I advance. First, it shows that in both the short and the long run $\sigma < 1$. Second, it has developed strong theoretical reasons, supported by empirical evidence, that on balance technological change has been labor augmenting. The next section shows that regressions that provide estimates of $\sigma < 1$ and labor-augmenting technical change can explain the decline in labor's share in US income.

III COMBINING THE COMPONENTS: DECLINE IN LABOR'S SHARE

This empirical analysis follows Antras (2004), who was the first to estimate the elasticity of substitution in a specification that expressly allowed for factor-augmenting technical change. Specifically, the production function is assumed to have a constant σ and factor-augmenting technical change such that the capital

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[18] In Acemoglu's theory, with $\sigma < 1$, capital-augmenting technical change reduces the capital share and thus dampens the incentives for both capital accumulation and capital-augmenting technical change.

[19] Bentolia and Saint-Paul (2003) use a more complex model and reach more nuanced conclusions. "We find for the euro area for the period 1970–2005 an aggregate elasticity of substitution below unity (about 0.7) and a pattern of factor-augmenting technical growth rates where labor-augmenting technical progress growth dominates in the long run while capital-augmenting technical progress plays a significant role in the interim period. We also importantly find evidence for a structural break in this pattern of biased technical progress at the end of the 1990s with an upward shift in capital augmenting technical progress and a downward shift in labor augmenting progress."

and labor augmentation grow at constant rates of λk and λl, respectively. The production function for output Y and time t is:

$$Y_t = [\ \delta(\ A_0^K\ e^{\lambda \mathrm{k.t}}\ K_t\ )^{\frac{\sigma-1}{\sigma}} + (1-\delta)(\ A_0^L\ e^{\lambda \mathrm{l.t}}\ L_t\ )^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \tag{4}$$

The first-order profit conditions require that the marginal product of each of the factors be equal to their prices:

$$\text{Log } (Y_t / K_t) = \alpha_1 + \sigma \log (R_t / P_t^Y\ ) + (1-\sigma)\ \lambda k.t + \varepsilon\ 1, t \tag{4a}$$

$$\text{Log } (Y_t / L_t = \alpha_2 + \sigma \log (W_t / P_t^Y\ ) + (1-\sigma)\ \lambda l.t + \varepsilon\ 2, t \tag{4b}$$

Subtracting equation (4a) from equation (4b) yields:

$$\text{Log } (K_t / L_t) = \alpha_3 + \sigma \log (W_t / R_t) + (1-\sigma)\ (\lambda l - \lambda k).t + \varepsilon\ 3, t \tag{4c}$$

One can also express the equations by reversing the dependent and independent variables:

$$\text{Log } (R_t\ /\ P_t^Y) = \ \alpha_4 + (1/\sigma\ ) \log (Y_t / K_t) - [(1-\sigma)/\sigma]\ \lambda k.t + \varepsilon\ 4, t \tag{4d}$$

$$\text{Log } (W_t / P_t^Y) = \ \alpha_5 + (1/\sigma\ ) \log (Yt\ / L_t) - [(1-\sigma)\ /\sigma]\ \lambda l.t + \varepsilon\ 5, t \tag{4e}$$

Subtracting equation (4d) from equation (4e) yields:

$$\text{Log } (W_t / R_t) = \ \alpha_6 + (1/\sigma) \log (K_t / L_t) - [(1-\sigma)\ /\ \sigma]\ (\lambda \mathrm{l} - \lambda k).t + \varepsilon\ 6, t \tag{4f}$$

These specifications are useful because running these regressions gives estimates of σ and they can be solved to provide estimates of the growth rates of labor- and capital-augmenting technical change. Changes in the effective capital-labor over time t $d\log k = (\lambda K.t + d\log K)/(\lambda l.t + d\log L)$ can then be calculated and used to predict changes in labor's share (Ls) using equation (1), which respecified in terms of the effective capital-labor ratio is:

$$.\ d\ln Ls = \ -(1 - \mathrm{Ls})\ \frac{\sigma-1}{\sigma}\ d\ln k \tag{5}$$

Data

Dale Jorgenson and his associates developed measures of labor and capital inputs, services, and prices. Their labor input measure combines data on work hours from the Bureau of Labor Statistics and labor matrices of 192 demographic characteristics (gender, class of worker, age, education) from Jorgenson, Ho, and Samuels (2012). Expressed as an index, it is thus a measure of the quantity of labor services. Given income of labor, the price of labor (the wage rate) is then derived. Similarly, the capital services measure used in the production function estimates reflects weighting of 90 types of assets divided into five major categories: intellectual property, equipment, structures, inventories, and land.[20] Given capital income

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[20] Intellectual property products are composed of three broad classes of assets: software (originally in a category called fixed business equipment and software), R&D, and artistic originals.

(i.e., the net operating surplus and the index of capital services), the price of capital (rate of profit) is then derived. Where ever possible, I use these data to estimate labor's share at the aggregate and industry level. However, for more disaggregated industry analysis, I use the data developed by the Bureau of Labor Statistics to explain total factor productivity at the industry level. These data also provide estimates of output and capital and labor inputs and prices.

Antras (2004) uses an earlier version of the Jorgenson data. He obtains estimates of σ ranging from 0.641 to 0.892. His estimates of net labor-augmenting technical change ($\lambda l - \lambda k$) obtained from equations (4c) and (4d) are 3.08 and 3.15 percent, respectively. In the Jorgenson data, the ratio of capital to labor service inputs increased at an annual average rate of 2.46 log points between 1948 and 1998. Antras' estimates provide a preview of the results to be reported below, in that they imply that on average over his period of estimation, the effective capital-labor ratio was declining. Indeed, the annual growth rate of net labor-augmenting productivity change was about half a percent higher than the growth rate of the capital-labor ratio. The average of Antras' estimates of σ is 0.78. Over the 50 years, given the initial labor share of 58 percent in 1948, using equation (4) leads to a prediction of a small decline of −0.031 log points in labor's share between 1948 and 1998. Labor's share in income in the Jorgenson data was 62 percent in 1998. Although not perfect, the estimates using this methodology thus do reasonably well in predicting the relative stability of labor's share in income over the five-decade period. Table 5 reports the results of estimates of equations (4c) and (4f) for various periods after σ and λl and λk are extracted from the results. The equations provide estimates of both σ and, after manipulation, the annual difference between labor- and capital-augmenting technical change. The results are quite mixed, and before 1980 the estimates of σ are not statistically significant (the σ estimates are significant for 1980–2010). In the *K/L* regression (specification 4c), between 1980 and 2010 a statistically significant ($p = .05$) estimate of 0.187 combined with net labor-augmenting change of 2.4 implies a negative effective capital-labor ratio and predicts a decline in labor's share of 8.8 log points, which is close to the 8.4 log point decline that actually took place. In the *W/R* regression (specification 4f) for the same period, σ is higher but less than 1 and less significant ($p = .10$). Moreover, with a decline in the effective capital-labor ratio of –0.0287, it predicts a decline in labor's share of 4.5 log points, about half the actual 8.4 log point fall. Averaging the two equations suggests $\sigma = 0.54$, an annual decline in k of 2 log points and a decline in labor's share of 6.7 log points compared with the actual decline of 8.4 log points.

Neither of the estimates of σ for the shorter period 1999–2010 are significant, although taken together the equations do a reasonably good job of predicting declines of –0.127 and –0.059, compared with the actual decline of –0.09. Indeed, the average of the two predictions—an estimate of $\sigma = 0.494$ and an annual change in k of –0.0229—leads to a prediction of –0.086, which is almost precisely correct.

The results explaining labor's share in manufacturing in table 6 are much stronger than those for the aggregate economy. Most of the coefficients in both specifications are significant, and in all periods they indicate that $\sigma < 1$. In addition, the equations track changes in the labor share over time. Over the period 1947–80, the averaged results closely predict the slight increase (2.5 log points) in the labor share that actually took place. The equations capture the dramatic change that took place after 1980. Both specifications indicate acceleration in net labor-augmenting technical change and lower σ after 1980. This combination of strong net labor-augmenting technical change and $\sigma < 1$ leads to predictions of large declines in labor's share of income. On average the equations do well in explaining the decline, especially over the past decade. Between 1980 and 2010, the actual decline of 37.1 log points exceeded the average predicted decline of 31.8 log points by 5.3 log points; between 1999 and 2010, the actual decline of 23.1 log points differed from the predicted decline by just 1.9 log points. In sum, it appears that this specification can explain the aggregate behavior of labor's share in US manufacturing since 1980.

Using data developed by the Bureau of Labor Statistics for estimating productivity growth, I undertook a similar exercise for individual US industries between 1987 and 2011 at the three-digit NAICS level. I report both equations (4c) and (4f). All regressions were run using the Prais-Winston method for dealing with autocorrelation. The shift-share analysis indicated that three manufacturing industries had changes that together account for two-thirds of the declining labor share within manufacturing. In all three industries, the estimated elasticities of substitution are very low and technical change is net labor augmenting and in excess of the increases in the actual capital-labor ratios, as reported in table 7. As a result, very large declines in the labor shares in log points are predicted. The W/R specifications are more accurate; on average their predictions of declines of 53 log points are fairly close to the 43 percent actually experienced.

Table 8 reports the results of the *K/L* and *W/R* regressions for all 18 three-digit manufacturing industries. Although the impacts were concentrated in the three industries discussed above, the declines in labor's share were pervasive, occurring in 14 of 18 industries and averaging 17.9 log points. In the *K/L* specification, only 10 of the estimates of σ are statistically significant (7 though at the $p = .01$ level). In no case in the *K/L* regressions does σ come close to unity. Indeed, the significant estimates are extremely low, ranging from 0.0331 for transportation and 0.0499 for petroleum to 0.286 for fabricated metals. The *W/R* regressions are generally stronger, with 13 significant estimates. Four estimates of σ are greater than 1, but none is significant; the significant estimates range from 0.090 (for transportation) to 0.755 (for plastics). Strikingly, in all 18 industries when *K/L* is the dependent variable and in 15 of the 18 when *W/R* is the dependent variable, there is net labor-augmenting technical change. Moreover, the magnitude of this change is greater than the increase in the capital-labor ratio in 14 cases with the *K/L* specification and 16 of the 18 cases with the *W/R* specification, implying that in the vast majority of manufacturing industries the effective capital-labor ratio was declining. The model does well qualitatively, although in some cases there are fairly large prediction errors that reflect the use of σ coefficients that are not significant (e.g., food, textiles, paper, and especially plastics). On average, because of these errors, the *K/L* model overpredicts an average decline in labor share of 41.4 log points versus the actual average decline of 17.9 log points. The *W/R* regressions have much smaller forecast errors and on average predict a decline of 17.5 percent, which is remarkably close to the actual average decline of 17.8 percent. All told, therefore, it appears that in addition to the industries that had the largest impact on labor's share in manufacturing, there were more pervasive combinations of low substitution elasticities and declining effective capital-labor ratios, which help explain why manufacturing experienced such large declines in labor's income share.

The information and mining sectors have played an important role in the declines in labor's share in income since 2000. Tables 9 and 10 report the estimates using the Jorgenson data for the posts and telecommunications (which includes IT) and mining sectors, respectively.

For the period 1980–2010, although both regressions are able to account for almost the entire decline in labor share of 32.6 log points in posts and telecommunications, the estimates of σ from the two regressions are quite different. The prediction of the *K/L* regression is based on a low σ and a decline in the effective capital-labor ratio; the prediction using the *W/R* regression combines an estimate of σ = 1.2 with an estimate of net capital-augmenting technical change that is not statistically significant. The mixed results lend some support to both the capital-deepening and the declining effective capital-labor explanations. Remarkably, however, despite the relatively small sample, both equations do well in explaining the large decline in labor's share after 1999. For this period the regressions provide very similar, statistically significant estimates of σ (0.8 for the *K/L* regression and 0.9 for the *W/R* regression), and both regressions estimate very substantial increases in labor-augmenting technical change. These estimates in turn imply declining effective capital-labor ratios and result in predictions of the decline in labor's share of 26.4 log points with errors of just over 1 log point. The equations explaining mining and quarrying also provide an account of the declining labor share after 1980, and especially after 2000, that can be couched in terms of a low σ and a declining effective capital-labor ratio (table 10). The *W/R* regressions have higher levels of significance and smaller errors in prediction, especially in the recent period. For the period 1947–79, the *W/R* regressions explain the declining labor share on the basis of $\sigma > 1$ and capital deepening as a result of net capital-augmenting technical change. These regressions also predict the declining labor share of 11.7 log points with only a small error. However, more recently, especially after 2000, as in the case of posts and telecommunications, both the *K/L* and *W/R* regressions estimate σ to be low (0.207 and 0.436, respectively) and find a decline in the effective capital-labor ratio to which a fall in actual capital-labor ratio contributes. The predictions of the *W/R* equation are very accurate (a decline of 18.2 log points versus an actual decline of 20.6). The *K/L* regression also predicts a decline but with an error of 8.7 log points. The earlier behavior of these sectors provides additional evidence that since 2000 the combination of $\sigma < 1$ and the declining effective capital-labor ratios explain the declines in labor's share in income.

In summary, for the period 1980–2010 there is overwhelming evidence that despite the measured increase in the capital-labor ratio, the effective capital-labor ratio has declined. This is the case for the total economy, the manufacturing sector as a whole, the three industries that together accounted for more than two-thirds of the decline in labor share within manufacturing, the majority of the three-digit industries within manufacturing, and the mining sector. It is also the case for the posts and telecommunications sector since 2000.

IV CONCLUDING COMMENTS

The share of labor compensation in US national income has fallen to levels not seen since the 1950s. The decline has been especially concentrated in manufacturing, mining, and IT. In these sectors the explanation does not lie with relatively weak wage growth (as a result, say, of labor's reduced bargaining power because of globalization). Indeed, the rise in compensation in manufacturing has been similar to the rise elsewhere, and rates of return in manufacturing have increased. Instead, there is evidence that relatively rapid labor-augmenting technical change, in combination with $\sigma < 1$, has played the key role. This finding may seem paradoxical given the attention that has been focused on innovations in computers and automation, which might at first glance seem to be capital augmenting. However, in the Hicks framework, innovations are classified by their relative impact on the marginal products of capital and labor. It is quite possible that improvements in equipment and software could increase the marginal product of labor by more than they increase the marginal product of capital and thus induce a decline in the effective capital-labor ratio used to produce a given quantity of output.

It is also paradoxical to think that enhancing labor's productivity could reduce labor's share in income and reduce *W/R* ratios. This finding should not be surprising once it is recognized that technical change that doubles each worker's productivity is equivalent to doubling the number of workers in the labor force. Just as in the face of inelastic demand an increase in the supply of a product could reduce its price by enough to reduce total revenue, so, too, an increase in the effective labor-capital ratio could reduce labor's share in income, and even wages per worker, when labor and capital are not easily substituted.

In the Hicks terminology, labor-augmenting technical change, which at the margin encourages the use of labor rather than capital, is termed "capital saving." Thus another implication of labor-augmenting technical change is that less capital is required to produce a given amount of output. This implies that if output is constrained by inadequate demand, for example, investment would be weaker. The conventional wisdom is that there have been huge breakthroughs in IT that might have been expected to lead to unusually strong investment. Yet investment has been weak. This could be part of the explanation.

The issue of whether capital and labor are gross complements or substitutes is crucial for determining the impact of measures that seek to affect the functional distribution of income. The leading proponent of these factors as substitutes, Thomas Piketty (2014), argues that to address a development that he regards as inequitable, governments should slow capital formation by imposing higher taxes on capital and wealth. This paper suggests that such measures could be counterproductive and actually reduce labor's share in income by further lowering the effective capital-labor ratio. The evidence presented here corroborates the findings of many others in concluding that in the United States the elasticity of substitution between capital and labor is less than 1. Given this low elasticity, the cause of labor's recent falling share is the weakness of investment in the face of faster labor-augmenting technical change rather than more capital deepening. This finding suggests that measures that boost investment and capital formation would lead to higher wages, raise labor's share in income, and reduce income inequality.

A tax system that could achieve such a goal would be a progressive consumption tax, which would boost investment by removing the taxes on capital while at the same time allowing income to be redistributed by imposing higher taxes on people with higher levels of consumption. Such a system would also allow the United States to become a more competitive location for international investment.

The conclusions of this paper are salient for debates about the causes of some forms of income inequality. Its results are sufficiently important that they should be the subject of further research. This paper applied Occam's razor to explain changes in the functional distribution of income. It finds considerable evidence to support an explanation that points to the combination of σ's < 1 and declining effective capital-labor ratios. The simplest neoclassical explanation of the functional distribution of income thus appears to explain the facts. However, to produce these results, it made many simplifying assumptions. They include treating factors as homogenous and assuming competitive conditions (i.e., no variations in markups), constant returns to scale, constant elasticities of substitution between labor and capital, no adjustment costs or frictions, and factor-augmenting technical change that is characterized by constant exponential parameters. In addition, the estimates were derived using fairly primitive econometric methods, relying on ordinary least squares regressions and corrections for autocorrelation using the PRAIS method rather than time series or systems estimation methods.

Many of these assumptions and methodological choices deserve further scrutiny. The measures of capital and labor developed by Jorgenson, Ho, and Samuels (2012) used in most of the regressions were derived by aggregating inputs with fundamentally different characteristics. The measure of labor services, for example, reflects a weighting of 192 work-hour categories that are distinguished by gender, class of worker, age, and education. The measure of capital services reflects a weighting of 90 types of assets divided into major categories that include equipment, structures, inventories, land, and intellectual property, which in turn aggregates software, R&D, and artistic originals.

However, there is considerable evidence that the substitution possibilities between different types of capital and labor are not the same. For example, capital is often viewed as complementary to skilled labor but substitutable with unskilled labor (Griliches 1969, Krusell et al. 2000). In addition, different types of capital, such as equipment and structures, are viewed as having different substitution possibilities, both with each other and with other factors. These differences imply that the composition of capital and labor (i.e., the relative supplies of different types of labor and capital) could affect their aggregate substitution possibilities. For example, as Elsby, Hobjin, and Sahin (2013) show, if capital and skilled labor are less substitutable than capital and unskilled labor, an increase in the share of skilled workers in the labor force could result in a decline in the overall σ between capital and labor.[21]

In addition, with models with more than two factors, predictions about the impact of technical change on the functional distribution of income could be affected by the degree to which technical change augments particular types of capital and labor. Given the large number of studies that have concluded that skill-biased technical change has been a powerful source of the rising skill premium in the United States, there are good reasons why further disaggregation of the nature of technical change could be important.

In empirical work that seeks to capture these effects, the results will be affected by the manner in which the production function is modelled and the degree of substitution possibilities between different types of labor and capital that are assumed or calibrated. It is customary to try to capture this greater realism by building models that use nested production functions.

Krussel et al. (2000) undertake an exercise with four factors of production (structures, equipment, skilled labor, and unskilled labor). At the highest stage of aggregation, they specify a Cobb-Douglas production function that has one type of capital (structures) and a composite CES, which in turn combines two underlying CES production functions. One of them comprises skilled labor and equipment, which are assumed to be complements. This function is in turn nested in another function in which both skilled labor and equipment are assumed to be substitutes for unskilled labor.

Arpaia, Perez, and Pichelmann (2009) explain changes in European factors using such nested production functions. In their model, as capital and skilled labor are complements, capital-augmenting technical progress raises the skill premium. However, as unskilled labor is highly substitutable with the composite of capital and skilled labor, skilled capital-augmenting progress also leads to a decline in the overall labor share.

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[21] See Elsby, Hobjin, and Sahin (2013, 31-33) for a discussion of the impact of changes in the skills mix on σ.

As Atkinson (2009) discusses and these examples indicate, dealing with more than two factors adds considerable complexity to the analysis and entails making additional assumptions in order to ensure tractability and apply calibration methods (see also Elsby, Hobjin, and Sahin 2013). Moreover, as Atkinson discusses and Blackorby and Russell (1989) show, in general one cannot talk about two factors being complementary without specifying the direction of price change envisaged.

Factor diversity is not the only source of additional realism that might be relevant. Other sources of change that have been omitted could be important determinants of the functional distribution of income. As incorporated in their explanations of changes in the labor share in Europe, for example, Bentolia and Saint-Paul (2003) and Arpaia, Perez, and Pichelmann (2009) explicitly consider the potential role of changes in markups, the role of intermediate input prices, adjustment costs, and changes in the price and wage determining processes. Rognlie (2015) also finds an important role for markup changes. Combining the view that capital's share is higher because of higher markups with the findings here presents a puzzle, as it might have been expected that increased globalization would reduce rather than raise markups. This issue needs further exploration.

Considerable literature has been devoted to developing econometric methodologies for estimating the elasticity of substitution that may be more suitable than the methods applied here. Antras (2004) and others who apply his methodology use generalized instrumental variables to correct for the endogeneity of the regresssors and time series methods to correct for nonstationarity and the possibility of spurious correlations. Klump, McAdam, and Willman (2007) use normalized production functions, as recommended by Klump and De La Grandville (2000). They also allow for more complex functional forms for factor-augmenting technical change that can accommodate exponential, logarithmic, and hyperbolic growth as special cases. Their estimation uses a three-equation supply-side system that includes the estimation of both the production function and factor income equations and contains cross-equation parameter restrictions. León-Ledesma, McAdam, and Willman (2010) demonstrate using Monte-Carlo methods that this combination of normalization and joint modeling of the production function and first-order conditions produces superior estimates. Additional research using these techniques should be undertaken to explore whether the conclusions obtained here are robust. These potential complications notwithstanding, as a first approximation, contrary to the views of many, the canonical neoclassical model of the functional distribution of income appears to work remarkably well.

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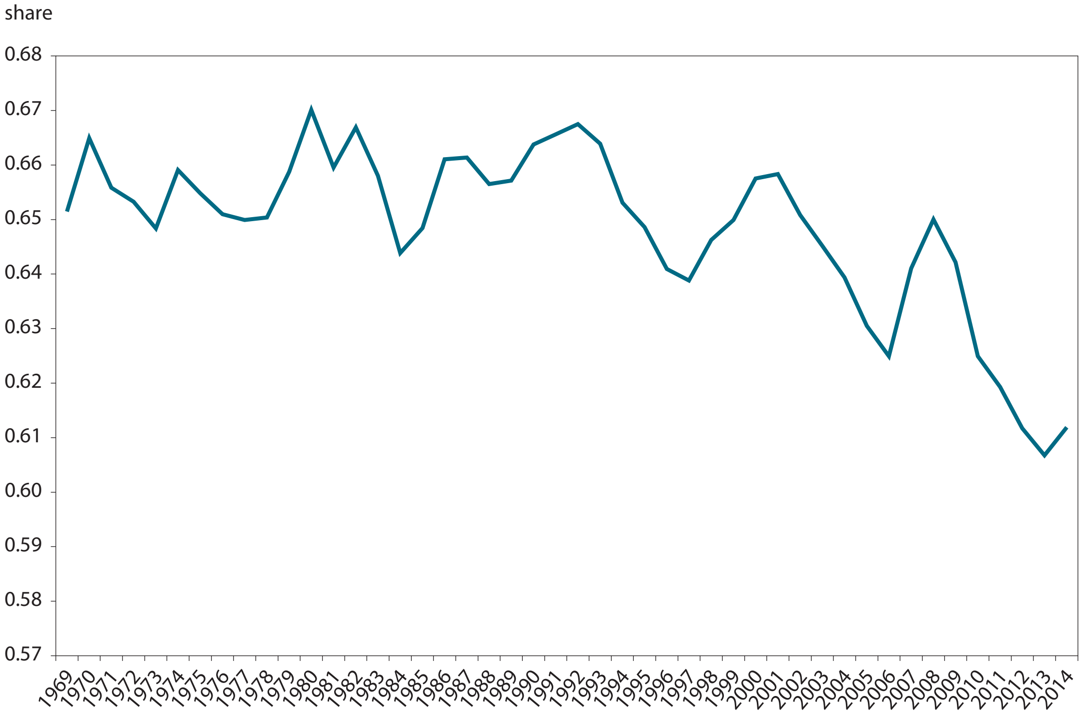
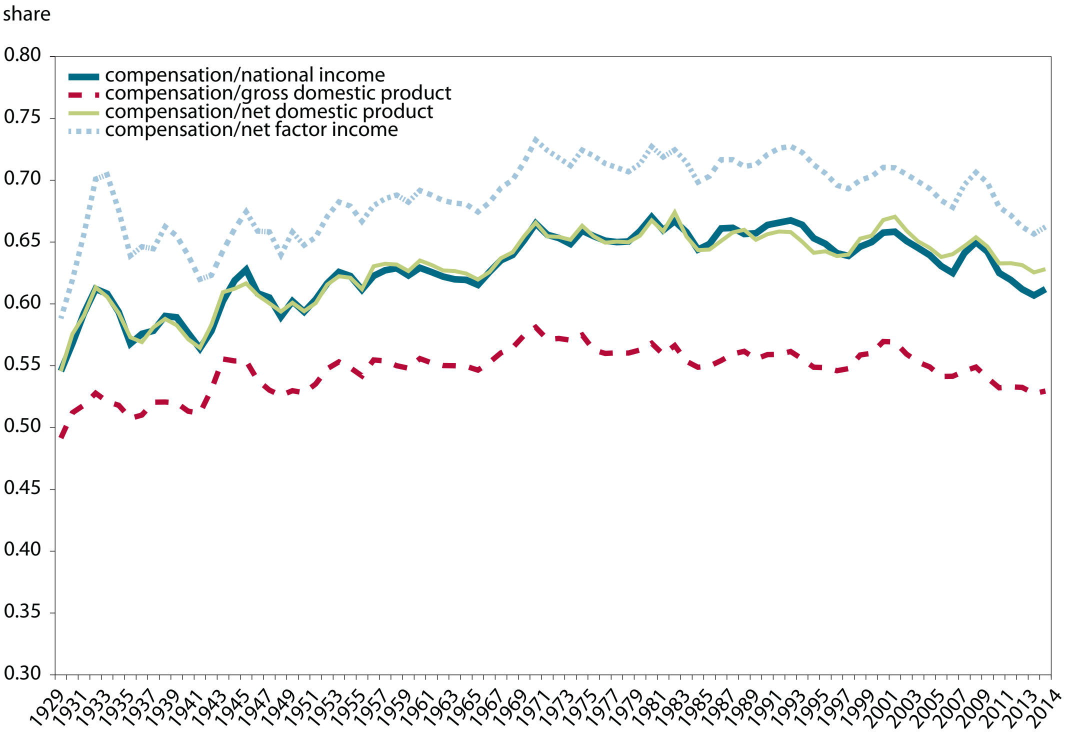
Figure 1 **Share of labor compensation in US national income, 1969–2014**



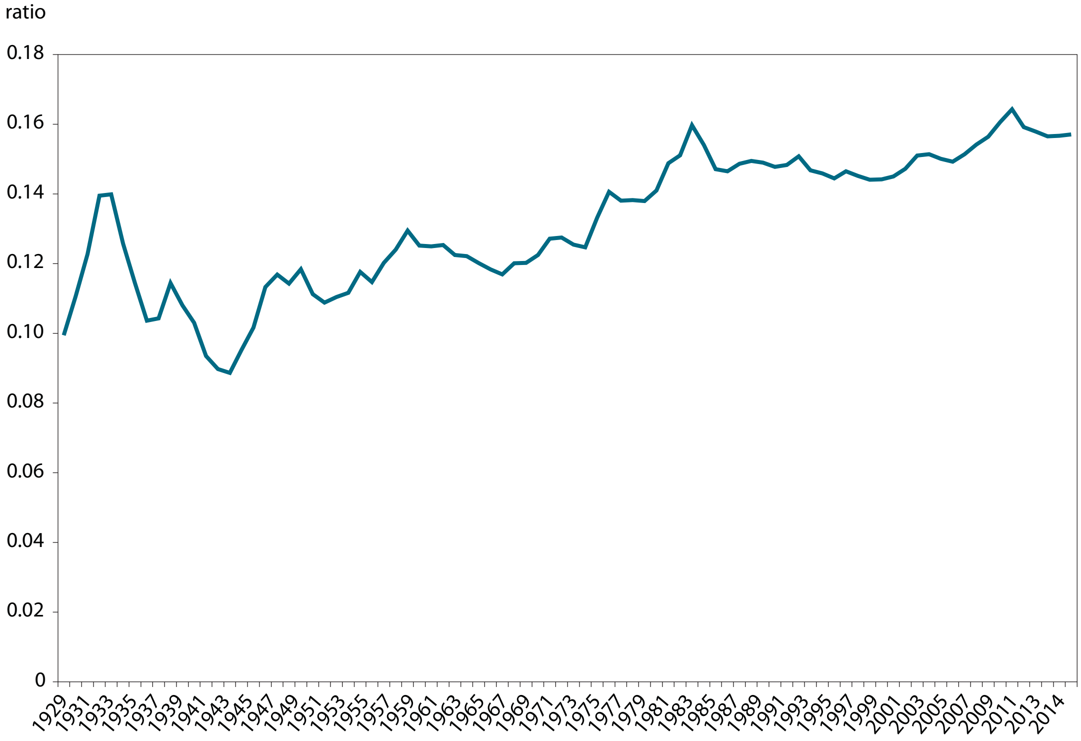
Source: BEA National Income Accounts, Table 1.12.

Figure 2 **Share of labor compensation in various national income and output measures, 1929–2014**



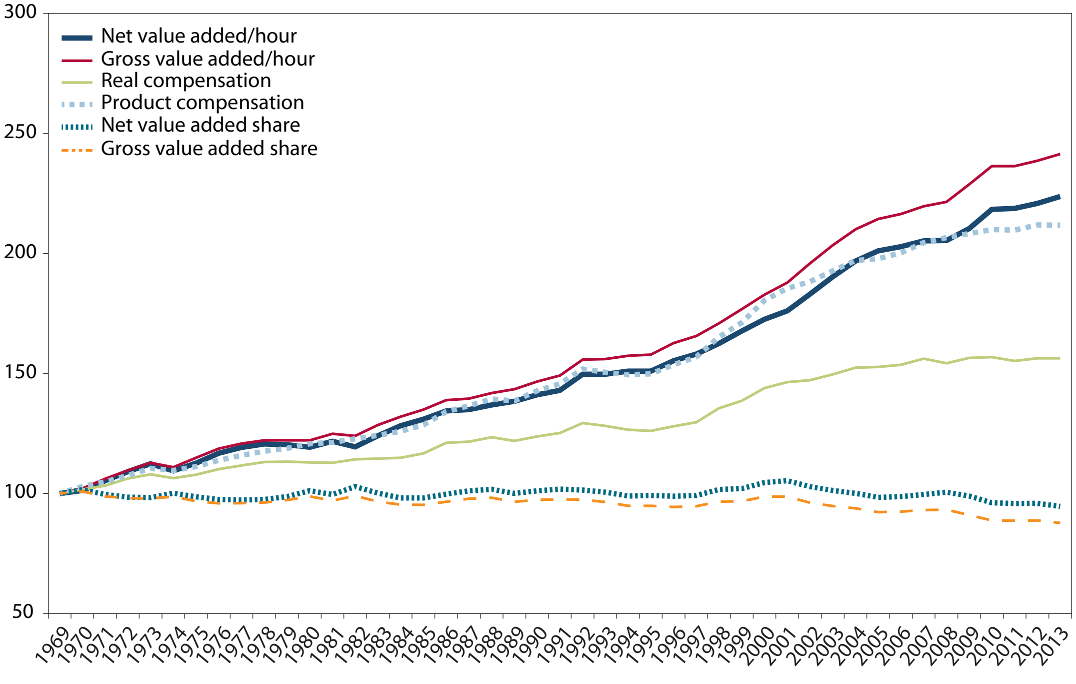
Source: BEA National Income Accounts, Table 1.12.

Figure 3 **Ratio of capital depreciation to GDP, 1929–2014**



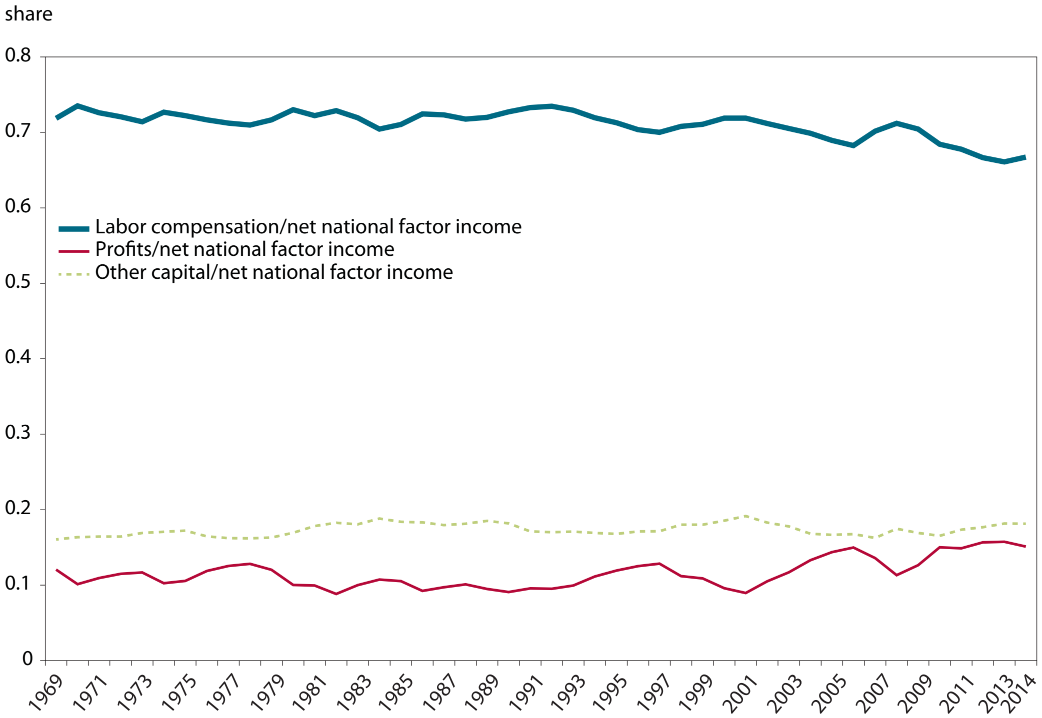
Source: Bureau of Economic Analysis.

Figure 4 **Gross and net labor productivity and various real hourly compensation measures and labor compensation shares in US business sector, 1969–2013**



Sources: Bureau of Economic Analysis and Bureau of Labor Statistics.

Figure 5 **Share of labor compensation, corporate profits, and other capital income in net national factor income, 1969–2014**



Source: BEA National Income Accounts, Table 1.12.

Table 1 Shift-share analysis of sectoral changes in labor share, 2000–12

Sector	GDP share		Labor compensation share				Due to:		Industry impact on decline (percent)
	2000	2012	2000	2012	Change	Total impact	Between sectors	Within sectors	
Agriculture	1.0	1.2	0.31	0.21	–0.095	–0.002	–0.001	–0.001	4.9
Mining	1.1	2.6	0.33	0.21	–0.115	–0.007	–0.004	–0.003	17.6
Manufacturing	15.1	12.5	0.59	0.46	–0.135	–0.017	–0.001	–0.017	44.4
Utilities	1.8	1.7	0.28	0.26	–0.020	–0.000	0.000	–0.000	0.4
Construction	4.5	3.6	0.66	0.64	–0.030	–0.002	–0.001	–0.001	4.9
Wholesale trade	6.1	5.9	0.52	0.48	–0.048	–0.003	0.000	–0.003	7.2
Retail trade	6.8	5.7	0.58	0.55	–0.030	–0.002	–0.000	–0.002	4.8
Transportation and warehousing	3.0	2.9	0.67	0.58	–0.085	–0.003	–0.000	–0.002	6.5
Information	4.6	4.8	0.52	0.35	–0.171	–0.008	–0.000	–0.008	21.2
Finance, insurance, real estate, rental, and leasing	19.4	19.5	0.25	0.24	–0.010	–0.003	–0.000	–0.002	6.4
Professional and business services	10.8	11.9	0.75	0.71	–0.032	–0.002	0.002	–0.004	4.8
Educational services, health care, and social assistance	6.6	8.2	0.83	0.83	0.004	0.004	0.004	0.000	–11.4
Arts, entertainment, recreation, accommodation, and food services	3.8	3.7	0.60	0.62	0.020	0.001	–0.000	0.001	–1.8
Other services, except government	2.7	2.2	0.61	0.71	0.100	0.002	–0.000	0.002	–4.9
Government	12.9	13.5	0.79	0.80	0.006	0.002	0.001	0.001	–5.0
GDP	100.0	100.0	0.57	0.53		–0.039	0.001	–0.040	

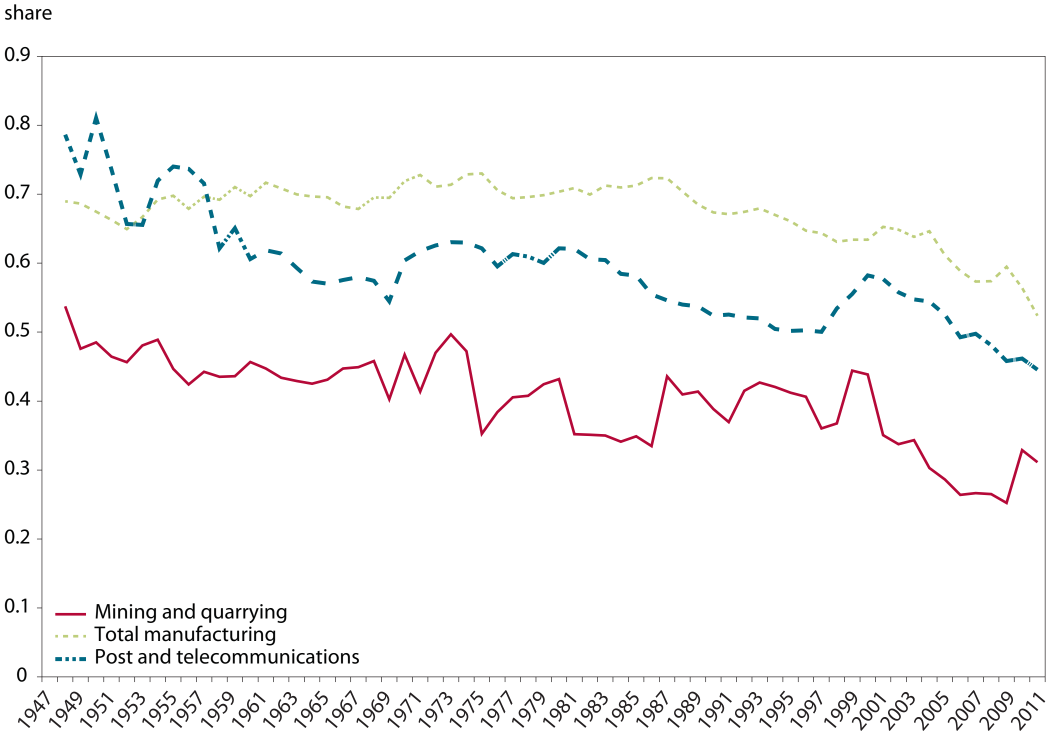
Source: US Bureau of Economic Analysis, www.bea.gov.

Table 2 Shift–share analysis of sectoral changes in labor share, 1987–2011 (unrevised data)

	GDP share		**Labor compensation share**				**Due to:**		**Industry impact on decline**
Sector	**1987**	**2011**	**1987**	**2011**	**Change**	**Total impact**	**Between sectors**	**Within sectors**	(percent)
Agriculture, forestry, fishing, and hunting	1.66	1.15	0.202	0.251	0.050	0.002	0.002	0.001	–9.2
Mining	1.54	1.92	0.404	0.278	–0.126	–0.003	–0.001	–0.002	11.4
Utilities	2.66	1.98	0.245	0.239	–0.005	0.002	0.002	–0.000	–8.0
Construction	4.44	3.51	0.683	0.686	0.004	–0.001	–0.001	0.000	3.1
Manufacturing	17.38	11.49	0.678	0.523	–0.156	–0.024	–0.006	–0.018	87.9
Wholesale trade	6.03	5.61	0.538	0.518	–0.020	–0.001	0.000	–0.001	3.5
Retail trade	7.30	6.01	0.603	0.551	–0.051	–0.003	–0.000	–0.003	12.5
Transportation and warehousing	3.22	2.97	0.687	0.590	–0.097	–0.003	–0.000	–0.003	11.6
Information	4.17	4.29	0.450	0.403	–0.047	–0.002	–0.000	–0.002	8.0
Finance, insurance, real estate, rental, and leasing	17.95	20.29	0.233	0.236	0.003	–0.007	–0.008	0.001	27.4
Professional and business services	8.12	12.50	0.667	0.687	0.020	0.006	0.004	0.003	–23.8
Educational services, health care, and social assistance	5.86	8.70	0.800	0.818	0.018	0.008	0.006	0.002	–28.9
Arts, entertainment, recreation, accommodation, and food services	3.22	3.92	0.618	0.589	–0.029	–0.001	0.000	–0.001	3.1
Other services, except government	2.56	2.45	0.610	0.664	0.054	0.001	–0.000	0.001	–4.7
Government	13.90	13.23	0.848	0.849	0.001	–0.002	–0.002	0.000	6.2
GDP	100.00	100.00	0.578	0.551	–0.027	–0.027	–0.003	–0.024	100.0

Source: US Bureau of Economic Analysis, www.bea.gov.

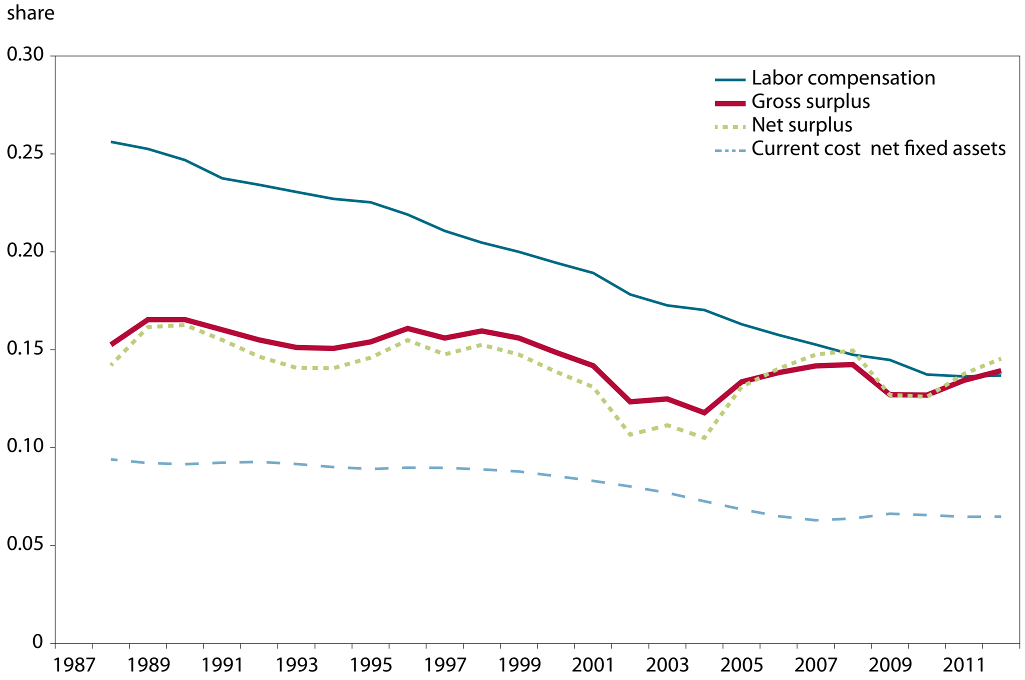
Figure 6 Labor share in factor value-added: Total and selected industries, 1947–2011



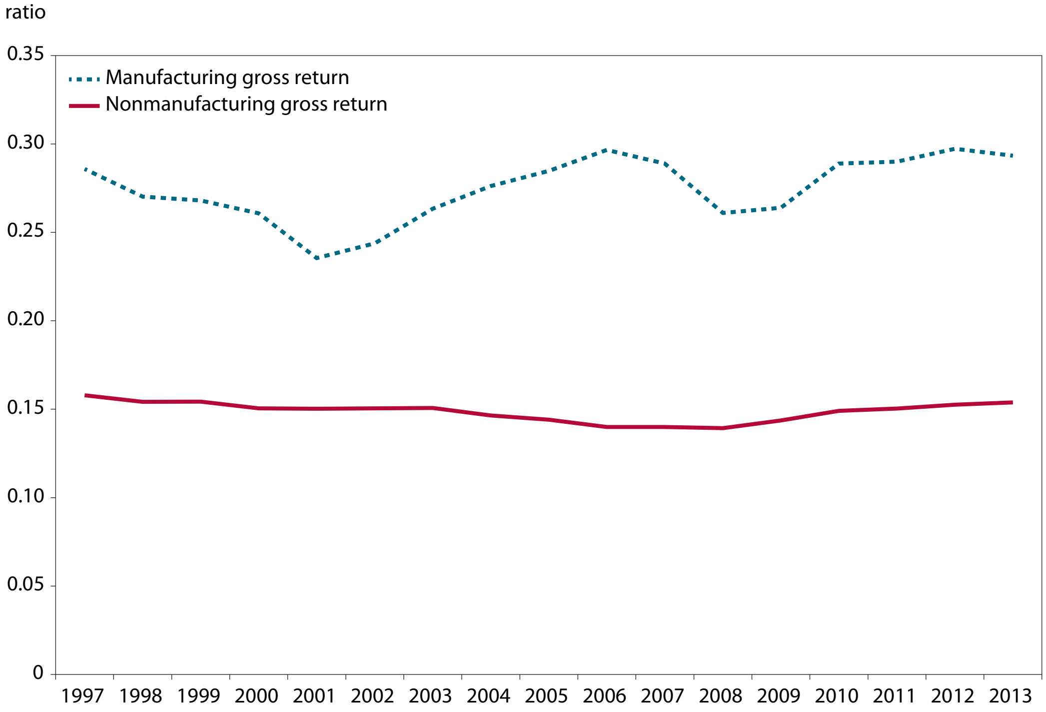
Source: Jorgenson, Ho, and Samuels (2012).

Figure 7 Manufacturing: Relative shares and rates of return

a. Share of manufacturing in private industry (unrevised data), 1987–2011



b. Ratio of gross operating surplus to net fixed capital stock in manufacturing and nonmanufacturing



Source: BEA National Income Accounts.

Table 3 Shift-share analysis of changes in labor share in manufacturing, 1987–2011 (unrevised data)

	Value share		Labor ompensation share				Due to		
Sector	**1987**	**2011**	**1987**	**2011**	**Change**	**Impact**	**Between industry shifts**	**Within industry shifts**	**Percent of total impact**
Petroleum and coal products	2.3	9.8	0.432	0.122	–0.309	–0.049	–0.018	–0.030	31.3
Chemical products	9.9	14.6	0.496	0.352	–0.144	–0.030	–0.009	–0.021	19.1
Computer and electronic products	10.3	13.1	0.817	0.577	–0.240	–0.028	0.004	–0.031	17.8
Food and beverage and tobacco products	10.8	12.4	0.503	0.420	–0.082	–0.013	–0.003	–0.010	8.3
Machinery	8.0	7.6	0.755	0.641	–0.114	–0.009	–0.000	–0.009	5.8
Primary metals	3.9	2.9	0.798	0.619	–0.178	–0.006	–0.001	–0.005	4.1
Miscellaneous manufacturing	2.7	4.6	0.704	0.579	–0.125	–0.005	0.000	–0.006	3.4
Motor vehicles, bodies and trailers, and parts	7.7	4.4	0.755	0.710	–0.045	–0.005	–0.003	–0.002	2.9
Plastics and rubber products	3.9	4.0	0.670	0.560	–0.110	–0.004	–0.000	–0.004	2.8
Textile mills and textile product mills	2.6	1.1	0.776	0.621	–0.155	–0.003	–0.001	–0.002	2.0
Apparel and leather and allied products	2.7	0.7	0.779	0.720	–0.058	–0.002	–0.002	–0.000	1.6
Furniture and related products	2.2	1.5	0.780	0.668	–0.112	–0.002	–0.001	–0.002	1.5
Printing and related support activities	3.2	1.8	0.828	0.833	0.005	–0.002	–0.002	0.000	1.2
Electrical equipment, appliances, and components	4.2	2.7	0.671	0.658	–0.012	–0.000	0.000	–0.000	0.1
Fabricated metal products	8.3	7.1	0.699	0.700	0.001	–0.000	–0.000	0.000	0.1
Nonmetallic mineral products	2.9	1.9	0.696	0.713	0.018	0.000	–0.000	0.000	–0.1
Paper products	4.7	3.1	0.593	0.562	–0.031	0.000	0.001	–0.001	–0.3
Wood products	2.4	1.3	0.655	0.721	0.066	0.001	0.000	0.001	–0.7
Other transportation equipment	7.2	5.4	0.702	0.738	0.036	0.002	–0.000	0.002	–1.0
Manufacturing	100.0	100.0	0.678	0.523	–0.156	–0.155	–0.035	–0.121	100.0

Source: US Bureau of Economic Analysis, www.bea.gov.

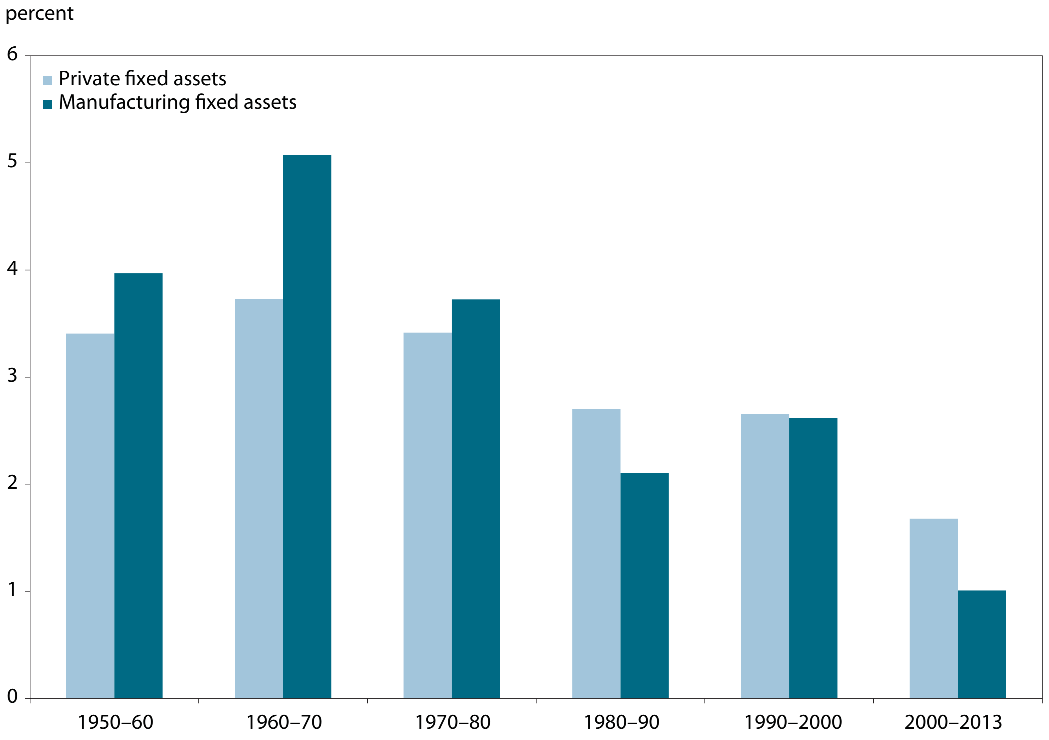
Table 4 Shift-share decomposition of changes in labor payroll share in manufacturing, NAICS six-digit category

	1980	2000	2009	Change in share, 1980–2009	Percent of change	Change in share, 2000–2009	Percent of change
Payroll share in							
manufacturing value-added	0.411	0.313	0.270	–0.139	100	–0.043	100
Due to:							
Changes in six-digit industry shares				–0.023	16.2	–0.010	22.5
Within six-digit industry share changes				–0.116	83.8	–0.033	77.5

NAICS = North American Industry Classification System

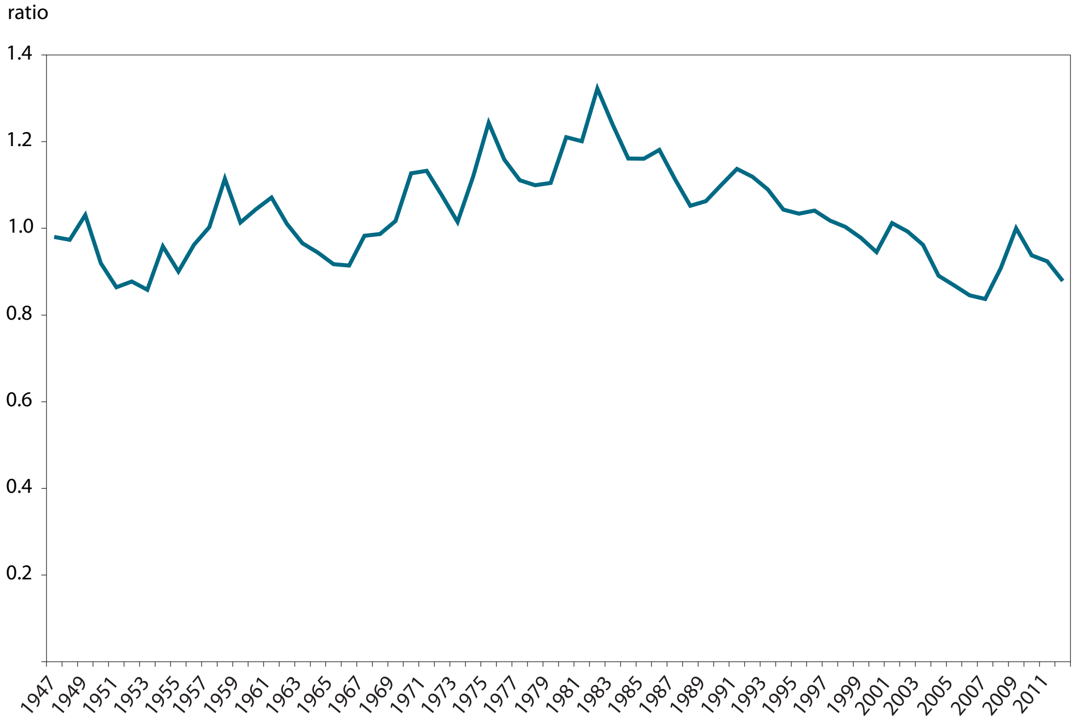
Source: NBER-CES Manufacturing Industry Database (473 six-digit industries).

Figure 8 Average annual growth in private industry fixed assets net capital stock, 1950–2013



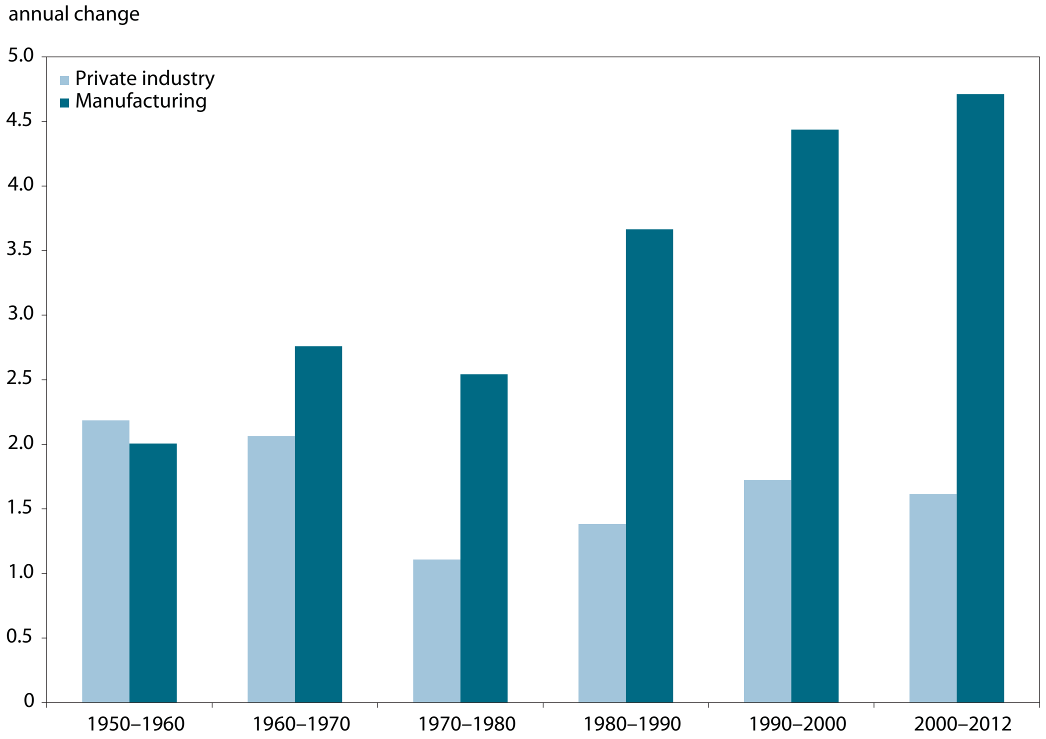
Source: Bureau of Economic Analysis.

Figure 9 Ratio of net fixed assets/real output in US manufacturing,1947–2012



Source: Bureau of Economic Analysis.

Figure 10 Annual change in ratio of net fixed capital stock to full-time equivalent employment, 1960–2012



Source: Bureau of Economic Analysis.

Figure 11 US nonresidential investment as a share of GDP, 1980–2013

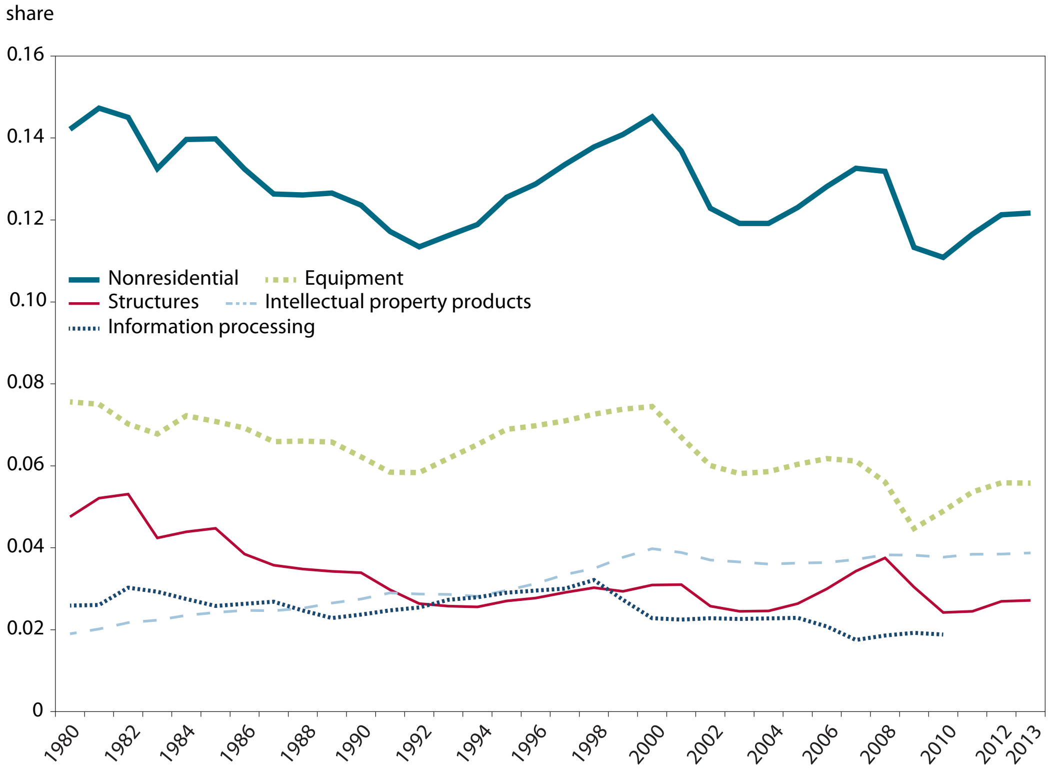


Table 5 Regression results for total industry

	Regression result			Effective capital-labor ratio			Change in labor share		
	$1/\sigma$	σ	Year coefficient	$\lambda l - \lambda k$	*dlog(K/L)*	*dlog(k)*	Predicted	Actual	Error
K/L regression									
1947–1979		0.136	0.0227***	0.026	0.024	–0.002	–0.161	0.166	0.327
1980–2010		0.187**	0.0196***	0.024	0.022	–0.002	–0.088	–0.084	0.004
1999–2010		0.100	0.0230***	0.026	0.023	–0.003	–0.127	–0.090	0.038
W/R regression									
1947–1979	0.720	1.389	0.015	0.052	0.024	–0.027	0.101	0.166	0.064
1980–2010	1.125*	0.889	–0.006	0.051	0.022	–0.029	–0.045	–0.084	–0.039
1999–2010	0.758	1.319	–0.007	–0.028	0.023	0.051	–0.059	–0.090	–0.030
Average									
1947–1979		0.762	0.019	0.039	0.024	–0.015	–0.030	0.166	0.196
1980–2010		0.538	0.007	0.038	0.022	–0.015	–0.066	–0.084	–0.018
1999–2010		0.710	0.008	–0.001	0.023	0.024	–0.093	–0.090	0.004

*, **, *** denote statistical significance at the 10, 5, 1 percent level, respectively.

Source: Author's calculations.

Table 6 Regression results for total manufacturing

	Regression result			Effective capital-labor ratio			Change in labor share		
	$1/\sigma$	σ	Year coefficient	$\lambda l - \lambda k$	*dlog(K/L)*	*dlog(k)*	Predicted	Actual	Error
K/L regression									
1947–1979		0.423***	0.0196***	0.034	0.034	−0.000	−0.001	0.025	0.026
1980–2010		0.311***	0.0324***	0.047	0.035	−0.012	−0.328	−0.371	−0.043
1999–2010		0.275*	0.0412***	0.057	0.040	−0.017	−0.215	−0.231	−0.016
W/R regression									
1947–1979	1.039***	0.962	0.003	−0.079	0.034	0.113	0.058	0.025	−0.033
1980–2010	1.411***	0.709	−0.0393**	0.096	0.035	−0.061	−0.308	−0.371	−0.062
1999–2010	1.791**	0.558	−0.0749**	0.095	0.040	−0.055	−0.208	−0.231	−0.023
Average									
1947–1979		0.693	0.011	−0.023	0.034	0.057	0.029	0.025	−0.004
1980–2010		0.510	−0.003	0.071	0.035	−0.036	−0.318	−0.371	−0.053
1999–2010		0.417	−0.017	0.076	0.040	−0.036	−0.212	−0.231	−0.019

*, **, *** denote statistical significance at the 10, 5, 1 percent level, respectively.

Source: Author's calculations.

Table 7 Regression results for manufacturing industries with largest impacts, 1987–2011

	Regression result			Effective capital-labor ratio			Change in labor share		
	$1/\sigma$	σ	Year coefficient	$\lambda l - \lambda k$	*dlog(K/L)*	*dlog(k)*	Predicted	Actual	Error
K/L regression									
Petroleum		0.0499***	0.0257***	0.027	0.023	−0.004	−0.772	−0.444	0.328
Chemicals		0.049	0.0331***	0.035	0.031	−0.004	−0.771	−0.318	0.452
Computer and electronic products		0.0803***	0.0631***	0.069	0.061	−0.008	−0.893	−0.543	0.350
W/R regression									
Petroleum	6.981***	0.143	−0.201***	0.034	0.023	−0.011	−0.635	−0.444	0.191
Chemicals	2.006**	0.499	−0.0557*	0.055	0.031	−0.025	−0.247	−0.318	−0.071
Computer and electronic products	4.463***	0.224	−0.280***	0.081	0.061	−0.020	−0.694	−0.543	0.151
Average									
Petroleum		0.097		0.030	0.023	−0.007	−0.703	−0.444	0.259
Chemicals		0.274		0.045	0.031	−0.014	−0.509	−0.318	0.190
Computer and electronic products		0.152		0.075	0.061	−0.014	−0.793	−0.543	0.251

*, **, *** denote statistical significance at the 10, 5, 1 percent level, respectively.

Source: Author's calculations.

Table 8 Regression results for 18 three-digit manufacturing industries

		Regression result			Effective capital-labor ratio			Change in labor share		
	Industry	**$1/\sigma$**	**σ**	**Year coefficient**	**$\lambda l - \lambda k$**	***dlog(K/L)***	***dlog(k)***	**Predicted**	**Actual**	**Error**
	K/L regression, 1987–2011									
1	Food	0.003	0.003	0.0124***	0.012	0.012	–0.001	–2.856	–0.147	2.709
2	Textiles	0.039	0.039	0.0334***	0.035	0.030	–0.004	–1.085	–0.314	0.771
3	Apparel and leather	0.142**	0.142	0.0579***	0.067	0.061	–0.007	–0.398	–0.116	0.281
4	Wood	0.0994**	0.099	0.0199**	0.022	0.023	0.001	0.112	0.207	0.095
5	Paper	0.027	0.027	0.0215***	0.022	0.020	–0.002	–0.836	–0.086	0.750
6	Printing	0.087	0.087	0.0301***	0.033	0.031	–0.002	–0.228	–0.059	0.169
7	Petroleum	0.0499***	0.050	0.0257***	0.027	0.023	–0.004	–0.772	–0.444	0.328
8	Chemicals	0.049	0.049	0.0331***	0.035	0.031	–0.004	–0.771	–0.318	0.452
9	Plastics	–0.010	–0.010	0.0321***	0.032	0.028	–0.004	4.203	–0.246	–4.450
10	Nonmetallic minerals	0.255***	0.255	0.0142***	0.019	0.021	0.002	0.047	0.037	–0.011
11	Primary metals	0.127***	0.127	0.0170***	0.019	0.012	–0.007	–0.500	–0.313	0.188
12	Fabricated metals	0.286***	0.286	0.0151***	0.021	0.016	–0.005	–0.130	0.009	0.139
13	Machinery	0.254***	0.254	0.0338***	0.045	0.034	–0.011	–0.323	–0.287	0.036
14	Computer and electronic products	0.0803***	0.080	0.0631***	0.069	0.061	–0.008	–0.893	–0.543	0.350
15	Electrical equipment	0.062	0.062	0.0349***	0.037	0.033	–0.004	–0.572	–0.089	0.484
16	Transportation	0.0331***	0.033	0.0410***	0.042	0.039	–0.003	–1.020	–0.008	1.011
17	Furniture	0.0687*	0.069	0.0340***	0.037	0.031	–0.005	–0.742	–0.237	0.505
18	Miscellaneous	0.043	0.043	0.0296***	0.031	0.028	–0.003	–0.667	–0.268	0.399
	W/R regression, 1987–2011									
1	Food	0.161	6.211	0.002	0.003	0.012	0.009	–0.077	–0.147	–0.070
2	Textiles	0.519	1.927	–0.009	–0.019	0.030	0.049	–0.238	–0.314	–0.076
3	Apparel and leather	1.383***	0.723	–0.031	0.080	0.061	–0.019	–0.072	–0.116	–0.044
4	Wood	1.406*	0.711	0.02	–0.049	0.023	0.073	0.295	0.207	–0.088
5	Paper	3.601***	0.278	–0.0631***	0.024	0.020	–0.005	–0.117	–0.086	0.031
6	Printing	0.278	3.597	0.0234*	0.032	0.031	–0.002	0.012	–0.059	–0.070
7	Petroleum	6.981***	0.143	–0.201***	0.034	0.023	–0.011	–0.635	–0.444	0.191
8	Chemicals	2.006**	0.499	–0.0557*	0.055	0.031	–0.025	–0.247	–0.318	–0.071
9	Plastics	1.324***	0.755	–0.026	0.079	0.028	–0.051	–0.165	–0.246	–0.081
10	Nonmetallic minerals	2.879***	0.347	–0.0348***	0.019	0.021	0.002	0.041	0.037	–0.004
11	Primary metals	3.707***	0.270	–0.0734***	0.027	0.012	–0.015	–0.404	–0.313	0.091
12	Fabricated metals	1.602***	0.624	–0.013	0.022	0.016	–0.006	–0.034	0.009	0.043
13	Machinery	2.233***	0.448	–0.0639***	0.052	0.034	–0.018	–0.216	–0.287	–0.071
14	Computer and electronic products	4.463***	0.224	–0.280***	0.081	0.061	–0.020	–0.694	–0.543	0.151
15	Electrical equipment	1.068	0.936	0.006	–0.086	0.033	0.120	0.081	–0.089	–0.170
16	Transportation	10.17***	0.098	–0.385***	0.042	0.039	–0.003	–0.282	–0.008	0.273
17	Furniture	2.542***	0.393	–0.0740***	0.048	0.031	–0.017	–0.261	–0.237	0.024
18	Miscellaneous	0.441	2.268	0.002	0.004	0.028	0.024	–0.132	–0.268	–0.136

*, **, *** denote statistical significance at the 10, 5, 1 percent level, respectively.

Source: Author's calculations.

Table 9 Regression results for posts and telecommunications

	Regression results			Effective capital-labor ratio			Change in labor share		
	$1/\sigma$	σ	Year coefficient	$\lambda l - \lambda k$	*dlog(K/L)*	*dlog(k)*	Predicted	Actual	Error
K/L regression									
1947–1979		–0.047	0.0504***	0.048	0.047	–0.001	0.270	–0.230	–0.500
1980–2010		0.186*	0.0511***	0.063	0.057	–0.006	–0.320	–0.326	–0.006
1999–2010		0.798***	0.0540***	0.267	0.063	–0.204	–0.248	–0.264	–0.015
W/R regression									
1947–1979	–0.498	–2.008	0.0497*	0.033	0.047	0.014	–0.278	–0.230	0.048
1980–2010	0.820*	1.220	–0.011	–0.061	0.057	0.118	–0.263	–0.326	–0.063
1999–2010	1.112***	0.899	–0.0595***	0.531	0.063	–0.468	–0.252	–0.264	–0.012
Average									
1947–1979		–1.028		0.041	0.047	0.007	–0.004	–0.230	–0.226
1980–2010		0.703		0.001	0.057	0.056	–0.292	–0.326	–0.035
1999–2010		0.849		0.399	0.063	–0.336	–0.250	–0.264	–0.014

*, **, *** denote statistical significance at the 10, 5, 1 percent level, respectively.

Source: Author's calculations.

Table 10 Regression results for mining and quarrying

	Regression results			Effective capital-labor ratio			Change in labor share		
	$1/\sigma$	σ	Year coefficient	$\lambda l - \lambda k$	*dlog(K/L)*	*dlog(k)*	Predicted	Actual	Error
K/L regression									
1947–1979		0.132*	0.0340***	0.039	0.036	–0.003	–0.284	–0.117	0.166
1980–2010		0.307***	0.0182***	0.026	0.023	–0.004	–0.099	–0.077	0.023
1999–2010		0.207*	–0.003	–0.003	–0.010	–0.006	–0.119	–0.206	–0.087
W/R regression									
1947–1979	0.952***	1.050	–0.007	–0.135	0.036	0.171	–0.109	–0.117	–0.009
1980–2010	1.934***	0.517	–0.0320***	0.034	0.023	–0.012	–0.134	–0.077	0.057
1999–2010	2.293*	0.436	–0.025	0.019	–0.010	–0.029	–0.182	–0.206	–0.024
Average									
1947–1979		0.591		–0.048	0.036	0.084	–0.196	–0.117	0.079
1980–2010		0.412		0.030	0.023	–0.008	–0.117	–0.077	0.040
1999–2010		0.322		0.008	–0.010	–0.018	–0.151	–0.206	–0.055

*, **, *** denote statistical significance at the 10, 5, 1 percent level, respectively.

Source: Author's calculations.