To Augment Or Not To Augment?
A Conjecture On Asymmetric Technical Change*

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Abstract

Recent empirical evidence for the U.S. points to a non-increasing share of labor in income and complementarity between capital and labor. According to standard macroeconomic theory, these facts imply that productivity growth should be labor-augmenting. Analyzing post-war U.S. data, we however find that technical progress is rather evenly distributed across capital- and labor-intensive industries. To reconcile standard theory with the evidence, we stress inflation measurement errors in the data. If aggregate inflation is annually overstated by as little as a third of a percentage point, technical progress is already over 50 percent higher in labor-intensive industries than in capital-intensive industries.

JEL: E1, E13, E31, O31

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1 Introduction

Recent contributions by Karabarbounis and Neiman (2014), Piketty and Zucman (2014) and Autor et al. (2017), amongst others, point to a declining long-run share of labor in income for the U.S.. At the same time, a plethora of studies report complementarity between capital and labor, as documented by Chirinko (2008), Rognlie (2014), and Lawrence (2015). According to the fundamental insights of standard growth theory, the preceding configuration of facts requires technical change to be labor augmenting such that the effective capital-labor ratio is declining. Equally, another cohort of studies, including Gomme and Rupert (2004), Bridgman (2014) and Auerbach and Hassett (2015) for example, argues that reports of a declining labor share are due to definition and measurement problems. Instead, this research suggests that the variable has remained relatively close to its historical average. With a stable labor share, one of the famous Kaldor facts, labor-augmenting technical change is also required, but this time to a lower tune such that the effective capital-labor ratio is constant.

However, the general consensus in the literature is that technical progress is rather low in labor-intensive tasks (Baumol, 1969; Baumol et al., 2012; Young, 2014). Alas, it would appear that this observation creates a significant pitfall for the neoclassical growth model, which Jones and Romer (2010) label as “one of the great successes of growth theory”. Crucially, in this paper, we illustrate that the distribution of technical change across capital- and labor-intensive industries is highly sensitive to inflation measurement errors. In particular, we highlight that even the presence of small positive inflation biases could very well mean that technical change is notably labor augmenting.

Drawing on standard growth theory, higher productivity growth in more labor-intensive industries implies that technical progress is labor augmenting (i.e. Harrod neutral), while an even distribution of productivity growth across industries implies that technical progress is factor neutral (i.e. Hicks neutral). Significantly, our analysis employs an industry decomposition based on U.S. data to examine the distribution of technical change across U.S. industries independent of the substitution elasticity across capital- and labor-intensive tasks, thus circumventing the joint parameter estimation difficulties described in Diamond et al. (1978) for example.

Based on post-war U.S. data, we find that technical progress is rather evenly distributed across capital- and labor-intensive industries. To reconcile this evidence with a declining or stable labor share and a capital-labor elasticity of less than unity, we stress measurement problems in the raw data manifested in the form of many labor-intensive industries exhibiting zero or negative long-term productivity growth. The central explanation we posit for the phenomenon of non-positive long-run productivity growth rates is that the standard data overstate inflation by not, amongst other things, adequately accounting for quality and variety improvements in outptut.

Importantly, our analysis indicates that estimates of the distribution of technical progress across industries are quite sensitive to such measurement error, with notable labor-augmenting technical change materializing in the presence of relatively small inflation biases. To further elaborate, if aggregate inflation is annually overstated by as little as 0.30 percentage points, productivity growth in the economy's labor-intensive sector is already just over 1.5 times that in the capital-intensive sector. Marginally increasing the inflation bias to 0.42 percentage points results in a relative productivity growth quotient across the two sectors of approximately 2, consistent with balanced growth in our data. Meanwhile, an inflation bias of a little over half a percentage point raises this productivity growth ratio to around 2.5. In light of the myriad of studies documenting inflation measurement problems in historical post-war data, one should not reject with certainty the standard macroeconomic implication that productivity growth is labor augmenting.

The central finding that estimates of the economy-wide spread of technical change are highly sensitive to underlying measurement issues in the data is intimately connected to the studies of Baumol et al. (1985), Griliches (1992, 1998), Berndt et al. (2001), Hulten et al. (2001), Oulton (2001), Ahmad et al. (2003), Lebow and Rudd (2003), Triplett and Bosworth (2003) and Wölfl (2005), to mention but a few. A prominent theme running through this literature is that negative long-run productivity growth rates are likely the result of deficiencies in gauging real variables in services (i.e. inflation measurement problems), which constitute a substantial component of labor-intensive industries in our paper. Young (2014) reiterates that productivity estimates are mismeasured because they do not incorporate improvements in worker quality.

Our paper is also directly related to the literature focusing on the identification of the bias of technical change across capital and labor. León-Ledesma et al. (2010) indicate that it is possible to jointly estimate the capital-labor elasticity of substitution and the bias of technical change by estimating a system of equations under strong parametric assumptions at the aggregate level. However, as Diamond et al. (1978) point out, an estimation procedure entailing such strong parametric assumptions is notoriously problematic. Instead, we follow the approach of Oberfield and Raval (2014), in the sense that micro-level data is employed, and examine the long-run allocation of productivity growth across the economy. We differ from these two papers in that we focus on how inflation measurement issues affect estimates of the factor bias of productivity.

2 The Model

To illustrate the theoretical foundations of our empirical analysis, we adopt a standard two-sector neoclassical growth model, akin to the one employed in Acemoglu and Guerrieri (2008). The economy produces a final good, Y, which is a composite of the outputs Y_1 and Y_2 of two perfectly competitive intermediate sectors. Formally,

$$Y_t = \left(\gamma_1^{\frac{1}{\epsilon}} Y_{1,t}^{\frac{\epsilon-1}{\epsilon}} + (1-\gamma_1)^{\frac{1}{\epsilon}} Y_{2,t}^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{1}$$

where ϵ denotes the elasticity of substitution between sectors, γ_1 is the share of good 1 in final output, and t is time. Each sector produces output using a constant elasticity of substitution production technology,

$$Y_{1,t} = A_{1,t} K_{1,t}^{\alpha_1} L_{1,t}^{1-\alpha_1}, \quad \text{and} \quad Y_{2,t} = A_{2,t} K_{2,t}^{\alpha_2} L_{2,t}^{1-\alpha_2}, \tag{2}$$

where K_τ and L_τ are the quantities of capital and labor employed by sector $\tau \in \{1, 2\}$, A_τ is the total factor productivity of sector τ, α_τ is sector τ's share of capital in production, and the underlying industries composing these sectors are also characterized by Cobb-Douglas production functions.[1]

Assumption 1. *The labor intensity differs across sectors with* $1 - \alpha_1 > 1 - \alpha_2$.

The key result that emerges in the setups of Acemoglu and Guerrieri (2008) and Uzawa (1961) is that, under standard consumer preferences, a stable labor share arises when productivity growth is labor augmenting. In our neoclassical two-sector model, labor augmenting productivity growth implies that total factor productivity growth is higher in the more labor intensive industries. To see this, consider the following two production functions with labor augmenting technical change: $Y_{1,t} = K_{1,t}^{\alpha_1}(A_t L_{1,t})^{1-\alpha_1}$ and $Y_{2,t} = K_{2,t}^{\alpha_2}(A_t L_{2,t})^{1-\alpha_2}$. These functions are equivalent to those in Equation (2) if $A_t^{1-\alpha_1} = A_1$ and $A_t^{1-\alpha_2} = A_2$. Thus, in the light of assumption 1, the allocation of total factor productivity across capital and labor intensive industries bears implications for the factor bias of technical change. A stable labor share implies that total factor productivity growth is higher in the more labor intensive sector such that relative total factor productivity growth equals the relative labor share

$$\frac{\dot{A}_1/A_1}{\dot{A}_2/A_2} = \frac{1-\alpha_1}{1-\alpha_2}. \tag{3}$$

In Uzawa's setup it is notoriously difficult to identify the bias of technical change as León-Ledesma et al. (2010) and Diamond et al. (1978) among others point out. This is because Uzawa's setup requires a joint estimation of both elasticity of substitution and productivity due to the implicit

[1] Herrendorf et al. (2015) find that Cobb-Douglas functions provide a good approximation for production at sectoral and underlying industry levels. In robustness checks, we found that employing constant elasticity of substitution functions with plausible non-unitary elasticities did not yield significantly different results.

assumption that $\alpha_1 = 0$ and $\alpha_2 = 1$. This assumption turns Equation (1) into

$$Y_t = \left(\gamma_1^{\frac{1}{\epsilon}} \underbrace{[A_{1,t} L_{1,t}]}_{Y_{1,t}}^{\frac{\epsilon-1}{\epsilon}} + (1-\gamma_1)^{\frac{1}{\epsilon}} \underbrace{[A_{2,t} K_{2,t}]}_{Y_{2,t}}^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}. \tag{4}$$

If we relax the assumption that $\alpha_1 = 0$ and $\alpha_2 = 1$, data for $Y_{1,t}$ and $Y_{2,t}$ become available. Then Equation (1) is just

$$Y_t = \left(\gamma_1^{\frac{1}{\epsilon}} \underbrace{[A_{1,t} K_{1,t}^{\alpha_1} L_{1,t}^{1-\alpha_1}]}_{Y_{1,t}}^{\frac{\epsilon-1}{\epsilon}} + (1-\gamma_1)^{\frac{1}{\epsilon}} \underbrace{[A_{2,t} K_{2,t}^{\alpha_2} L_{2,t}^{1-\alpha_2}]}_{Y_{2,t}}^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}. \tag{5}$$

Thus, we can approximate the economy-wide tilt of technical change independent of the goods elasticity by estimating total factor productivity, A_1 and A_2, from Equation (2). In the next section, we employ post-war U.S. industry (i.e. sub-sector) data and follow this approach to gauge the economy-wide distribution of technical change.

3 Empirical Analysis

We retrieve time series data on $Y_{1,t}$, $Y_{2,t}$, $L_{1,t}$, $L_{2,t}$, $K_{1,t}$, $K_{2,t}$ and Y_t over the period 1948-2008 from the U.S. Bureau of Economic Analysis (BEA) repository which comprises national income and product accounts (NIPA) statistics. Following Gollin et al. (2002) and Bernanke and Gürkaynak (2002), information on α_1 and α_2 is acquired by computing the labor share based on both BEA and U.S. Bureau of Labor Statistics (BLS) data pertaining to the interval 1997-2006 in the case of the former and the interval 1987-2008 in the case of the latter. The relatively stable capital-output ratios in the BEA data in panels A and B of Figure 1 suggest that industry capital shares α_j are approximately constant in the long run. Since our focus is on the long run, we look at the evolution of shares across two distant points in time using 11-year averages with the intervals 1948-1958 and 1998-2008 corresponding to initial and final observations t and $t-1$ respectively. Figure 1 provides an additional check by also employing the intial period 1978-1988. The compound annual productivity growth rate for industry/sector i in our analysis is defined accordingly as

$$g_{A_i} = \left(\frac{A_{i,t}}{A_{i,t-1}}\right)^{\frac{1}{50}} - 1 = \left(\frac{\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right)}{\left(\frac{K_{i,t}}{K_{i,t-1}}\right)^{\alpha_i}\left(\frac{L_{i,t}}{L_{i,t-1}}\right)^{1-\alpha_i}}\right)^{\frac{1}{50}} - 1. \tag{6}$$

3.1 Productivity Growth Allocations Across Industries

3.1.1 Raw Data Analysis

Table 1 ranks the 20 available NAICS industries by labor intensity displayed. In line with the sectoral Cobb-Douglas production functions of Equation (2), we are able to separate the economy into two roughly stable fractions, namely, a labor-intensive sector and a capital-intensive sector as shown at the bottom of Table 1. The upper panel of the table also indicates which industries belong to the labor-intensive sector $\tau = 1$ (l) and which belong to the capital-intensive sector $\tau = 2$ (c) based on our calculations. The labor-intensive sector has an average labor share of $1 - \alpha_1 = 0.79$ according to BEA data or 0.77 according to BLS data and its share in output of all private industries amounts to roughly 60 percent. The capital-intensive sector's labor share is $1 - \alpha_2 = 0.37$ using BEA data or 0.40 using BLS data and it takes up the remaining output share of about 40 percent.

Turning attention to the allocation of productivity growth within the economy, panels C and D of Figure 1 plot the relation between productivity growth and the capital-output ratio across industries. The figure indicates that there is no tendency for productivity growth to be higher in more labor intensive industries. Instead, panel C suggests a small positive correlation between technical progress and the capital-output ratio. This observation does not rest comfortably with features of the economy thought to be required for balanced growth. In light of the standard macroeconomic framework outlined in Section 2, this allocation of productivity growth implies that the economy would become more labor intensive over time.

In order to maintain a stable economy-wide labor intensity, Equation (3) in combination with our BEA data implies that productivity growth in the more labor-intensive sector (sector 1) needs to be $(1 - \alpha_1)/(1 - \alpha_2) = 0.79/0.37 = 2.1$ times as high as in the capital-intensive sector (sector 2). Relying on BLS labor share data, Equation (3) indicates that a productivity growth ratio of $(1 - \alpha_1)/(1 - \alpha_2) = 0.77/0.40 = 1.9$ is required. Taking the average of BEA- and BLS-based figures, a ratio of roughly 2 would be required along the balanced growth path. However, based on the raw data, the productivity growth rates of Table 1 do not suggest that this is indeed the case. Specifically, the productivity growth quotient across the two aforementioned sectors amounts to only $1.15/1.15 = 1$ in column (8) where BEA factor shares are employed and $1.14/1.24 = 0.92$ in column (9) where BLS factor shares are used.

Crucially, Table 1 reveals that measurement problems are a feature of the data. In particular, productivity over the long run has either declined or remained stable in 8 out of the 20 industries as highlighted by a star, 6 of which fall under the labor-intensive sector. The main explanation for the phenomenon of non-positive long-run productivity growth rates is that the standard data overstate inflation by not, amongst other things, appropriately accounting for quality and variety improvements in output as Griliches (1992, 1998), Ahmad et al. (2003) and Wölfl (2005) argue.

We now turn to reducing inflation in the data and gauging the degree to which inflation must be overstated for the productivity estimates to be consistent with standard macroeconomic theory. As we will show, plausible small measurement errors in inflation can significantly affect conclusions about the economy-wide distribution of technical change.

3.1.2 Adjusted Data Analysis

To illustrate how downward revisions of inflation affect the sectoral productivity estimates, we reduce inflation directly in the data. Toward this end, we have to make two assumptions about capital and output inflation at the industry level. First, we assume that capital inflation falls symmetrically across industries.[2] Second, we assume that output inflation falls primarily in the

[2]This assumption is key and plausible because the composition of capital in the two industries is very similar.

more labor intensive industries.[3]

Our results are reported in Table 2. Column (1) of the table shows the sizes of the downward annual sectoral output-inflation revisions, and the resultant downward annual aggregate output-inflation adjustments.[4] Panel A repeats the raw data results of Table 1 which suggest that technical progress is approximately factor neutral. Meanwhile, panel B provides results in the case of a zero inflation adjustment in the capital-intensive sector combined with a 0.5-0.9 percentage point (pp) downward inflation adjustment in the labor-intensive sector. Offering a further check, panel C introduces an inflation adjustment in the capital-intensive sector too, thereby lowering the discrepancy in inflation adjustments across sectors. More precisely, panel C reports results in the case of a 0.1 percentage point inflation adjustment in the capital-intensive sector while maintaining a 0.5-0.9 percentage point inflation bias in the labor-intensive sector.

Two central messages emerge from the table. The first takeaway is that the spread of technical change is highly sensitive to inflation measurement error. The second takeaway is that the productivity growth ratio across sectors of $g_{A_1}/g_{A_2} = 2$ required for balanced growth can be achieved with an annual aggregate inflation bias of as low a 0.42 percentage points. In particular, focusing on our benchmark estimates in column (6) of panel B, we find that productivity growth in the labor-intensive sector is already over 50 percent higher than in the capital-intensive sector when annual aggregate inflation is overstated by as little as 0.30 percentage points. To further illustrate the sensitivity of estimates, observe in panel B that fractionally increasing the aggregate inflation bias from 0.42 to 0.54 results in disproportionately more pronounced labor-augmenting technical change than in the case of an increase in the bias from 0.30 to 0.42. Notably, under the BEA factor shares, panel B shows that productivity growth in the labor-intensive sector reaches 2.50 times that

[3]This assumption is plausible given that 6 industries in the labor-intensive sector which account for 27.6 percent of GDP over 1998-2008 exhibit zero or negative productivity growth in the standard data, while the latter can be said for only 2 industries within the capital-intensive sector which account for 10.2 percent of GDP. Moreover, this assumption of an asymmetric adjustment is also supported by Griliches (1992, 1998), Ahmad et al. (2003) and Wölfl (2005) who argue that measurement issues in real variables, i.e. inflation, are likely to cause the service sector (which predominantly lies in the labor-intensive industries) to exhibit negative productivity growth rates.

[4]The aggregate inflation adjustment is a value added weighted average of sectoral inflation revisions. As shown in Table 1, the stable long-run sectoral value added shares of 0.60 and 0.40 are the weights employed.

in the capital-intensive sector when the aggregate inflation bias is only about half a percentage point.

Amending panel B with a −0.10 percentage point output inflation revision in the capital-intensive sector, annual productivity growth in the labor-intensive sector decreases marginally due to symmetrically higher capital price inflation across sectors. Conversely, productivity growth in the capital-intensive sector increases. As panel C shows, although the productivity growth ratios fall slightly, the pattern of results that materializes is the same as in panel B. Lastly, inspecting both BEA- and BLS-based ratios across panels B and C, we highlight overall that an annual aggregate inflation bias in the region of two to three fifths of a percentage point would be sufficient to induce a stable labor share in the economy. Put differently, labor-augmenting technical change of a magnitude consistent with balanced growth is still viable if it turns out that annual inflation is fractionally overstated.

4 Discussion

Is it misleading to propound an inflation bias of the size that we require for an economy-wide stable labor share? While the literature may not be able to provide a definitive answer to this question at the moment, there are indications that some type of downward correction may be warranted. Indeed, we contend that the inflation measurement error examined in this paper is certainly not implausible. First, it is important to emphasize that the degree of inflation bias observed in the data is still a widely debated topic, as recent publications by Byrne et al. (2015) and Syverson (2016) amongst others have shown. Second, available estimates of the bias in historical data typically pertain to consumer prices.

Both policymakers and academic researchers have stressed quality bias in particular in the U.S. consumer price index (CPI). In 1995, the Senate Finance Committee appointed the Boskin commission to investigate the magnitude of the measurement error in the CPI. Boskin et al. (1996,

1998) found that the U.S. CPI was characterized by an annual upward bias of 1.1 percentage points, with the set of plausible values ranging from 0.8 to 1.6 percentage points. They further reported that over half of the total bias, namely 0.6 of the 1.1pp, was ascribed to unincorporated quality improvements. Following a survey of the evidence on inflation bias, Lebow and Rudd (2003) estimate that the CPI overstates the rate of change in the cost of living by about 0.9 percentage points per year and provide a confidence interval lying between 0.3 and 1.4 percentage points. Similarly, these authors highlight that a significant contributor to this bias is the inability to fully capture welfare improvements from quality changes and the introduction of new items.

The primary source of the aggregate inflation bias that the literature has advocated is the services sector.[5] Unlike with tangible goods, some services such as medical care, entertainment and education are more exposed to price measurement error due to the difficulty of identifying standard output units for these categories. As a result, quality and productivity improvements are more likely to be associated with price changes, than increases in consumer welfare equivalent to quantity increases, thus exaggerating aggregate output inflation figures. In addition, the question of what constitutes output in certain services industries is debatable. The health care industry, for example, is a diverse industry that produces a wide range of goods and services. Erroneously limiting the class of goods and services considered under output for that industry may markedly downward bias corresponding estimates of productivity. Errors like these can go a long way toward explaining the relatively sizable negative productivity growth rates of Table 1 e.g. -0.7% in *Health Care*.

While the latest numbers do not suffer to the same degree as before from the issues raised by the Boskin commission almost two decades ago, there are still reasons to believe that a non-negligible positive inflation bias still exists. As Schmitt-Grohé and Uribe (2012) point out, the reinforcements and improvements in hedonic pricing methods have acted to attenuate the bias in CPI inflation figures. Furthermore, chain weighting in BEA data has eliminated roughly half of the Boskin estimate. On the other hand, using the latest data available, Lebow and Rudd (2003) find

[5] See, for example, Rappoport (1987) and Kroch (1991) for earlier accounts of inflation in this sector.

that a quality bias of almost 40 basis points per annum still persists, which is still about two-thirds of the original Boskin estimate based on data over 1995-1996. Lebow and Rudd (2003) also note that "substitution bias" has been increasing sharply since the mid-1990s and should act to boost inflation bias estimates. Meanwhile Gordon (2006) highlights that the Boskin estimates themselves were understated, and that the same can be said about the estimates of most contemporary studies. Allowing for various unaccounted factors, the author reports that inflation bias is at least 1 percent per year, suggesting that perhaps it is even higher. Therefore, we consider the inflation bias sizes proposed in our paper to be quite modest, representing lower bound values (see Table 2).

Finally, examining panel B of Table 2, we note that an inflation adjustment of around two-fifths of a percentage point, for example, means that the labor-intensive sector's adjusted 1948-1958 real output as a fraction of the corresponding 1998-2008 figure is 0.13 compared to the unadjusted value of 0.18. Importantly, we expound the point that such adjustments in real output would not be unrealistic. More generally, given that the nature of services, the structure of the economy, and preferences have vastly changed over time, it would be extremely difficult to ascertain with certainty that real output 60 years ago was 18 and not 13 percent of today's output in that sector.

Overall, we thus argue that an annual inflation bias of around two-fifths to three-fifths of a percentage point does not lie within an implausible region of measurement error for our historical dataset. Based on our estimates, the implication is that we cannot confidently reject the hypothesis that technical change is labor augmenting in the U.S..

5 Conclusions

In light of standard growth theory, evidence on complementarity between capital and labor and a declining, or relatively stable, labor share in post-war U.S. data implies that technical progress must be labor augmenting. Using an industry decomposition to study the distribution of technical change in historical U.S. data, we however find that technical progress is rather evenly spread across capital- and labor-intensive industries. Explaining this result, we stress the existence of highly plausible inflation measurement errors manifested in the form of zero or sizably negative long-term productivity growth rates in almost half of our industries. Importantly, we observe that these non-positive productivity growth rates are skewed toward the labor-intensive sector. We then illustrate that estimates of the economy-wide allocation of technical change are highly sensitive to such measurement issues.

If aggregate inflation is annually overstated by as little as a third of a percentage point, technical progress is already over 50 percent higher in labor-intensive industries than in capital-intensive industries. Moreover, with an upward inflation bias in the region of two to three fifths of a percentage point, labor-augmenting technical change becomes sufficiently strong to induce an economy-wide stable labor share consistent with balanced growth. Given the well documented inflation measurement issues in the literature, our analysis demonstrates that technical progress could very well be notably labor augmenting even in the presence of modest lower bound inflation biases. Thus, our paper should provide food for thought to any studies formulating conclusions about the spread of technical change and the predictions of standard growth theory based on raw data analyses.

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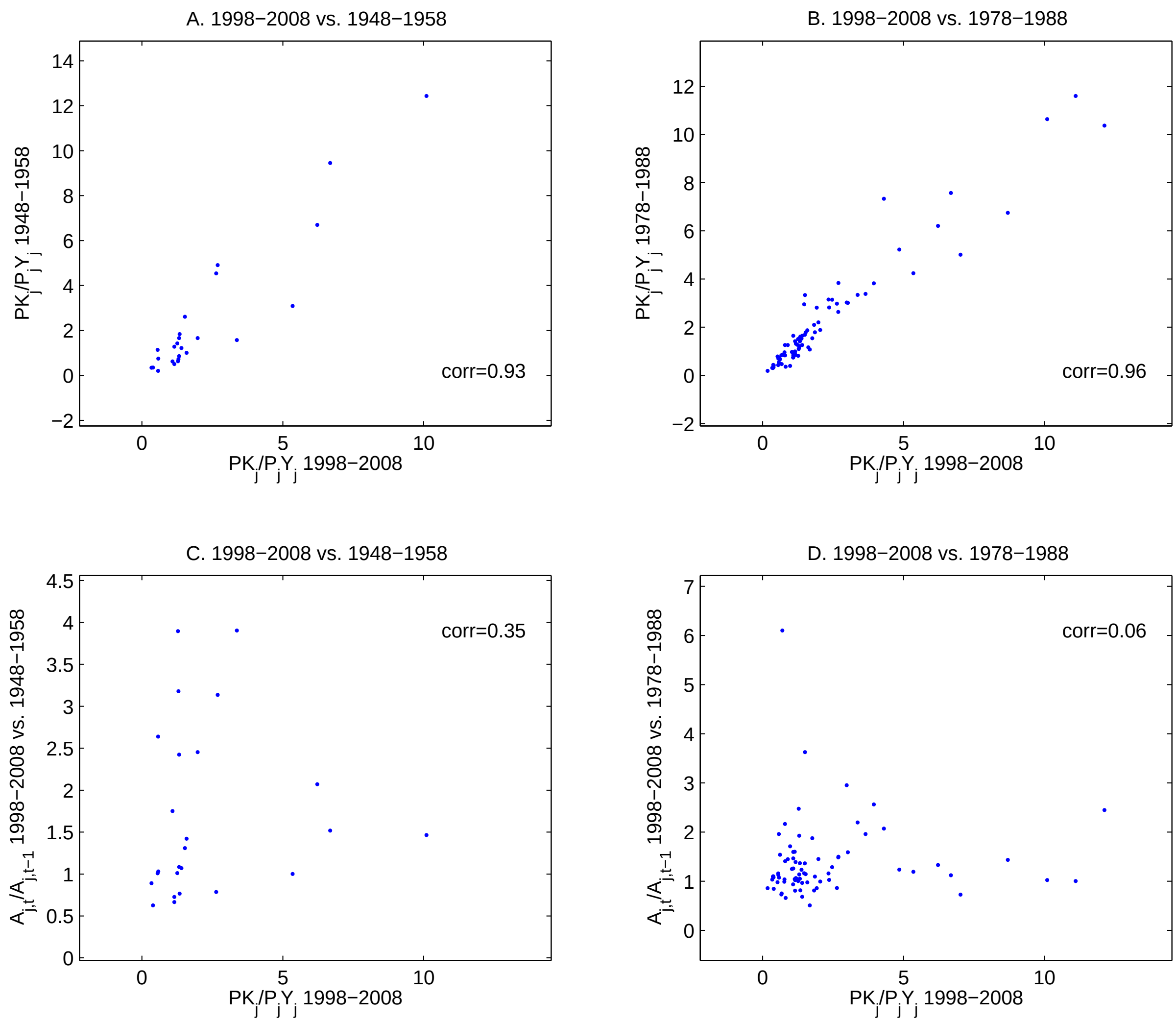
Figure 1: Capital-Output Ratios and Productivity Growth Rates.



Notes: Panels A and B show the capital-output ratios for 2-digit NAICS industries. Panels C and D show the relation between the capital-output ratios and the productivity growth rates across these industries. The numbers are constructed based on the BEA NAICS industry data. Values correspond to those in Table 1.

Table 1: Industry Decomposition of the post-war private U.S. economy by NAICS industries

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(*Sector*) Industry	NAICS	$\frac{P_iY_i}{PY}$ (%) 1948-1958	$\frac{P_iY_i}{PY}$ (%) 1998-2008	$1-\alpha_i$ BEA	$1-\alpha_i$ BLS	$\frac{Y_{i,t-1}}{Y_{i,t}}$ (%)	$\frac{K_{i,t-1}}{K_{i,t}}$ (%)	$\frac{L_{i,t-1}}{L_{i,t}}$ (%)	g_{A_i} (%) BEA	g_{A_i} (%) BLS
(l) Educational services*	61	0.42	1.05	0.99	0.67	23.00	16.86	18.07	-0.48	-0.53
(l) Health care, social assistance*	62	2.06	7.23	0.90	0.84	12.89	6.67	9.74	-0.64	-0.68
(l) Management of companies	55	1.71	1.93	0.88	0.87	22.18	11.85	35.96	0.70	0.67
(l) Administrative, waste mgmt*	56	0.75	3.25	0.86	0.85	7.03	8.16	6.93	0.02	0.02
(l) Construction*	23	5.10	5.37	0.83	0.86	54.27	20.02	37.74	-0.94	-0.91
(l) Arts, entertainment, recreation	71	0.65	1.09	0.81	0.58	15.32	22.34	19.47	0.53	0.60
(l) Other services, except government	81	3.20	2.85	0.80	0.91	42.82	23.01	54.24	0.13	0.31
(l) Profnl, scientific, tech services*	54	1.83	7.51	0.79	0.86	9.79	2.58	12.02	-0.23	-0.01
(l) Retail trade	44, 45	9.46	7.49	0.78	0.77	16.57	16.04	34.37	1.13	1.11
(l) Transportation, warehousing	48, 49	5.98	3.33	0.75	0.74	21.62	73.77	65.90	2.31	2.32
(l) Durable goods	33, 321, 327	17.62	8.91	0.74	0.66	15.91	21.24	91.18	2.77	2.54
(l) Accommodation, food services*	72	2.61	3.16	0.73	0.76	21.66	20.46	22.43	0.02	0.03
(l) Wholesale trade	42	6.99	6.78	0.71	0.69	8.80	4.91	43.72	1.96	1.88
(c) Finance, insurance*	52	3.54	8.36	0.59	0.71	14.32	2.27	26.16	-0.80	-0.20
(c) Information	51	3.41	5.61	0.53	0.46	7.36	6.49	45.81	1.84	1.55
(c) Nondurable goods	31, 32	13.07	6.77	0.52	0.49	24.98	29.81	117.89	1.80	1.72
(c) Agriculture, forestry, fishing, hunting	11	6.24	1.15	0.51	0.36	27.44	62.17	180.30	2.76	2.42
(c) Mining*	21	2.75	1.80	0.37	0.32	58.37	33.93	147.84	0.00	-0.16
(c) Utilities	22	2.11	1.93	0.34	0.29	18.51	26.80	79.60	1.49	1.39
(c) Real estate, rental and leasing	53	10.51	14.44	0.09	0.20	15.24	21.80	27.34	0.76	0.81
labor-intensive sector		58.38	59.94	0.79	0.77	17.78	23.14	34.19	1.15	1.14
capital-intensive sector		41.62	40.06	0.37	0.40	18.77	21.24	71.83	1.15	1.24
all private industries	11-81	100.00	100.00	0.62	0.62	18.21	21.51	40.58	1.13	1.13

Notes: The table presents the authors' calculations based on data drawn from the U.S. Bureau of Economic Analysis (BEA) and U.S. Bureau of Labor Statistics (BLS). $i \in \{\tau, j\}$ where $\tau \in \{1, 2\}$ denotes sectors, with $\tau = 1$ for the labor-intensive sector (l) and $\tau = 2$ for the capital-intensive sector (c), and j denotes sub-sectors or industries. For the initial period, we take $t-1 = 1948-1958$, while we set the end period to $t = 1998-2008$. $1-\alpha_i$ denotes the labor share. $Y_{i,t-1}/Y_{i,t}$, $K_{i,t-1}/K_{i,t}$, and $L_{i,t-1}/L_{i,t}$ denote the real output, real capital stock, and labor of 1948-1958 expressed as percentages (%) of their respective 1998-2008 values. g_{A_i} denotes estimates of the compound annual productivity growth rate in percent (%) based on Cobb-Douglas production functions. A star highlights an industry with either zero or negative productivity growth.

Table 2: Inflation-Adjusted Productivity Estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	adj. (pp)	$\frac{Y_{\tau,t-1}}{Y_{\tau,t}}$ (%)	$\frac{K_{\tau,t-1}}{K_{\tau,t}}$ (%)	$\frac{L_{\tau,t-1}}{L_{\tau,t}}$ (%)	g_{A_τ} (%) BEA	$\frac{g_{A_1}}{g_{A_2}}$ BEA	g_{A_τ} (%) BLS	$\frac{g_{A_1}}{g_{A_2}}$ BLS
A. no adjustment								
labor intensive	0.00	17.78	23.14	34.19	1.15		1.14	
capital intensive	0.00	18.77	21.24	71.83	1.15	***1.00***	1.24	***0.92***
capital/aggregate	0.00							
B. capital intensive 0.0pp, labor intensive 0.5-0.9pp								
labor intensive	0.50	13.96	19.99	34.19	1.58		1.56	
capital intensive	0.00	18.77	18.35	71.83	0.96	***1.64***	1.06	***1.47***
capital/aggregate	0.30							
labor intensive	0.70	12.67	18.85	34.19	1.75		1.73	
capital intensive	0.00	18.77	17.30	71.83	0.89	***1.98***	0.99	***1.75***
capital/aggregate	0.42							
labor intensive	0.90	10.95	17.78	34.19	2.02		2.00	
capital intensive	0.00	18.77	16.31	71.83	0.81	***2.50***	0.92	***2.18***
capital/aggregate	0.54							
C. capital intensive 0.1pp, labor intensive and 0.5-0.9pp								
labor intensive	0.50	13.96	19.60	34.19	1.57		1.55	
capital intensive	0.10	17.04	17.99	71.83	1.13	***1.39***	1.23	***1.26***
capital/aggregate	0.34							
labor intensive	0.70	12.67	18.49	34.19	1.74		1.72	
capital intensive	0.10	17.04	16.96	71.83	1.06	***1.65***	1.16	***1.48***
capital/aggregate	0.46							
labor intensive	0.90	10.95	17.43	34.19	2.01		1.99	
capital intensive	0.10	17.04	15.99	71.83	0.98	***2.05***	1.09	***1.83***
capital/aggregate	0.58							

Notes: The table presents the authors' calculations based on data drawn from the U.S. Bureau of Economic Analysis (BEA) and U.S. Bureau of Labor Statistics (BLS). $\tau \in \{1,2\}$ equals 1 for the labor-intensive sector and 2 for the capital-intensive sector. For the initial period, we take $t-1 = 1948-1958$, while we set the end period to $t = 1998-2008$. $Y_{\tau,t-1}/Y_{\tau,t}$, $K_{\tau,t-1}/K_{\tau,t}$, and $L_{\tau,t-1}/L_{\tau,t}$ denote the real output, real capital stock, and labor of 1948-1958 expressed as percentages (%) of their respective 1998-2008 values. g_{A_τ} denotes estimates of the compound annual productivity growth rate in percent (%) based on Cobb-Douglas production functions. pp denotes the percentage point inflation adjustment. The table shows inflation adjustments for output prices in the labor-intensive sector, output prices in the capital-intensive sector, capital prices (which are treated symmetrically across sectors), and aggregate output prices. Capital and aggregate output prices are characterized by the same rate of inflation adjustment.