Is It Structural Change, or Is Capital's Compensation Outpacing Labor's across More Industries?: The Case of U.S. Labor Productivity, 1982-1997

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1. Introduction

A book in memory of Wassily Leontief would hardly be complete without some piece on the structure of the American economy. After all Professor Leontief had developed his first input-out table using U.S. data and subsequently published his first three books with the purpose of examining the structure of the American economy (1941, 1951, 1953).[1] It was with this in mind that the editors of this book, along with Bart Los, teamed up to put new trimmings on some of the pioneering work laid out by our esteemed predecessor. The team seemed particularly well equipped with Dietzenbacher and Los having made prior investigations into structural decomposition analysis (Dietzenbacher, 2001; Dietzenbacher, Hoehn, and Los, 2000; Dietzenbacher and Los 2000, 1998, 1997) and with Lahr well attuned to U.S. industry trends and the availability and nature of American national accounts data.

According to BEA fugures, the annual growth of real U.S. gross product originating (GPO) declined since 1980. While it averaged near 7.5 percent during the 1980s, it dipped to something closer to 5.1 percent in the 1990s. A cursory decomposition reveals that labor compensation's share of GPO simultaneously edged downward, from an decadal average 58.5 percent in the 1980s to 58.0 percent in the 1990s, a perceptible if

[1] The well-known Leontief Paradox also stemmed from his examination of the structure of American trade (Leontief, 1956, 1958). He had also published an article on this topic in *Scientific American* in 1965.

not precipitous fall. Indeed, U.S. labor costs did not parallel those in other G-7 nations, despite rather similar patterns in productivity growth (Cobet and Wilson, 2002).

Analysts have clamored to figure out what caused such dramatic changes in the U.S. economy. Various rationales have been put forward, the most viable being the end of the Breton Woods system of controlled exchange rates fortified by two major oil price shocks and the "Plaza Accord," an international agreement that lowered the value of U.S. currency (Cobet and Wilson, 2002). In any case, it became immediately clear that the pre-existing trend of the economy to shift out of manufacturing and into a more service-based mode of operation was a partial intermediate cause for both of the deleterious trends in GPO of the 1990s.

Certainly, much of the shift out of goods-producing industries can be attributed to the increasing ease of transferring capital across national boundaries toward lower-priced semi-skilled labor surely encouraged by new bilateral trade agreements—GATT and NAFTA (Bordo, Eichengreen, and Irwin, 1999). BEA data show that in 1970 manufacturing jobs comprised 21.5 percent of the workforce. In contrast, by 1980, manufacturing's share of employment had reduced to 14.1 percent, and by 2000 to 11.4 percent. At the same time the service industries grew rapidly. From 63.9 percent in 1970 to 70.2 percent in 1980 and 79.2 percent in 2000. Although some of the service jobs created were in high-paying "symbolic analytic services,"[2] evidence suggests that the many part-time retail-based jobs also added likely counteracted and overwhelmed the surge in this new type of service-industry labor.

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[2] Reich (1991) seems to have been the first to recognize the fundamental composition of this new branch of the U.S. labor force.

From 1973 to 1990 labor costs rose on average by 4.1 percent annually in nominal terms (Cobet and Wilson, 2002). Nonetheless, many researchers have documented the relative stagnancy of average real compensation per worker during the period. Nearly three decades of rapid income growth and narrowing income differentials stopped abruptly in the 1970s. Real incomes not only started to grow more slowly,[3] but they also became more unequally distributed (Blank, 1997; Danziger and Gotschalk, 1995; Levy and Murnane, 1992; Harrison and Bluestone, 1990). In summary, it would seem during the past decade or so U.S. labor has not been reaping its usual share of the benefits of productivity growth.

This led us to follow up on Leontief's suggestion that "it would very be interesting to see how modern technological change has affected the demand for labor" (Foley, 1998, p. 127), something toward which much of his professional life was apparently devoted. Unlike the case of capital, there are limits to the how much the demand for labor can be reduced. This reduction limit makes the examination of labor's demand particularly interesting from a social research perspective. As suggested by Leontief later in his interview with Duncan Foley, when the demand for labor approaches the economy's minimum tolerable limit, household-level social problems crop up with greater frequency within that economy. Indeed, this symptom of labor demand's lower bound is reflects the concern expressed by researchers who found that U.S. labor income per worker had stagnated in the 1980s. Moreover, advances in the analysis of economic

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[3] Gordon (1997) suggests that in the 1970s and 1980s the influx of many new labor market entrants (women, baby boomers, and immigrants—the latter both legal and illegal) affected the productivity of service industries in much the same way that immigrants did between 1890-1913. That is their presence may have dampened real wages and delayed the introduction of some labor-saving devices.

structural change during the past decade or so afforded new ways of examining some of Leontief's goals.

So why did capital apparently benefit from enhanced productivity at the expense of U.S. workers during the 1990s? Did technological change, indeed, play a role as Leontief might suppose? Could a new regime in the structure of U.S. final demand be a cause? Or is it simply that the U.S. economy is divesting into industries that are more laden with property-type income than labor compensation? In order to investigate the answers to these questions, we opted to structurally decompose U.S. labor productivity along the lines recently applied by Dietzenbacher, Hoen, and Los (2000) in the *Journal of Regional Science*. To address our main policy concern, we decompose labor compensation's share of value added into effects due to trends (labor compensation and nonlabor income) at the sector level and effects due to structural change (final demand and technology).

We lay out the description of our research approach and results as follows. In the next section we describe some methodological aspects of structural decompositions, including how they can be related to certain well-known index number types. In Section 3, we propose a very specific decomposition of compensation's share of value added that enables us to analyze, over time, compensation per hour worked as well as value added per hour worked as well as the structural effects of technology and final demand change. We propose using a Fisher-type index in the our empirical analysis. In Section 4, we describe the data we used and how we prepared it for the application at hand. In Section 5, we analyze and discuss the results of the decompositions. This is followed by a set of research conclusions.

2. *Methodological aspects of structural decompositions*

Structural decompositions aim at disentangling the change in some variable into the changes in the constituent parts of this variable. In input-output economics, the decomposition forms typically have an additive form. The simplest example of such a decomposition is in explaining the change in the value of a basket of goods into the price changes of the goods and the quantity changes of the goods in the basket. If we denote the value at time 0 as $v(0)$ and the price and quantity of the goods as $p_i(0)$ and $q_i(0)$, we have $v(0) = \Sigma_i p_i(0) q_i(0)$, or in matrix terms $v(0) = \mathbf{p}(0)'\mathbf{q}(0)$. The additive decomposition forms would be given by

$$
\begin{aligned}
v(1) - v(0) &= [\mathbf{p}(1)'\mathbf{q}(1) - \mathbf{p}(0)'\mathbf{q}(1)] + [\mathbf{p}(0)'\mathbf{q}(1) - \mathbf{p}(0)'\mathbf{q}(0)] && (1)\\
&= [\mathbf{p}(1)'\mathbf{q}(0) - \mathbf{p}(0)'\mathbf{q}(0)] + [\mathbf{p}(1)'\mathbf{q}(1) - \mathbf{p}(1)'\mathbf{q}(0)] && (2)
\end{aligned}
$$

The term between the first brackets indicates the value change due to price changes, using the quantities in period 1 as weights in (1) and those of period 0 in (2). Similarly, the term between the second brackets gives the value change caused by quantity changes with prices of period 0 as weights in (1) and those of period 1 in (2). Because there is a priori no reason why one form should be preferred to the other, typically the arithmetic average is used. That is,

$$
\begin{aligned}
v(1) - v(0) &= 0.5[\mathbf{p}(1) - \mathbf{p}(0)]'[\mathbf{q}(0) + \mathbf{q}(1)] + 0.5[\mathbf{p}(0) + \mathbf{p}(1)]'[\mathbf{q}(1) - \mathbf{q}(0)]\\
&= 0.5(\Delta\mathbf{p})'[\mathbf{q}(0) + \mathbf{q}(1)] + 0.5[\mathbf{p}(0) + \mathbf{p}(1)]'(\Delta\mathbf{q}) && (3)
\end{aligned}
$$

In the present paper, we use multiplicative decomposition forms (see Dietzenbacher, Hoen and Los, 2000) which is more in line with the theory of index numbers. In the example above, instead of disentangling the absolute difference in the values, the relative change in the values is to be examined. Similar to equations (1) and (2), we now have

$$\frac{v(1)}{v(0)} = \frac{\mathbf{p}(1)'\mathbf{q}(1)}{\mathbf{p}(0)'\mathbf{q}(1)} \frac{\mathbf{p}(0)'\mathbf{q}(1)}{\mathbf{p}(0)'\mathbf{q}(0)} \tag{4}$$

$$= \frac{\mathbf{p}(1)'\mathbf{q}(0)}{\mathbf{p}(0)'\mathbf{q}(0)} \frac{\mathbf{p}(1)'\mathbf{q}(1)}{\mathbf{p}(1)'\mathbf{q}(0)} \tag{5}$$

Note that the first term on the right hand side of (4) equals the Paasche price index, while the second term gives the Laspeyres quantity index. Similarly, the first term in (5) is the Laspeyres price index and the second term is the Paasche quantity index. In the same way as we did in (3) we take the average of the two decompositions. However, instead of using the arithmetic average, now the geometric average should be used. That is,

$$\frac{v(1)}{v(0)} = \left(\frac{\mathbf{p}(1)'\mathbf{q}(1)}{\mathbf{p}(0)'\mathbf{q}(1)} \frac{\mathbf{p}(1)'\mathbf{q}(0)}{\mathbf{p}(0)'\mathbf{q}(0)} \right)^{0.5} \left(\frac{\mathbf{p}(0)'\mathbf{q}(1)}{\mathbf{p}(0)'\mathbf{q}(0)} \frac{\mathbf{p}(1)'\mathbf{q}(1)}{\mathbf{p}(1)'\mathbf{q}(0)} \right)^{0.5} \tag{6}$$

The first term on the right hand side is the Fisher price index and the second term is the Fisher quantity index.

As is well known, Fisher indexes satisfy certain desirable properties, of which we discuss three. First, the factor reversal test requires that if the price index is multiplied by the quantity index the value index, i.e. $v(1)/v(0)$, is obtained. Equation (6) immediately shows that this holds for the Fisher indexes, in contrast to the Lapeyres or the Paasche indexes, for example. Second, the time reversal test requires that the index for period 1 with period 0 as its base multiplied with its reverse (i.e. the same index for period 0 with period 1 as its base), equals one. If we take the Fisher price index (i.e. the first term in

(6)) as an example, we have to multiply it with the index that is obtained by replacing all 0's by 1's (and vice versa). It is easily seen that this yields one. Again, in contrast to the Fisher indexes, the Laspeyres and the Paasche indexes do not satisfy the time reversal test. Third, the test for symmetry requires that the price index becomes the corresponding quantity index, once $\mathbf{p}(1)$ and $\mathbf{p}(0)$ are replaced by $\mathbf{q}(1)$ and $\mathbf{q}(0)$, respectively, and vice versa. The Laspeyres, the Paasche and the Fisher indexes satisfy this test for symmetry.

The discussion above, where the value change has been decomposed into a component reflecting the effect of price changes and another component indicative of the quantity changes, is an example of the simplest possible decomposition. That is, it is a decomposition where the variable under consideration (i.e. the value of a basket of goods) consists of just two underlying determinants (viz. prices and quantities of the goods). In most structural decomposition studies in input-output economics, the variable under consideration consists of a much larger number of determinants. This also increases the number of possible decomposition forms tremendously. The forms that have been used the most are the so-called polar decompositions (see Dietzenbacher and Los, 1998). For the ease of exposition, suppose the change in the scalar z is to be decomposed into its three constituent parts, based on $z = \mathbf{a}'\mathbf{B}\mathbf{c}$, where $\mathbf{a}$ and $\mathbf{c}$ are vectors and $\mathbf{B}$ is a matrix. The two polar decompositions in a multiplicative format are as follows.

$$\frac{z(1)}{z(0)} = \frac{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(1)}{\mathbf{a}(0)'\mathbf{B}(1)\mathbf{c}(1)} \frac{\mathbf{a}(0)'\mathbf{B}(1)\mathbf{c}(1)}{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(1)} \frac{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(1)}{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(0)} \tag{7}$$

$$= \frac{\mathbf{a}(1)'\mathbf{B}(0)\mathbf{c}(0)}{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(0)} \frac{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(0)}{\mathbf{a}(1)'\mathbf{B}(0)\mathbf{c}(0)} \frac{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(1)}{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(0)} \tag{8}$$

Note that the polar decomposition in (7) can be viewed as an approach "from left to right". That is, starting from $z(1) = \mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(1)$, first change $\mathbf{a}(1)'$ into $\mathbf{a}(0)'$, next change **B**(1) into **B**(0), and finally change **c**(1) into **c**(0). The decomposition in (8) reflects an approach "from right to left", where first **c** is changed, then **B** and finally $\mathbf{a}'$.

Just as we did with the forms in (4) and (5), we again take the geometric average, which yields the Fisher-type of indexes.

$$\frac{z(1)}{z(0)} = \left(\frac{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(1)}{\mathbf{a}(0)'\mathbf{B}(1)\mathbf{c}(1)}\frac{\mathbf{a}(1)'\mathbf{B}(0)\mathbf{c}(0)}{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(0)}\right)^{0.5}\left(\frac{\mathbf{a}(0)'\mathbf{B}(1)\mathbf{c}(1)}{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(1)}\frac{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(0)}{\mathbf{a}(1)'\mathbf{B}(0)\mathbf{c}(0)}\right)^{0.5} \times \left(\frac{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(1)}{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(0)}\frac{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(1)}{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(0)}\right)^{0.5} \qquad (9)$$

The first term on the right hand side, which we call the a-index, reflects the change in z brought about by the change in the vector a. Similarly, the second and third term indicate the change in z due to the change in the matrix **B** and vector **c**, respectively. They will be termed the **B**-index and the **c**-index.

Note that these indexes satisfy the factor reversal and the time reversal test. The factor reversal test requires that the **a**-index multiplied by the **B**-index and by the **c**-index equals $z(1)/z(0)$, which exactly is what equation (9) expresses. The **a**-index above is the index for period 1 with period 0 as its base. Replacing the 0's by 1's and vice versa, yields the **a**-index for period 0 with period 1 as its base. The time reversal test requires that if these two different **a**-indexes are multiplied the answer should be equal to one. The test for symmetry needs to be extended first. For example, we say that the **a**-index is symmetric to the **B**-index if replacing $\mathbf{a}(1)'$ and $\mathbf{a}(0)'$ by **B**(1) and **B**(0), respectively, and vice versa turns the **a**-index into the **B**-index (and vice versa). It readily follows that the **B**-index is not symmetric to another index. However, the **a**-index and the **c**-index are symmetric.

In the general case, the variable z consists of k parts. That is $z = \mathbf{x}_1\mathbf{x}_2...\mathbf{x}_k$, where each of the components may be a scalar, vector or matrix. The $\mathbf{x}_i$-index (with i = 1, …, k) obtained from taking the geometric average of the two polar decompositions yields in this case

$$\left(\frac{\mathbf{x}_1(1)...\mathbf{x}_{i-1}(1)\mathbf{x}_i(1)\mathbf{x}_{i+1}(0)...\mathbf{x}_k(0)}{\mathbf{x}_1(1)...\mathbf{x}_{i-1}(1)\mathbf{x}_i(0)\mathbf{x}_{i+1}(0)...\mathbf{x}_k(0)}\frac{\mathbf{x}_1(0)...\mathbf{x}_{i-1}(0)\mathbf{x}_i(1)\mathbf{x}_{i+1}(1)...\mathbf{x}_k(1)}{\mathbf{x}_1(0)...\mathbf{x}_{i-1}(0)\mathbf{x}_i(0)\mathbf{x}_{i+1}(1)...\mathbf{x}_k(1)}\right)^{0.5} \qquad (10)$$

Again, the $\mathbf{x}_i$-indexes satisfy the factor reversal and the time reversal test, while the $\mathbf{x}_1$-index and the $\mathbf{x}_k$-index are symmetric.

The discussion above provides some theoretical basis for using the Fisher-type of indexes in a decomposition study. An empirical motivation for using this type of indexes is given in Dietzenbacher and Los (1998). The Fisher-type of indexes are derived from averaging the two polar decompositions, obtained from the "left to right" and the "right to left" approach. However, there is *a priori* no reason why the sequence of changes should be ordered in this way. For example, it is also possible that first **B** is changed, after which **c** is changed, while $\mathbf{a}'$ is changed last. This ordering would yield

$$\frac{z(1)}{z(0)} = \frac{\mathbf{a}(1)'\mathbf{B}(0)\mathbf{c}(0)}{\mathbf{a}(0)'\mathbf{B}(0)\mathbf{c}(0)}\frac{\mathbf{a}(1)'\mathbf{B}(1)\mathbf{c}(1)}{\mathbf{a}(1)'\mathbf{B}(0)\mathbf{c}(1)}\frac{\mathbf{a}(1)'\mathbf{B}(0)\mathbf{c}(1)}{\mathbf{a}(1)'\mathbf{B}(0)\mathbf{c}(0)}$$

Hence, in the case of k determinants this would lead to $k!$ equally plausible decomposition forms. Dietzenbacher and Los (1998) examined all these forms for an additive decomposition and found that the arithmetic average of the two additive polar decomposition forms was extremely close to the average of all $k!$ decomposition forms.

3. *Decomposing the labor income share in value added*

This section presents the decomposition forms that will be applied later to US input-output tables. The definitions, all for industry i, are:

v_i = value added (in 1996 dollars)
w_i = labor income (in 1996 dollars)
l_i = labor inputs (either in hours worked)
$\pi_i = v_i / l_i$ = labor productivity
$\alpha_i = w_i / l_i$ = earnings per hour worked
$\lambda_i = l_i / x_i$ = hours worked per 1996 dollar of gross output
$\sigma_i = w_i / v_i$ = labor income share in value added.

The totals are obtained by summation, i.e. $v = \Sigma_i v_i$, $w = \Sigma_i w_i$ and $l = \Sigma_i l_i$, while the overall ratios are obtained as the ratios of the totals, i.e. $\pi = v/l$, $\alpha = w/l$ and $\sigma = w/v$. Our aim is to decompose the overall labor income share in value added. To this end write

$$\sigma = \frac{w}{v} = \frac{w/l}{v/l} = \frac{\alpha}{\pi} \tag{11}$$

The numerator gives the overall earnings per hour worked can be written as

$$\alpha = \frac{w}{l} = \frac{\boldsymbol{\alpha}'\hat{\boldsymbol{\lambda}}\mathbf{x}}{\boldsymbol{\lambda}'\mathbf{x}} = \boldsymbol{\alpha}'\mathbf{s}$$

so that the overall ratio α is the weighted average of the sectoral ratios α_i. The vector of weights is given by $\mathbf{s} = (\hat{\boldsymbol{\lambda}}\mathbf{x})/(\boldsymbol{\lambda}'\mathbf{x})$, where s_i denotes the sectoral labor input as a share of the total labor inputs (i.e. $s_i = \lambda_i x_i / \Sigma_i \lambda_i x_i = l_i / \Sigma_i l_i$). Further, $\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \equiv \mathbf{Lf}$, where $\mathbf{A}$ denotes the matrix of input coefficients, $\mathbf{f}$ the final demand vector, and $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ the Leontief inverse. Substitution yields

$$\alpha = \frac{\boldsymbol{\alpha}'\hat{\boldsymbol{\lambda}}\mathbf{Lf}}{\mathbf{e}'\hat{\boldsymbol{\lambda}}\mathbf{Lf}},$$

where $\mathbf{e}'$ denotes the row summation vector, i.e. (1,…,1). In the same way we find that the denominator in (11), i.e. the overall labor productivity, can be written as

$$\pi = \frac{v}{l} = \frac{\boldsymbol{\pi}'\hat{\boldsymbol{\lambda}}\mathbf{x}}{\boldsymbol{\lambda}'\mathbf{x}} = \boldsymbol{\pi}'\mathbf{s} = \frac{\boldsymbol{\pi}'\hat{\boldsymbol{\lambda}}\mathbf{Lf}}{\mathbf{e}'\hat{\boldsymbol{\lambda}}\mathbf{Lf}}.$$

The overall labor productivity is the weighted average of sectoral labor productivities, again using sectoral labor input shares (in total labor inputs) as weights. This implies for the ratio of aggregate labor income to value added

$$\frac{w}{v} = \frac{\boldsymbol{\alpha}'\hat{\boldsymbol{\lambda}}\mathbf{Lf}}{\boldsymbol{\pi}'\hat{\boldsymbol{\lambda}}\mathbf{Lf}}.$$

The two polar decompositions now yield that σ_1 / σ_0 equals

$$\left(\frac{\boldsymbol{\alpha}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_1}{\boldsymbol{\alpha}_0'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_1}\right)\left(\frac{\boldsymbol{\pi}_0'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_1}{\boldsymbol{\pi}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_1}\right)\left(\frac{\boldsymbol{\alpha}_0'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_1}{\boldsymbol{\alpha}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_1\mathbf{f}_1}\frac{\boldsymbol{\pi}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_1\mathbf{f}_1}{\boldsymbol{\pi}_0'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_1}\right)\left(\frac{\boldsymbol{\alpha}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_1\mathbf{f}_1}{\boldsymbol{\alpha}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_1}\frac{\boldsymbol{\pi}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_1}{\boldsymbol{\pi}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_1\mathbf{f}_1}\right)\left(\frac{\boldsymbol{\alpha}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_1}{\boldsymbol{\alpha}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_0}\frac{\boldsymbol{\pi}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_0}{\boldsymbol{\pi}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_1}\right)$$

and

$$\left(\frac{\boldsymbol{\alpha}_1'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_0}{\boldsymbol{\alpha}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_0}\right)\left(\frac{\boldsymbol{\pi}_0'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_0}{\boldsymbol{\pi}_1'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_0}\right)\left(\frac{\boldsymbol{\alpha}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_0\mathbf{f}_0}{\boldsymbol{\alpha}_1'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_0}\frac{\boldsymbol{\pi}_1'\hat{\boldsymbol{\lambda}}_0\mathbf{L}_0\mathbf{f}_0}{\boldsymbol{\pi}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_0\mathbf{f}_0}\right)\left(\frac{\boldsymbol{\alpha}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_0}{\boldsymbol{\alpha}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_0\mathbf{f}_0}\frac{\boldsymbol{\pi}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_0\mathbf{f}_0}{\boldsymbol{\pi}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_0}\right)\left(\frac{\boldsymbol{\alpha}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_1}{\boldsymbol{\alpha}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_0}\frac{\boldsymbol{\pi}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_0}{\boldsymbol{\pi}_1'\hat{\boldsymbol{\lambda}}_1\mathbf{L}_1\mathbf{f}_1}\right)$$

Each of the two polar decompositions disentangles the changes in the aggregate labor share into five effects. The five Fisher-type indexes are obtained by taking the geometric average of the two corresponding effects. Note that in the polar decompositions, the first term relates to changes in the real earnings per hour worked. The second term indicates how labor productivity changes affect the total effect, whereas the third term reflects the contribution of changes in the labor inputs required per unit of gross output. The fourth and fifth term relate to changes in economic structure (i.e. changes in the input coefficients and changes in the final demands, respectively), which are common determinants in structural decomposition analyses.

An important and frequently neglected aspect in structural decompositions is that it is (often only implicitly) assumed that the determinants are independent of each other. For example, the first term in the polar decompositions above measures what the effects would have been of sectoral changes in the real earnings per hour worked, had all other variables (i.e. $\boldsymbol{\lambda}, \boldsymbol{\pi}$, $\mathbf{L}$ and **f**) remained constant. Clearly, it is not always possible to change a certain variable without changing any of the others (see Dietzenbacher and Los, 2000, for an example where independency does not hold and for a solution to the problems induced by dependent variables). In the present case, however, there are no binding definitions that endanger the independency of the determinants. Yet, we emphasize that the determinants may be expected to be dependent to some extent in empirical cases, in the sense that they correlate. Note that π_i is the labor productivity, while $1/\lambda_i$ equals gross output divided by labor, which Wolff (1994) recommends for measuring labor productivity. Also note that the real rate of labor compensation $\alpha_i = w_i / l_i$ is included in labor productivity $\pi_i = v_i / l_i$, the difference between v_i and w_i being all non-labor income in sector *i*. So, an increase in labor productivity will induce an increase in the real rate of labor compensation and/or nonlabor income per hour worked. The relationship between the variables is that $\lambda_i(\pi_i - \alpha_i)$ equals the share of nonlabor income in the gross output value.

So far, we have examined the decomposition of the overall labor income share in value added. Similar results are obtained when we are interested in the contributions to labor share changes for a group of aggregated sectors (say all manufacturing industries taken together, or all service industries consolidated). To this end define the following aggregation vector $\mathbf{g}'$ = (1,…,1, 0,…,0), or

$$g_i = \begin{cases} 1 \text{ if } i \text{ is part of the aggregate industry} \\ 0 \text{ if } i \text{ is not part of the aggregate industry} \end{cases}$$

For the earnings per hour worked in the aggregate industry *I*, we then have

$$\alpha_I = \frac{\mathbf{g}'\hat{\boldsymbol{\alpha}}\hat{\boldsymbol{\lambda}}\mathbf{Lf}}{\mathbf{g}'\hat{\boldsymbol{\lambda}}\mathbf{Lf}} = \mathbf{g}'\hat{\boldsymbol{\alpha}}\mathbf{s}$$

where $\mathbf{s} = \hat{\boldsymbol{\lambda}}\mathbf{x}/(\mathbf{g}'\hat{\boldsymbol{\lambda}}\mathbf{x})$. In the same way, we have for the labor productivity

$$\pi_I = \frac{\mathbf{g}'\hat{\boldsymbol{\pi}}\hat{\boldsymbol{\lambda}}\mathbf{Lf}}{\mathbf{g}'\hat{\boldsymbol{\lambda}}\mathbf{Lf}} = \mathbf{g}'\hat{\boldsymbol{\pi}}\mathbf{s}$$

and $\sigma_I = \alpha_I / \pi_I$. The rest of the analysis is similar to the analysis for the changes in the overall labor share in value added.

4. Description of the Data Used

To test the approach described at the end of the previous section, we elected to use a recent series of U.S. national input-output tables. In particular, we decided to analyze the effect of structural change on U.S. productivity with the benchmark tables for 1982, 1987, and 1992 produced by the U.S. Bureau of Economic Analysis (BEA). We also opted to use BEA's 1997 annual table to this series in lieu of the impending benchmark table for that same year. BEA's benchmark and 1997 annual tables contain 498 sectors. While other U.S. interindustry tables for intermediate years, these tables alone reflect best the prevailing average national technology.

One of the issues in performing decomposition analyses with interindustry tables is that their cell values are in terms of the nominal value of shipments. Hence, changes over time in any interindustry coefficients can reflect price changes, technological changes, or both. Therefore in order to isolate technology change, the values in the interindustry tables should be set in constant value terms. Fortunately the U.S. Bureau of Labor Statistics (BLS) has developed an annual series of input-output accounts in constant value terms (presently, 1996 dollars) for the years 1983 to 1998. These accounts have 192 sectors, including government. The BLS accounts also include estimates of employment (in terms of jobs) and hours worked by sector for each year.

The problem with using the BLS accounts alone is that the technology inherent in the interindustry portion of them is strictly that from the 1992 BEA benchmark table. Indeed, the annual real margins of the BLS tables (the finals demands, imports, value added and output accounts) along with the 1992 BEA Make and Use tables were employed by BLS to produce their constant dollar series of input-output accounts. Hence, we opted to follow BLS's lead and employed their margin accounts to aggregated version of three BEA benchmarks plus an annual table. Like van der Linden and Dietzenbacher (2001), we used RAS to "double deflate" the BEA tables into constant 1996 U.S. dollars. In the case of the 1982 BEA table, we applied 1983 BLS margins, understanding that this adjustment while imprecise is the best that can be done given the available data.

The only account that we used that was not provided within the context of BLS's or BEA's input-output accounts were those for national labor income. We produced them using techniques similar to those described by Lahr (2001) for regions. That is, for a given year, estimates of detailed industry payrolls were obtained from the U.S. Bureau of Census's *County Business Patterns* data. These then were enhanced using nominal data on the compensation of employees by industry from more-aggregate gross product accounts. We next calculated labor income-output ratios in nominal terms. These same ratios were assumed to hold in real terms.

5. Causes of Labor's Declining Share of Value Added

Decomposition of the aggregate economy

Table 1 shows the aggregate results of our decomposition. The figures in the column labeled "Total" show that by 1997 labor's share of value added for *nongovernment* sectors at 55.1 percent had declined to 88.7 percent of its 1982 share of 62.1 percent. This compares to BEA's measured modest decline from 59.5 to 57.8 percent (a decline in share of 2.9 percent) for *all* sectors, including government, for the same years. Further since the value of "Total" is less than one for each successive period, we can gather that the decline has been a rather steady one over the entire study period, although things may have leveled off somewhat between 1987 and 1992, a period when

U.S. wages were rising somewhat more steeply compared to other portions of the last two decades.

That the components of change for the second decomposition are typically stronger show that trends in industry mix change have enhanced the effects of the components of change in labor compensation's share of value added. On the whole, however, the components of the two polar decompositions provide similar findings.

Although they conflict with regard to the general direction of the effect, they concur that final demand provided little impetus for change in labor compensation's share of value added. Because of the conflicting directions, the Fisher Index shows **f** inducing even less change.

The remaining components demonstrate stronger similarities across the two decompositions. Because of this, we confine the balance of the discussion of our results for the entire economy to the Fisher Index only.

Did the change in input mix influence the demand for labor? Well, it seems that while input mix consistently had a deleterious effect on the labor share of value added over the period of study in any case. Its influence seems to have been not so strong, however, on the order of only 0.2 percent annually over the entire study period. This influence was virtually nonexistent between 1987 and 1992. Professor Leontief would have been disappointed by this finding.

For all industries together, the inverse of productivity, the $\boldsymbol{\pi}$ term, enhanced its downward pressure on compensation's share of value added at an annual average rate of 1.6 percent from 1982 to 1997. Indeed, productivity's negative influence accelerated during each successive subperiod, from 1982 to 1987 it exerted a downward influence on the order of 1.3 percent annually, from 1987 to 1992 the influence was 1.7 percent annually, and from 1992 to 1997 it was 1.9 percent annually. This term's influence is negative because productivity forms the denominator of the ratio represented by compensation's share of value added.

The numerator of that ratio is real compensation per hour worked, **α**. Hence, it should not be surprising that after **π, α** is the next most influential variable on compensation share of value added. The influence of hourly compensation on the change in compensation's share of value added rose at a rate of 0.5 percent annually. Most of its influence was wielded during a period the wage inflation just prior to the recession of the early 1990s (i.e., between 1987 and 1992), when it rose at a rate of 1.2 percent annually. During the five years just prior to that period, there was no measurable effect of the hourly rate of compensation on compensation's share of value added. During the five years following 1992, its effectual stagnancy returned.

Decomposition by major sector

The changes by major sector (primary, manufacturing, and services) were generally quite similar to those of the aggregate economy. There were some differences, however, so we recount them here.

Not surprisingly, however, most of the differences appear in primary industries, which are quite erratic because their behavior is motivated (dampened) by weather (agriculture) and labor strife (mining). It therefore is characterized by heavily cyclicity, which may not be well captured by an analysis undertaken on five-year intervals. In any case, Table 2 shows that labor compensation actually improved its share of valued added by 21.8 percent in the primary industries between 1982 and 1987: in our analysis it is the only industry in any period to show any improvement. Its share edged downward, however, during each subsequent five-year period.

Perhaps more significant is that structural components had a relatively strong effect on compensation's share in the primary industries. Their directions were no different from that of the aggregate economy, however. Final demand change had a particularly heavy negative effect on compensation's share between 1982 and 1987. Its negative effect moderated somewhat between 1987 and 1992 and then actually gave a lift to compensation's share of value added between 1992 and 1997, essentially compensating for the losses it caused of the prior five years.

Hourly compensation and productivity generally had much stronger effects in the primary industries than in either of the other two major sectors. This phenomenon could be due to the retirement of less productive mines and agricultural land as the nation's less-developed trade partners were able to enter the market.

The results for Manufacturing and Services sectors (Tables 3 and 4, respectively) had far fewer unique trends worth reporting. For Manufacturing sectors the most interesting new thing that can be said is that the structural change components had even less influence on compensation's share of value added than they did for the aggregate economy. Indeed, they were all almost negligible. In the case of the Service sectors, the productivity and hourly compensation components were the smallest of the three major sectors examined. Indeed, the share deteriorated by only 9.1 percent during the study period compared to a fall of 23.6 percent for Manufacturing and a net rise of 17.5 percent for the primary industries.

6. Conclusions

So, in answer the question set out in the title of this paper, capital's compensation has been outpacing labor's across more industries. While we cannot identify why this is so, we have demonstrated that structure change and changes in industry mix have not been main causes. Naturally one can hypothesize that it can be any one or a combination of a number of factors such as:

- A decline of union membership;
- A strengthened mandate to get return to stockholders; or
- A recent trend in co-option of labor in the ownership of capital through retirement and mutual funds.

From prior studies of technology change, we might have hypothesized that *input mix* would have little effect on compensation's share of value added during a 15-year span. And there were only a few notable changes in the composition of final demand during the period. On the other hand, the U.S. experienced a wholesale shift in the economy from a manufacturing base to a service one during the study period. Hence, we were somewhat surprised by the very small effect of *industry mix* across all three major industries.

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Table 1: Decomposition of Labor Compensation's Share of Value Added for the Aggregate U.S. Economy, 1982-1997

	1982-1997	1982-1987	1987-1992	1992-1997
Total	0.8869	0.9486	0.9894	0.9450
α_1	1.0481	0.9931	1.0609	1.0108
π_1	0.8171	0.9453	0.9238	0.9161
λ_1	1.0110	0.9983	1.0108	1.0112
L_1	1.0158	1.0079	1.0008	1.0077
f_1	1.0084	1.0044	0.9979	1.0015
α_2	1.1155	1.0088	1.0678	1.0207
π_2	0.7548	0.9264	0.9172	0.9086
λ_2	1.0415	1.0017	1.0138	1.0170
L_2	1.0205	1.0113	1.0013	1.0069
f_2	0.9911	1.0020	0.9952	0.9950
Fischer index				
α	1.0813	1.0009	1.0643	1.0157
π	0.7854	0.9358	0.9205	0.9124
λ	1.0261	1.0000	1.0123	1.0141
L	1.0181	1.0096	1.0010	1.0073
f	0.9997	1.0032	0.9966	0.9982

Table 2: Decomposition of Labor Compensation's Share of Value Added for U.S. Primary Industries (includes Construction), 1982-1997

	1982-1997	**1982-1987**	**1987-1992**	**1992-1997**
Total	1.1753	1.2179	0.9894	0.9753
α_1	2.3301	1.7558	1.1576	1.1615
π_1	0.5049	0.7360	0.8619	0.7992
λ_1	0.9338	0.9599	1.0062	0.9849
L_1	1.0941	1.0506	1.0133	1.0200
f_1	0.9779	0.9346	0.9727	1.0457
α_2	2.4368	1.8851	1.1607	1.1889
π_2	0.4988	0.7265	0.8603	0.7955
λ_2	0.9597	0.9766	0.9989	0.9881
L_2	1.0610	1.0264	1.0156	1.0127
f_2	0.9496	0.8873	0.9766	1.0307
Fischer index				
α	2.3828	1.8193	1.1592	1.1751
π	0.5018	0.7312	0.8611	0.7973
λ	0.9466	0.9682	1.0026	0.9865
L	1.0774	1.0384	1.0144	1.0163
f	0.9636	0.9107	0.9747	1.0382

Table 3: Decomposition of Labor Compensation's Share of Value Added for U.S. Manufacturing Industries, 1982-1997

	1982-1997	**1982-1987**	**1987-1992**	**1992-1997**
Total	0.7636	0.8743	0.9788	0.8923
α_1	1.1806	1.0159	1.0922	1.0710
π_1	0.6381	0.8505	0.9025	0.8262
λ_1	0.9933	1.0023	0.9966	1.0004
L_1	1.0007	0.9983	0.9994	1.0014
f_1	1.0196	1.0113	0.9969	1.0066
α_2	1.2273	1.0243	1.0962	1.0807
π_2	0.6212	0.8399	0.8984	0.8278
λ_2	1.0073	1.0037	1.0010	1.0031
L_2	0.9904	1.0010	0.9986	0.9958
f_2	1.0039	1.0114	0.9943	0.9985
Fischer index				
α	1.2037	1.0201	1.0942	1.0758
π	0.6296	0.8452	0.9005	0.8270
λ	1.0003	1.0030	0.9988	1.0017
L	0.9956	0.9997	0.9990	0.9986
f	1.0117	1.0114	0.9956	1.0026

Table 4: Decomposition of Labor Compensation's Share of Value Added for U.S. Service Industries, 1982-1997

	1982-1997	1982-1987	1987-1992	1992-1997
Total	0.9067	0.9698	0.9798	0.9543
α_1	1.0078	0.9886	1.0423	0.9929
π_1	0.8723	0.9815	0.9258	0.9451
λ_1	1.0109	0.9914	1.0131	1.0099
L_1	1.0182	1.0089	1.0005	1.0087
f_1	1.0021	0.9992	1.0016	0.9983
α_2	1.0547	0.9961	1.0483	1.0005
π_2	0.8219	0.9694	0.9176	0.9384
λ_2	1.0293	0.9921	1.0147	1.0143
L_2	1.0260	1.0129	1.0022	1.0088
f_2	0.9904	0.9994	1.0016	0.9933
Fischer index				
α	1.0310	0.9924	1.0453	0.9967
π	0.8467	0.9754	0.9217	0.9418
λ	1.0201	0.9918	1.0139	1.0121
L	1.0221	1.0109	1.0014	1.0087
f	0.9962	0.9993	1.0016	0.9958