Preliminary – Comments Welcome

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Information Technology, Education, and the Sources of Economic Growth across U.S. Industries

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April 12, 2002

Abstract

This paper generates new industry-level data to examine the sources of the U.S. economic resurgence after 1995. We employ a production possibility frontier to aggregate across industries and show that investment in information technology (IT), increases in the employment of non-college educated workers, and productivity gains account for the surge in output. A closer look at the underlying industry data shows enormous variation in patterns of input accumulation and productivity growth. We conclude that failure to account for this variation can create a misleading perception of the sources of economic growth.

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*We are grateful to Jon Samuels for excellent research assistance and NBER/CRIW pre-conference participants for helpful comments on an earlier version of this paper. The views expressed are those of the authors and do not necessarily reflect those of the Federal Reserve System or the Federal Reserve Bank of New York.

I. Introduction

The unusual combination of more rapid growth and slower inflation in the 1990's initiated a strenuous debate among economists about whether improvements in America's economic performance can be sustained. This debate has given way to a broad, if not all-embracing, consensus that improved productivity growth can continue.[1] Moreover, many believe the behavior of information technology (IT) provides the key to the recent surge in economic growth. Productivity growth in IT-producing industries has risen in importance, generating a relentless decline in the prices of information technology equipment. As a consequence, the enhanced role of IT investment as a source of economic growth is the most conspicuous feature of the U.S. economy since 1995 and a productivity revival is under way in many important IT-using industries.[2]

The foundation for the American growth resurgence is the development and deployment of semi-conductors. The well-known decline in IT prices is rooted in developments in semi-conductor technology that are widely understood by technologists and economists. This technology has found its broadest applications in computing and telecommunications equipment, but has reduced the cost and improved the performance of many other products embraced by businesses and households alike. Jorgenson (2001) shows that a substantial acceleration in the rate of IT price declines occurred in 1995, triggered by a much sharper acceleration in the price declines of semi-conductors in 1994. This can be traced to a shift in the product cycle for semi-conductors from three years to two years that occurred in 1995.

The American economy has undergone a remarkable revival since the mid-1990's with accelerating growth in output, labor productivity, and total factor productivity. Our first objective is to quantify the economy-wide sources of growth for 1958-1999 and various sub-periods, using data constructed at the industry level. This "bottom-up" approach complements the "top-down" analysis approach employed in the earlier work cited above. The key advantage of using industry-level data is that we are able to trace the sources of U.S. economic growth to their industry origins.

A second objective is to account for the sharp acceleration in the level of activity since 1995 and to document the role of investments in information technology and education. In Section II we show that the appropriate framework for analyzing the impact of information technology is the production possibility frontier, which includes outputs of IT-producing industries, as well as inputs of IT capital services. Two important advantages of this framework are that the prices of IT outputs and inputs are

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[1]See, for example, Baily (2002), Congressional Budget Office (2002), Council of Economic Advisors (2002), DeLong (2002), Jorgenson, Ho, and Stiroh (forthcoming), Jorgenson and Stiroh (2000), McKinsey Global Institute (2001), Oliner and Sichel (2000, forthcoming), and Whelan (forthcoming). Gordon (2002) offers a more pessimistic view.
[2]Baily and Lawrence (2001) and Stiroh (forthcoming) provide industry comparison and Brynjolffson and Hitt (2000) survey firm-level results.

linked through the prices of IT capital services, and that it can be built up directly from the underlying industry data. Finally, we report details of our industry production accounts and show the critical importance of IT capital deepening and education across U.S. industries.

The production possibility frontier includes growth rates for value-added in IT-producing industries and Non-IT industries, as well as capital and labor inputs. Capital input is divided between IT and Non-IT capital inputs, and labor input between college-educated and non-college educated workers. The key IT-producing industries are computers, telecommunications, equipment, semi-conductors, and software. Unfortunately, these are contained within broader industries in the industry classification used in this study, so we have identified IT-producing industries with Industrial Machinery and Equipment (SIC #35) and Electronic and Electrical Equipment (SIC #36). Software is part of Services, but we have excluded this from our definition of IT value-added, because Services is very large by comparison with software.

Capital input from information technology equipment corresponds to the services flowing from the installed stocks of computer hardware, telecommunications equipment, and software. Semi-conductors are an intermediate good and will appear later as an intermediate input into the industries that produce computers and telecommunications equipment, as well as many other industries. College-educated workers are often identified as "knowledge workers" who make use of information technology equipment, so we have divided labor input between college and non-college educated workers. Obviously, not every knowledge worker is a college graduate, nor is every college graduate a knowledge worker.

Table 1 gives the results of a growth accounting decomposition for value-added, based on the production possibility frontier incorporating industry-level data. This decomposition is given for the period 1958-1999 and the sub-periods 1958-1973, 1973-1990, 1990-1995, and 1995-1999 and is based on annual data for the period as a whole. While this breakdown of periods is conventional, a word about the choice of sub-periods is useful at this point. The year 1973 is the beginning of the energy crisis of the 1970's and is the beginning of a slowdown in economic growth that is readily apparent in the data. The year 1991 is the end of the last recession during the period covered by our data set and the year 1995 corresponds to a surge in economic growth, as well as the acceleration in the rate of decline of IT prices.

Table 1 and Figure 1 highlight the rising contributions of IT-producing industries to U.S. economic growth. Although the importance of these industries has steadily increased, this contribution has increased by more than fifty percent during the surge in growth after 1995. The contribution of IT inputs into production more than doubled after 1995 as the pace of IT price declines accelerated. In response to these price changes, firms, households, and governments have accumulated IT equipment much more rapidly than other forms of capital. The gradual rise in the relative importance of IT explains the steady rise in the quality of capital before 1995 and the jump that took place in the contribution of capital quality after 1995. Note, however, that the contribution of Non-IT equipment still predominates in the overall contribution of capital input, the most important source of U.S. economic growth throughout the period 1958-1999.

The contribution of labor input is next in importance as a source of U.S. economic growth and has played a vital role in the resurgence of the American economy after 1995. The contribution of college-educated workers has dominated the growth of labor input throughout the period 1958-1999, despite the fact that these workers are considerably less numerous than non-college workers. This reflects the fact that college-educated workers have higher marginal products on average, as can be seen in the wage premium. The rise in the relative proportion of these workers in the labor force is an important part of the explanation of the increase in labor quality represented in Table 1. However, non-college workers have been considerably more significant in the growth revival after 1995. While the contribution of college-educated workers declined slightly during this sub-period, the contribution of non-college workers almost doubled. As the unemployment rate fell in the late 1990's, many workers with relatively less education and experience entered the ranks of the employed labor force.

Finally, total factor productivity (TFP) has been the least important of the three major sources of U.S. economic growth – capital input, labor input, and total factor productivity. In fact, TFP growth almost disappeared after 1973. During the past decade productivity growth revived modestly during the sub-period 1990-1995 and jumped sharply after 1995. A substantial portion of this increase can be traced to IT-producing industries, although other industries also showed modest increases.

The results from aggregation across industry data are quite similar to the aggregate studies cited above, with the recent resurgence of the U.S. economy raising the growth rate of aggregate value-added by more than one-and-one-half percentage points. Slightly more than one-half percentage point of the post-95 revival is due to the surge in IT capital accumulation, while more than a third of a percentage point is due to higher investment in Non-IT tangible assets. College-educated workers played a slightly diminished role, but non-college workers contributed slightly less than a third of a percentage point. Finally, the remaining one-third percentage point is due to faster growth in total factor productivity.

Value-added growth is the sum of the growth in hours and average labor productivity (ALP). Table 2 and Figure 2 provide a breakdown between growth in hours and growth in ALP. For the period 1958-1999 ALP predominates in output growth, rising at 1.85 percent per year, while hours have increased at 1.53 percent per year. As is well-known and discussed in Section II, ALP growth depends on capital deepening, labor quality growth, and the growth of TFP. We have divided capital deepening between IT and Non-IT capital inputs and labor quality among college-educated and non-college workers and the reallocation of hours between these two categories. Finally, TFP growth can be decomposed into the contribution from component sectors and reallocation effects.

Figure 2 reveals the well-known labor productivity slowdown of the 1970's and 1980's and the acceleration in labor productivity growth in the late 1990's. The slowdown through 1990 reflects reduced deepening of capital, especially non-IT capital. The growth rate of ALP stabilized during the first half of the 1990's as capital deepening continued to slump, but labor quality growth accelerated and total factor productivity growth underwent a modest revival. A slowdown in hours generated a further slide in the growth of output, however. In previous cyclical recoveries in the postwar period, output growth had accelerated during the recovery, powered by more rapid growth of both hours and ALP.

Accelerating growth during 1995-1999 reflects the acceleration in the growth of hours worked of nearly a percentage point and a rise in ALP growth of more than half a percentage point. Tracing this to its sources in Table 2, we see that capital deepening rose by half a percentage point, accounting for virtually all the rise in ALP growth. The one-third percent increase in TFP growth was almost offset by a drop in the growth rate of labor quality. This can be traced to all three components of labor quality – college educated workers, non-college workers, and reallocation of hours between the two groups. In short, the decline can be attributed to the surge in employment of non-college workers after 1995.

Finally, in Table 2 and Figure 3 we divide the growth in TFP into components associated with IT-producing and Non-IT producing industries. As expected, this reveals a gradual rise in the contribution from IT-producing industries that has continued throughout the period 1958-1999. Productivity growth in Non-IT industries has averaged around zero since 1973, but did revive modestly after 1995. Two additional components of TFP growth are the reallocations of capital and labor inputs among industries. These capture differences in marginal products of these inputs in different industries. For the period as a whole the reallocations are relatively small, but reallocations of labor input fluctuate considerably from sub-period to sub-period, reflecting the rising and falling employment levels in various industries.

As an addendum in Table 2, we have compared value-added growth from the production possibility frontier with an unweighted sum of value-added for all industries. We have defined the difference between the two measures of value-added as the reallocation of value-added among industries, capturing differences in the price of a unit of value-added. Jorgenson, Gollop, and Fraumeni (1987) show that this price must be the same for all industries if the production possibility frontier can be reduced to an aggregate production function. While they also show that these reallocations were modest in size for the period covered by their study, 1948-1979, the results in Table 2 reveal that the reallocations are no longer small and, in particular, that they differ by almost a quarter of a percentage point between 1990-1995 and 1995-1999. This reveals the size of the aggregation error that results from assuming the existence of an aggregate production function and emphasizes the critical importance of employing an aggregate production possibility frontier to accurately assess the sources of economic growth.

In Section II we outline a framework for analyzing the role of information technology in the American growth resurgence at both aggregate and industry levels. This section also presents our methodology for aggregating output, capital, labor, and intermediate inputs, and productivity over industries, first introduced by Jorgenson, Gollop, and Fraumeni (1987). In this framework a key role is played by a weighting scheme proposed by Domar (1961). This scheme captures the relative importance of each industry in value-added, as well as the relative importance of value-added in the industry's output. This is essential for capturing the impact of sources of growth at the industry level, both in the industry where growth occurs and in the industries that purchase the output of this industry.

In Section III we present our methodology for measuring output and intermediate inputs. A key feature of this methodology is the use of inter-industry transactions tables to allocate the sources of U.S. economic growth among industries. In Section IV we outline the methods we have used in measuring capital input. Constant quality price indexes for information technology equipment are essential for separating changes in performance for the change in price for a given level of performance. The cost of capital is the key concept for capturing the economic impact of information technology prices. Section V outlines our methods for measuring labor input.

Finally, in Section VI we present an analysis of the sources of U.S. economic growth at the industry level. The contributions of capital and labor inputs and gains in economy-wide productivity presented in Tables 1 and 2 and Figures 1-3 reflect the evolution of the production structure of all industries in the U.S. economy, and Section VI describes the underlying industry data. Changes in this production structure at the industry level cumulate into the determinants of aggregate economic growth as technologies evolve and economic incentives are altered accordingly, and it is critical to describe and analyze changes at the industry level. As above, we focus special attention on the role of the IT-producing industries, investments in IT tangible assets, and investments in the human capital of knowledge workers.

II. Productivity and Aggregation

a) Industry Production Functions

We begin with an industry production function that exhibits constant returns to scale and write the production function as:

$$(2.1) \qquad Y_j = f(K_j, L_j, X_j, T)$$

where Y is industry output[3], K is capital service flow, L is labor input, and X is intermediate input, and T as an indicator of efficiency, all for industry j. The variables K, L, and X are each aggregates of many components and Equation (2.1) represents a function that is assumed to be separable in these components.

Let P_{Yj}, $P_{K,j}$, $P_{L,j}$, and $P_{X,j}$ denote the corresponding prices for outputs and inputs, respectively. All variables are also indexed by time, but the t subscript is suppressed unless necessary. Under the neoclassical assumptions of constant returns to scale and competitive markets, a translog index of industry *productivity growth* may be defined as:

$$(2.2) \qquad v_{T,j} \equiv \Delta \ln Y_j - \bar{v}_{K,j} \Delta \ln K_j - \bar{v}_{L,j} \Delta \ln L_j - \bar{v}_{X,j} \Delta \ln X_j$$

where $\bar{v}$ is the two-period average share of the subscripted input in nominal output. For example, the *value share* for capital is:

$$(2.3) \qquad \bar{v}_{K,j} = \frac{1}{2}\left(\frac{P_{K,j,t} K_{j,t}}{P_{Y,j,t} Y_{j,t}} + \frac{P_{K,j,t-1} K_{j,t-1}}{P_{Y,j,t-1} Y_{j,t-1}} \right)$$

and similarly for labor and intermediate inputs. Note that the neoclassical assumptions imply $P_{Y,j} Y_j = P_{K,j} K_j + P_{L,j} L_j + P_{X,j} X_j$ so that value and cost shares coincide for each input.[4]

Under the same assumptions, we write industry *labor productivity* (output per hour) as:

$$(2.4) \qquad \Delta \ln y_j = \bar{v}_{K,j} \Delta \ln k_j + \bar{v}_{L,j} \Delta \ln LQ_j + \bar{v}_{X,j} \Delta \ln x_j + v_{T,j}$$

where lower-case letters refer to per hour variables. The terms on the right-hand side are referred to as the contributions of capital deepening, labor quality, and intermediate input deepening, and productivity growth. We discuss the importance of each of these factors in Section VI.

We require the concept of industry value-added for *aggregation over sectors*. Assuming that the production function is separable, we define *value-added*, V_j, implicitly from the equation:

$$(2.5) \qquad \Delta \ln Y_j = \bar{v}_{X,j} \Delta \ln X_j + \bar{v}_{V,j} \Delta \ln V_j$$

where:

$$(2.6) \qquad \bar{v}_{V,j} = \frac{1}{2}\left(\frac{P_{K,j,t} K_{j,t} + P_{L,j,t} L_{j,t}}{P_{Y,j,t} Y_{j,t}} + \frac{P_{K,j,t-1} K_{j,t-1} + P_{L,j,t-1} L_{j,t-1}}{P_{Y,j,t-1} Y_{j,t-1}} \right)$$

where $P_{V,j} V_j = P_{K,j} K_j + P_{L,j} L_j$ is value-added in nominal terms and P_{Vj} is the price of value-added.

Equations (2.2) and (2.5) provide an alternative definition of industry *productivity growth*:

$$(2.7) \qquad v_{T,j} \equiv \bar{v}_{V,j} \Delta \ln V_j - \bar{v}_{K,j} \Delta \ln K_j - \bar{v}_{L,j} \Delta \ln L_j$$

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[3] We refer to this simply as "output," while others refer to it as "gross output." We use the simpler term because we believe it to be the preferred measure of output.
[4] See Hall (1988) and Basu and Fernald (1995, 1997) for alternative assumptions and implications.

b) Aggregation across Industries

To provide a view of the economy as a whole, we next consider aggregation across industries. Jorgenson, Gollop, and Fraumeni (1987) show that an aggregate production function requires the very stringent assumption that value-added functions across industries are identical up to a scalar multiple. Here we employ an aggregate production possibility frontier introduced by Jorgenson (1995a) and used by Jorgenson and Stiroh (2000) and Jorgenson (2001). This methodology suppresses the industry dimension for inputs and assumes each input earns the same marginal product in all industries. We compare this with aggregation over industries for all variables across industries, which maintains the industry dimension for all data and accounts for the observed variation in prices of value-added and all inputs across industries.

i) Aggregate Production Possibility Frontier

We define the *production possibility frontier* as the efficient combination of outputs and inputs for the economy as a whole. *Value-added*, *V*, consists of value-added from all *J* industries and is produced from primary inputs and technology as:

$$(2.8) \qquad V(V_1,...V_J) = f(K,L,T)$$

where *V*, *K*, *L* are aggregate value-added, capital services, and labor input, respectively, which are defined below.

The production possibility frontier does not impose the assumption of perfect substitution of value-added between industries required for existence of an aggregate production function. We define value-added as translog index over industry value-added:

$$(2.9) \qquad \Delta \ln V = \sum_j \overline{w}_j \Delta \ln V_j$$

where w_j is the average share of industry value-added in aggregate value-added :

$$(2.10) \qquad \overline{w}_j = \frac{1}{2}\left(\frac{P_{V,j,t}V_{j,t}}{\sum_j P_{V,j,t}V_{j,t}} + \frac{P_{V,j,t-1}V_{j,t-1}}{\sum_j P_{V,j,t-1}V_{j,t-1}} \right)$$

and V_j is from Equation (2.5).[5]

There are many types of capital, K_k, (e.g., computers and tractors) and labor inputs, L_l, (e.g., high school educated men and college educated women) and market equilibrium requires that each input earns the same return in all industries. This assumption allows us to simply sum each input across industries to obtain aggregate capital services and labor input:

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[5]The use of the same subscript *j* in the numerator and denominator of Equation (2.10) is to avoid the proliferation of symbols; the different references should be obvious. This applies to similar expressions throughout the paper.

$$(2.11)\quad \begin{aligned} K_k &= \sum_j K_{k,j} \\ L_l &= \sum_j L_{l,j} \end{aligned}$$

where the *k* subscript indexes the type of capital and *l* indexes the type of labor.

Aggregate *capital services* and *labor input* are then defined as the translog index of the heterogeneous types of capital and labor:

$$(2.12)\quad \begin{aligned} \Delta \ln K &= \sum_k \overline{w}_k \Delta \ln K_k \\ \Delta \ln L &= \sum_l \overline{w}_l \Delta \ln L_l \end{aligned}$$

where $\overline{w}_k$ and $\overline{w}_l$ are defined analogously to $\overline{w}_j$ in Equation (2.10), and P_K and P_L are the corresponding price indices for capital and labor, respectively.

We then define *total factor productivity* (TFP) growth as:

$$(2.13)\quad v_T \equiv \Delta \ln V - \overline{v}_K \Delta \ln K - \overline{v}_L \Delta \ln L$$

where the capital share is defined as:

$$(2.14)\quad \overline{v}_K = \frac{1}{2}\left(\frac{P_{K,t}K_t}{P_{K,t}K_t + P_{L,t}L_t} + \frac{P_{K,t-1}K_{t-1}}{P_{K,t-1}K_{t-1} + P_{L,t-1}L_{t-1}} \right)$$

and similarly for labor.

As above, we can estimate the sources of *aggregate labor productivity* (value-added per hour worked) as:

$$(2.15)\quad \Delta \ln v \equiv \overline{v}_K \Delta \ln k + \overline{v}_L \Delta \ln LQ + v_T$$

where the definition of the determinants is the same as above, except that there is no intermediate component in the aggregate value-added concept.

ii) Domar Aggregation over Industries

An alternative approach developed by Jorgenson, Gollop, and Fraumeni (1987) provides estimates of aggregate productivity growth, but maintains the industry accounts as the basic building blocks. This avoids the assumption of mobility of inputs across industries and allows a decomposition of aggregate productivity growth to the industry level sources.[6]

We begin with the definition of productivity growth from the production possibility frontier (Equation (2.15)) and industry productivity growth (Equation (2.2)). Multiply industry productivity growth by the industry share of aggregate value-added ($\overline{w}_j$), divide through by the industry share of value-added in output ($\overline{v}_{V,j}$), and sum across all industries. This gives:

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[6]Note that Domar (1961) did assume mobility across industries.

$$(2.16)\quad \sum_j \frac{\overline{w}_j}{\overline{v}_{V,j}} v_{T,j} = \sum_j \overline{w}_j \Delta \ln V_j - \sum_j \overline{w}_j \frac{\overline{v}_{K,j}}{\overline{v}_{V,j}} \Delta \ln K_j - \sum_j \overline{w}_j \frac{\overline{v}_{L,j}}{\overline{v}_{V,j}} d \ln L_j$$

Subtracting Equation (2.16) from Equation (2.13) yields the following decomposition of productivity growth from the aggregate production function:

$$(2.17)\quad \begin{aligned} v_T = & \left(\sum_j \frac{\overline{w}_j}{\overline{v}_{V,j}} v_{T,j} \right) \\ & + \left(\sum_j \overline{w}_j \frac{\overline{v}_{K,j}}{\overline{v}_{V,j}} \Delta \ln K_j - \overline{v}_K \Delta \ln K \right) \\ & + \left(\sum_j \overline{w}_j \frac{\overline{v}_{L,j}}{\overline{v}_{V,j}} \Delta \ln L_j - \overline{v}_L \Delta \ln L \right) \end{aligned}$$

$$v_T = \sum_j \frac{\overline{w}_j}{\overline{v}_{V,j}} v_{T,j} + REALL_K + REALL_L$$

The first set of parentheses is the sum of "Domar-weighted" industry productivity, the second set is the reallocation of capital across industries ($REALL_K$), and the third is the reallocation of labor across industries ($REALL_L$). Productivity growth from the aggregate production possibility frontier exceeds Domar-weighted industry productivity when the reallocation terms are positive. This happens when the industries with the higher price of capital have the higher growth rate of capital input, and when the industries with the higher price of labor have the higher growth rate of labor input.[7] The construction of K_j and L_j will be discussed in more detail in Sections IV and V below.

iii) Aggregate Production Function

An alternative aggregation methodology, employed by Jorgenson, Gollop, Fraumeni (1987), is the aggregate production function. The price of a unit of value-added must be the same across all industries in order to replace the production possibility frontier with the aggregate production function. Under this assumption, value-added from the aggregate production function, V_{PF}, *is* defined as a simple sum across industries:

$$(2.18)\quad V_{PF} = \sum_j V_j$$

We define the difference in the growth rates of value-added from the production possibility frontier (Equation 2.9) and the aggregate production function (Equation 2.18) as the *reallocation of value-*

[7]Note that if we used capital stocks rather than capital services, there would be no $REALL_K$ term because a given asset has the same price across all industries. This means the sums and the translog indexes across industries are identical. Service prices for each asset, however, do differ across industries due to rates of returns and taxes, so we will get $REALL_K$ values.

added. This difference shows the cost of the error in aggregation that results from assuming the existence of an aggregation production function.

III. Measuring Output and Intermediate Inputs

This section describes our methodology for measuring intermediate inputs. The use of index numbers for measuring industry intermediate inputs is described in detail in Jorgenson, Gollop and Fraumeni (1987, Chapter 5). This method, which uses time series of input-output (IO) tables, was also employed in Jorgenson (1995c) for the period 1948-85. Here we describe the updates and modifications of these two earlier studies.

a) Notation

m_i	quantity of imports of commodity *I*
$P_{m,i}$	price of imported commodity *i*
$P_{YT,i}$	price of output to purchasers from industry *j*
$Q_{X,i}$	quality index of intermediate input of industry *j*
v	value shares
$X_{i,j}$	quantity of input *i* into industry *j*
$P_{X,i}$	price of commodity *i* to buyers
X_j	index of intermediate input into industry *j*
Y_j	quantity of output of industry *j*
$P_{Y,i}$	price of output to producer in industry *j*
YC_i	quantity of domestically produced commodity *I*
$P_{YC,i}$	price of domestically produced commodity *i*
YS_i	quantity of total supply of commodity *I*
$M_{j,i}$	MAKE matrix; value of commodity *i* made by *j*

b) Methodology

We assume that the production function for industry *j* has *M* distinct intermediate inputs, and that the function is separable so that we rewrite Equation (2.1) as:

$$(3.1) \qquad Y_j = f(K_j, L_j, X_j, T); \qquad X_j = X(X_{1,j}, X_{2,j}, ...X_{M,j})$$

where there are M=35 commodities that correspond to our 35 private business industries.[8]

[8]We assumed that there are *M*=35 separate inputs. This is actually an aggregate of many commodities classified at a finer level of detail in the input-output accounts. Each industry obviously buys a basket of *i* that consists of different

Under the assumptions in Section II above, the value of output is equal to the value of all inputs:

$$(3.2) \quad P_{Y,j}Y_j = P_{K,j}K_j + P_{L,j}L_j + \sum_i P_{X,i}X_{i,j}$$

where $P_{X,i}$ denotes the price of input commodity *i*, and is assumed to be the same for all buyers of *i*.

We define the *intermediate input index* as a translog index of its components:

$$(3.3) \quad \Delta \ln X_j = \sum_i \bar{v}_{i,j} \Delta \ln X_{i,j}$$

where the weights are again the average shares of the components in total value of intermediate input:

$$(3.4) \quad \bar{v}_{i,j} = \frac{1}{2}\left(\frac{P_{X,i,t}X_{i,j,t}}{\sum_i P_{X,i,t}X_{j,t}} + \frac{P_{X,i,t-1}X_{i,j,t-1}}{\sum_i P_{X,i,t-1}X_{i,j,t-1}} \right)$$

and the price index of intermediate input, $P_{X,j}$ is simply the value of all components divided by the quantity index. Note that the price is specific to industry *j* even if the component prices are the same because the shares of the various components are different for each industry.

We define the *unweighted intermediate input* of industry *j* as:

$$(3.5) \quad I_j = \sum_j X_{i,j}$$

We then define the *quality index of intermediate input* as:

$$(3.6) \quad Q_{X,j} = \frac{X_j}{I_j}$$

which reflects the changes in composition of aggregate intermediate input, a rise in this index indicates that the components that grew faster are the higher priced ones.

Value shares of intermediate input in total output range from 30% to 80% depending on the industry. To better understand this large input we also construct two components indices, an energy intermediate input index (E_j) and a non-energy intermediate input index (M_j), to complete the familiar KLEM classification of inputs. The list of commodity inputs is the same as the list of industries given in Table 3 plus noncompetitive imports. Of the 35+1 items identified, we classify the energy group as (5) coal mining, (6) petroleum and gas mining, (18) Petroleum Refining, (32) Electric Utilities, (33) Gas Utilities, and the nonenergy group as the remaining 31 commodities. The remainder of the paper focuses

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quantities of the sub-commodities. Thus if one were to construct the price of basket *i* using the prices of the sub-commodities then one would get different $P_{X,i}$'s for each buyer. Our assumption is that all buy the same basket and face the same price of *i*.

on the index of intermediate inputs index and we do not discuss the energy and material components in detail.

The output of a given commodity by all industries and the input of this commodity by all industries are identical and system of industry accounts must retain this balance. We derive both outputs and inputs from a time series of inter-industry transactions tables. These tables consist of a Use Table that allocates the commodity among the industry and final demand categories that use it and the Make Table that allocates the commodity to the industries that produce it. The tables are shown schematically in Appendix Figure 1.

In the Use Table, the jth column represents industry j, and the ith row represents commodity i. In value terms, the sum of column j is the industry output, which equals the value of output to the producer plus the output (sales) taxes, T_j :

$$(3.7)\quad \begin{aligned} P_{YT,j}Y_j &= P_{Y,j}Y_j + T_j \\ P_{Y,j}Y_j &= P_{K,j}K_j + P_{L,j}L_j + \sum_i P_{X,i}X_{i,j} \end{aligned}$$

where the price received by the seller is $P_{Y,j}$ and the price paid by buyers is $P_{YT,j}$. $P_{K,j}K_j$ and $P_{L,j}L_j$ are the values of capital service and labor input, respectively, and are discussed in detail in the following sections.

Each industry may make several commodities[9], and each commodity may be produced by several industries. $M_{j,i}$ is the value of commodity i produced by j. The output of industry j is thus:

$$(3.8)\quad P_{YT,j}Y_j = \sum_i M_{j,i}$$

Let YC_i denote the quantity of domestically produced commodity i, and VC_i the total value; this implies:

$$(3.9)\quad VC_i = P_{YC,i}YC_i = \sum_j M_{j,i}$$

We assume that each commodity is an aggregate of the various components and the price of the ith commodity, $P_{YC,,i}$, is given by:

$$(3.10)\quad \ln P_{YC,i} = \sum_j \frac{M_{j,i}}{VC_i} \ln P_{YT,j}$$

The Use Table also includes sales to final demand. In Appendix Figure 1 the symbol F_i refers to the final demand for commodity i which is broken down into the familiar categories of consumption, investment, government, exports and imports:

$$(3.11) \quad F_i = c_i + i_i + g_i + x_i - m_i$$

The row sum of the Use Table is the supply-demand relation in value terms for (domestic) commodity i:

$$(3.12) \quad P_{YC,i} YC_i = \sum P_{X,i} X_{i,j} + P_{X,i} F_i$$

We can rewrite this as the total supply from domestic suppliers and imports, which equals the total demand:

$$(3.13) \quad P_{YC,i} YC_i + P_{m,i} m_i = \sum P_{X,i} X_i + P_{X,i} (c_i + i_i + g_i + x_i)$$

We assume that all buyers buy the same basket of commodity *i*, i.e., the same share of the imported variety. The quantity of the total supply of *i*, YS_i, is assumed to be a translog index of the two varieties, and the price is defined accordingly:

$$(3.14) \quad \begin{aligned} \Delta \ln YS_i &= \overline{v}_C \Delta \ln YC_i + \overline{v}_m \Delta \ln m_i \\ P_{X,i} YS_i &= P_{YC,i} YC_i + P_{m,i} m_i \end{aligned}$$

Note that this price $P_{X,i}$ is the price paid by producers for their input in Equation (3.2). This completes our inter-industry accounting system.

c) Data

We next describe the data sources and methods of construction of the inter-industry accounting system. The starting point is the official benchmark US Input-Output tables produced by the Bureau of Economic Analysis (BEA). These are available for the years 1963, 1967, 1972, 1977, 1982, 1987, and 1992.[10] In the version of the dataset described in Jorgenson (1995c) the time series of Use and Make tables were interpolated from the benchmark tables through 1977, and industry output time-series were taken from those published by the Bureau of Labor Statistics (BLS) Office of Employment Projections. Since then this Office has produced a time series of inter-industry transactions tables. We utilize these Use and Make tables for the years 1983-1999.[11]

We aggregate the BLS inter-industry transactions tables from 192 industries to 35.[12] The major differences are: (a) we treat owner-occupied housing as a direct purchase of capital input by the

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[9]For example, the hotel industry makes "hotel" and "restaurants".

[10]The latest tables are described in *Survey of Current Business*, November 1997, pg. 36.

[11]We are grateful to Charles Bowman, Carl Chentrens and James Franklin of the BLS for providing us with this data and patiently explaining the details. Readers may get this data from the Office of Employment Projections website at www.bls.gov/emp/

[12]The aggregation process involve reallocating special sectors like scrap, rest of the world, inventory valuation adjustment, general government, etc. These are reallocated to the 35 sectors and final demand in accordance to both Use and Make matrices.

household, i.e., in the K row of the C column of the Use Table, rather than as a purchase from the real estate industry; (b) privately owned electric utilities are consolidated with the government owned ones in SIC 32, so that "government enterprises" are smaller than the official category; (c) the government industry is simplified by consolidating government labor and capital into the L and K rows into the final demand column for government; (d) we impute the service flow from consumers' durable assets for additional capital services from consumption. Finally, nonprofit producers are treated symmetrically with the other producers. Our accounts are thus broader in scope than those limited to for-profit business sectors.

The total of all entries in each column of the Use Table is consistent with the time series for Industry Output and Employment produced by this BLS office.[13] This data set provides the value of output, the price index of output, and employment data for the same industries for the period 1972-99. We aggregated the 192 prices to output prices of our industries, $P_{YT,j}$. The exception to this is that for Communications Equipment (BLS industry #53) and Computer and Data Processing Services (industry #147) we replace the BLS prices with BEA prices that are adjusted for quality change.[14] The prices received by the producers are obtained by subtracting off the taxes (Equation (3.7)), and the price of commodities, $P_{YC,i}$, calculated from Equation (3.10).

The BLS data set also includes the final demand categories of *c,i,g,x,m* both in current and constant dollar terms. Using the information on imports by commodities we derive the deflator for imports, $P_{m,i}$. With these two sets of prices in hand we calculate a price index for total supply of commodity i using Equations (3.14). Finally, we derive intermediate input. The value of input i into industry j is given by the estimated Use matrix. The price $P_{X,i}$ has been calculated and hence we can derive the quantities, $X_{i,j}$. From Equations (3.3) and (3.4) we calculate the index of aggregate intermediate input.

For the period prior to the BLS time series of inter-industry transactions tables, 1958-82, we made use of two other sources. The previous version of these BLS tables for 1977-1995 was based on the 1987 benchmark table. We link the 1977-82 tables to the current tables for 1983-99. This was done by adjusting the old matrices to the new value of industry output using the method of iterative proportional fitting discussed by Jorgenson, Gollop, and Fraumeni (1987, p. 72). We linked the 1958-76 matrices reported by Jorgenson (1995c) and link them similarly. Our final set of matrices are consistent with the

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[13]This data was kindly provided by Jay Berman of the BLS. Different versions of the data are at www.bls.gov/emp/empind2.htm.

[14]This comes from the "Gross Output by Detailed Industry" file on the BEA's website www.bea.gov/bea/dn2/gpo.htm. The version used is the one corresponding to output described in Lum and Moyer (2000).

latest estimates of industry output from BLS, and the annual update of GDP published by the BEA in 2000.[15]

The major drawback of the BLS time series is that value-added is not broken down into capital, labor and indirect business taxes in the same way as the benchmark tables. To do this we employ the GDP by Industry data (Gross Product by Industry) produced by BEA.[16] These data give, for each industry, the various components of Gross Product – Compensation of Employees, Proprietors' Income, Corporate Profits, Indirect Business Taxes, and so on. The value of labor input described in Section V below is the sum of compensation of employees and the imputed value of self-employed labor income. The estimation of the value of capital input is described in Section IV, and includes the property-type income components, less the imputation for self-employed labor income, plus certain property taxes. The remainder of GDP after subtracting this labor and capital value is sales taxes net of subsidies, T_j.

d) Issues

i) Value-Added Breakdown

A major issue is that the GDP data are not consistent with the value-added data in the benchmark inter-industry transactions tables. We maintain the total of value-added for each industry estimated in the BLS tables and allocate it in the same proportions as those in the GDP by Industry produced by BEA. This gives us the values of capital income, labor income, and taxes, $P_{K,j}K_j$, $P_{L,j}L_j$ and T_j, respectively. The quantities of capital and labor input are the ones derived from the GDP by Industry data or the Census data described in IV and V below. The prices of capital input and labor input are then derived by dividing these estimated values with the quantities derived from GDP by Industry.

ii) Frequency of Inter-Industry Transactions Tables

A second difficulty in constructing a time series of inter-industry transactions tables is that the time series for GDP is published annually and is not consistent with the benchmark tables published every five years. The magnitude and sources of this discrepancy are discussed in BEA (1997).

iii) Consistency over Time

Consistency over time is another major problem. The 1972, 1977, and 1982 benchmark tables are based on the 1972 SIC while 1987 and 1992 are based on the 1987 SIC. Correspondingly, the annual GDP by Industry data have a break in 1987. In the case of annual GDP, data is provided for both classifications in 1987 and we apply the shares using the new classification to the pre-1987 series. For the

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[15] *Survey of Current Business*, August 2000.

inter-industry transactions tables we apply the method of iterative proportional fitting to the matrices based on the 1972 SIC, using industry outputs based on the 1987 SIC.

Our estimates of industry output and commodity prices are based on the BLS industry output and import prices. We assume that all buyers pay the same price for each commodity reflecting the absence of prices for different purchasers.

IV. Measuring Capital

This section outlines our approach to measuring the flow of capital services in each industry. The capital service flow methodology was originated by Jorgenson and Griliches (Jorgenson, 1995b) and extended to the industry level by Jorgenson, Gollop, and Fraumeni (1987). The key innovation is the construction of capital service flow estimates that account for the ongoing substitution between assets with different marginal products. We also incorporate recent methodological changes developed in Jorgenson and Stiroh (2000). These changes include the use of asset-specific revaluation terms in the service price equation and the assumption that capital service flows come on-line in the middle of the year.

a) Notation

We begin with notation for measures of investment, capital stocks, and capital services for individual assets and industry aggregates. As above, *k* refers to the specific asset and *j* refers to the industry; time subscripts are suppressed where possible. For individual assets, we have:

$I_{k,j}$ = quantity of investment

$P_{I,k,,j}$ = price of investment

δ_k = geometric depreciation rate

$Z_{k,j}$ = quantity of capital stock

$P_{I,,k,j}$ = price of capital stock

$K_{k,j}$ = quantity of capital services

$P_{K,k,j}$ = price of capital services

For industry aggregates:

I_j = quantity index of industry investment

$P_{I,j}$ = price index of industry investment

Z_j = quantity index of industry capital stock

$P_{Z,t}$ = price index of industry capital stock

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[16]This data is described in Lum and Moyer (2000). The detailed data are given at www.bea.gov/bea/dn2/gpo.htm.

K_j = quantity index of industry capital services

$P_{K,}$ = price of industry capital services

$Q_{K,j}$ = index of industry capital quality

b) Methodology for Estimating Capital Service Flows

For each industry, we begin with real investment in individual assets, $I_{k,j}$. We assume that the official price index for each asset transforms nominal investment into identically productive "efficiency units" over time so that investment across vintages are considered perfect substitutes in the production process. That is, any improvement in input characteristics, e.g., a faster processor in a computer, is incorporated into $I_{k,j}$ via appropriate deflation of the nominal investment series that transform recent vintages into an equivalent amount of efficiency units of earlier vintages. As a concrete example, the constant-quality price index for computer equipment translates more recent investment in faster, more powerful computers into more units of computers of constant, base-year efficiency. Thus, a more powerful or faster personal computer is represented by increases in $I_{k,j}$.

We then transform the real investment data into estimates of capital stock for each asset, industry, and year through the familiar perpetual inventory method. This is consistent with the perfect substitutability assumption across vintages and defines the *capital stock* for each industry and asset as:

$$(4.1) \qquad Z_{k,j,t} = Z_{k,j,t-1}(1-\delta_k) + I_{j,k,t} = \sum_{\tau=0}^{\infty}(1-\delta_k)^{\tau} I_{j,k,t-\tau}$$

where capital is assumed to depreciate geometrically at the rate δ_k.

Equation (4.1) has the well-known interpretation that the capital stock is the weighted sum of past investments, where weights are derived from the relative efficiency of capital of different ages that is captured by the geometric depreciation rate. Notice that the depreciation rates, δ_k, are indexed only by asset as they are assumed to be constant over time and the same for all industries. Finally, all capital is measured in base year efficiency units, so the appropriate price for valuing the capital stock is simply the investment price deflator, $P_{I,k}$.

The installed stock of capital $Z_{k,j}$ represents the accumulation of past investments, but we are primarily interested in $K_{k,j}$, the flow of capital services from that stock over a given period. This distinction is not critical at the level of individual assets, but becomes essential when one aggregates heterogeneous assets to form an industry or economy-wide aggregate. For individual assets, we simply assume that investment comes online in the mid-point of the year so the *flow of capital services* for each industry and asset is proportional to the arithmetic average of the current and lagged capital stock:

$$(4.2) \qquad K_{k,j,t} = q_{k,j}\left(0.5 \cdot Z_{j,k,t} + 0.5 \cdot Z_{j,k,t-1}\right)$$

where $q_{k,j}$ denotes this constant of proportionality, set equal to unity.

We estimate a price of capital services that corresponds to the quantity flow of capital services via a cost of capital formula developed by Hall and Jorgenson (1967). In equilibrium, investors are just indifferent between two alternatives: earning a nominal rate of return, i_t, on a different investment or buying a unit of capital, collecting a rental fee, and then selling the depreciated asset in the next period. For investors purchasing the asset, the cost of capital equals the marginal product in equilibrium. This implies the familiar *cost of capital* equation (or user-cost) for each asset in each industry:

$$(4.3) \qquad P_{K,k,j,t} = (i_{j,t} - \pi_{k,j,t}) P_{k,j,,t-1} + \delta_k P_{I,k,j,t}$$

where the asset-specific capital gains term is $\pi_{k.j,t} = (P_{I,k,j,t} - P_{I,k,j,t-1}) / P_{I,k,j,t-1}$ and $i_{j,t}$ is the nominal rate of return in industry *j*.

Th cost of capital accounts for the nominal rate of return, asset-specific depreciation, and an asset-specific revaluation term. An asset with a higher depreciation rate, for example, must receive a high capital service price and marginal product as compensation. Similarly, if an investor expects a capital losses ($\pi_{k,j,t}$<0), then a high service price is needed. Jorgenson and Stiroh (2000) and Oliner and Sichel (2000) discuss the importance of incorporating asset-specific revaluation terms for information technology assets that are experiencing rapid capital losses.

Tax considerations are also a key component of service price estimation as originally discussed by Hall and Jorgenson (1967) and elaborated on by Jorgenson and Yun (2001). We follow Jorgenson and Yun (2001) and Jorgenson and Stiroh (2000) and account for investment tax credits, capital consumption allowances, the statutory tax rate, property taxes, debt/equity financing, and personal taxes, by estimating an asset-specific, after-tax real rate of return for each asset in each industry, $r_{k,j,t}$, that enters the cost of capital formula:

$$(4.4) \qquad P_{K,k,j,t} = \frac{1 - ITC_{k,t} - \tau_t z_{k,t}}{1 - \tau_t} \left[r_{k,j,t} P_{I,k,j,t-1} + \delta_k P_{I,k,j,t} \right] + \tau_p P_{I,k,j,t-1}$$

where $ITC_{k,t}$ is the investment tax credit, τ_t is the statutory tax rate, $z_{k,t}$ is the capital consumption allowance, τ_p is a property tax rate, all for asset *k* at time *t*.

$r_{k,j,t}$ is calculated as:

$$(4.5) \qquad r_{k,j,t} = \beta_j [(1 - \tau_t) i_t - \pi_{k,j,t}] + (1 - \beta_j) \left[\frac{\rho_{j,t} - \pi_{k,j,t} (1 - t_q^g)}{(1 - t_q^e) \alpha_j + (1 - t_q^g)(1 - \alpha_j)} \right]$$

where β is the debt/capital ratio, i_t is the interest cost of debt, $\rho_{j,t}$ is the rate of return on equity, $\alpha_{j,t}$ is the dividend payout ratio, and t_q^g and t_q^e are the tax rates on capital gains and dividends, respectively. $\pi_{k,j,t}$ is the inflation rate for asset, which allows $r_{k,j,t}$ to vary across assets.

A complication, of course, is that $\rho_{j,t}$ is endogenous. To solve this problem, we assume the after-tax rate of return to all assets in each industry is the same and estimate $\rho_{j,t}$ as the return that exhausts the payment of capital across all assets in the corporate sector of each industry. That is, we estimate the rate of return and the capital service prices jointly to satisfy the following restrictions:

$$\text{(4.6)} \quad \begin{aligned} &\sum_k P_{K,k,j,t} K_{k,j,t} = P_{V,j,t} V_{j,t} - P_{L,j,t} L_{j,t} \\ &P_{K,k,j,t} = \frac{1 - ITC_{k,t} - \tau_t Z_{k,t}}{1 - \tau_t} \left[r_{k,j,t} P_{I,k,j,t-1} + \delta_k P_{I,k,j,t} \right] + \tau_p P_{I,k,j,t-1} \end{aligned}$$

where $r_{k,j,t}$ is defined as in Equation (4.5) and $P_{V,j,t}V_{j,t}$ is nominal industry value-added (price of value-added, $P_{V,j,t}$, multiplied by real value-added, $V_{j,t}$).[17]

Equations (4.1) through (4.6) describe our estimation procedure for the capital service flow and capital service price, $K_{k,j,t}$ and $P_{K,k,j,t}$, respectively, for each asset, industry, and period. Our productivity work, however, estimates aggregate capital services for each industry. Because of the exact aggregation properties discussed in Diewert (1980) and Fisher (1992), we employ translog quantity indices to generate aggregate capital services for each industry, as well as for industry capital stocks and investment aggregates.

The index of *industry capital services* is defined as the translog aggregate of the different capital assets as:

$$\text{(4.7)} \quad \Delta \ln K_j = \sum_k \bar{v}_{k,j} \Delta \ln K_{k,j}$$

where weights are the two-period average, nominal shares of capital income:

$$\text{(4.8)} \quad \bar{v}_{k,j,t} = \frac{1}{2} \left(\frac{P_{K,k,j,t} K_{k,j,t}}{\sum_k P_{K,k,j,t} K_{k,j,t}} + \frac{P_{K,k,j,t-1} K_{k,j,t-1}}{\sum_k P_{K,k,j,t-1} K_{k,j,t-1}} \right)$$

and the corresponding *price index of industry capital services*, $P_{K,j}$, is defined implicitly to make the value identity hold as:

$$\text{(4.9)} \quad P_{K,j} K_j = \sum_k P_{K,k,j} K_{k,j}$$

[17]Tax considerations vary across ownership sectors (corporate, non-corporate, and household). We account for these differences in our empirical work, but do not go into details here. See Jorgenson and Yun 2001, Chapter 2).

Similarly, the industry *quantity index of capital stock* is defined by:

$$(4.10) \quad \Delta \ln Z_j = \sum_k \overline{w}_{k,j} \Delta \ln K_{k,j}$$

where the weights are now the two-period average, nominal shares of capital stock:

$$(4.11) \quad \overline{w}_{k,j,t} = \frac{1}{2}\left(\frac{P_{I,k,j,t} K_{k,j,t}}{\sum_k P_{I,k,j,t} K_{k,j,t}} + \frac{P_{I,k,j,t-1} K_{k,j,t-1}}{\sum_k P_{I,k,j,t-1} K_{k,j,t-1}} \right)$$

and the corresponding *price index for the industry capital stock*, $P_{Z,j,t}$, is defined implicitly from:

$$(4.12) \quad P_{Z,j,t} Z_{j,t} = \sum_k P_{I,k,j,t} K_{k,j,t}$$

Finally, we define the *industry capital quality index*, $Q_{K,j,t}$ as:

$$(4.13) \quad Q_{K,j} = \frac{K_j}{Z_j}$$

and it follows that the growth of capital quality is defined as:

$$(4.14) \quad \Delta \ln Q_{K,j,t} = \Delta \ln K_{j,t} - \Delta \ln Z_{j,t}$$

There are several things to note about these equations. First, industry capital services and capital stocks uses the same detailed quantities ($K_{k,j}$) and aggregate via a translog index; the only difference is the use of service prices or asset prices in the weights. This implies that growth in capital quality reflects substitution towards assets with relatively high service price weights and higher marginal products. For example, the large depreciation rate and large negative revaluation term imply computers have a high marginal product, so their service weight exceeds their asset weight. This means that capital services will grow faster than capital stock, and the substitution towards assets with higher service prices is captured by our index of capital quality. Second, our measure of industry capital stock is implicitly a two-period average because it aggregates two-period average stocks using current asset prices.

Finally, to study the relative roles of information technology capital and other, non-IT capital, we define two further sets of indices for capital services, capital stocks, and investment based on the detailed investment data. The capital services of information technology, $K_{IT,j}$ includes the service flow from computer hardware, computer software, and telecommunications equipment, while non-IT capital service flow includes the services from all other equipment, structures, inventories, and land, $K_{NON,j}$. As with the decomposition of intermediate inputs into energy and materials, we simply create subindexes of capital services as:

$$
(4.15) \qquad \begin{aligned} \Delta \ln K_{IT,j} &= \sum_{k\in IT} \bar{v}_{IT,k,j} \Delta \ln K_{IT,j} \\ \Delta \ln K_{NON,j} &= \sum_{k\notin IT} \bar{v}_{NON,k,j} \Delta \ln K_{NON,j} \end{aligned}
$$

where the shares are now out of IT capital and non-IT capital, respectively.

c) Data

The key piece of data is the "Tangible Wealth Survey" produced by the Bureau of Economic Analysis (BEA), and described in Herman (2000a, 2000b). This data include detailed investment by industry and by assets and contain historical cost investment and chain-type quantity indices for 61 types of non-residential assets from 1901 to 1999, 48 types of residential assets from 1901 to 1999, and 13 different types of consumers' durable assets from 1925 to 1999. Non-residential investment is available for 62 industries, which we collapse in 35 private business industries at the one- or two-digit SIC level. We also create data for a private household and general government industry.

We made several adjustments to the data worth mentioning. First, for each of the 35 private business industries, we reclassify the BEA data on 61 non-residential assets into 52 non-residential assets. The residential assets and 13 consumers' durable assets are in the real estate and household industries. Second, we combined investment in residential equipment with "other equipment" in the nonresidential category. Third, we control the total value of investment in major categories (equipment and software, non-residential structures, residential structures, and total consumer durables) to match the NIPA totals. These adjustments lead to a complete time series of 57 assets in both current and chained 1996 dollars for each of the 35 business industries. The investment and capital data are then allocated across three ownerhship sectors – corporate, non-corporate, and households – based on earlier shares provided by BEA. The household and government industry data are more limited and there is no ownership breakdown. Finally, we use aggregate prices for each asset from the NIPA.

Geometric depreciation rates for the perpetual inventory calculations are primarily from Fraumeni (1997). Computers and automobiles, however, are important exceptions. BEA (1999) reports that depreciation for most computer components and peripherals is based on the work of Oliner (1993, 1994), is non-geometric, and varies over time. We estimated a best-geometric approximation to the latest depreciation profile for different types of computer assets; this generated an average geometric depreciation rate of 0.315, which we used for computer investment, software investment, and consumer durable purchases of computers, peripherals, and software. For autos, BEA derives a depreciation profile from new and used car prices. We again estimated a best geometric approximation to the depreciation profile for autos and used an estimate of 0.272.

We also gathered data on inventories and land to complete our capital estimates. Inventory data come primarily from the NIPA in the form of farm and non-farm inventories, allocated across industries. These are measured in current dollars with a corresponding price index. Inventories are assumed to have a depreciation rate of zero and do not face an investment tax credit or capital consumption allowance, so the capital service formula is a simplified version of Equation (4.4). The data on land is somewhat more problematic. Through 1995, the Federal Reserve Board published detailed data on land values and quantities in its "Balance Sheets for the U.S. Economy" study (Federal Reserve Board (1995, 1997)), but the underlying data became unreliable and are no longer published. We now use the limited land data available in the "Flow of Funds Accounts of the United States" and historical data described in Jorgenson (1990) to estimate a price and a quantity of private land. As a practical matter, this quantity series varies very little, so its major impact is to slow the growth of capital. Like inventories, the depreciation, investment tax credit, and capital consumption allowance for land is zero.

Finally, we gathered income on industry-level value-added from the "Gross Product Originating" database maintained by the BEA and described in Lum and Moyer (2000) and from the BLS as described above. The BEA data includes the value of (gross) output, value-added, and intermediate inputs for 62 industries from 1947 to 1999. We aggregated industries to match the 35 private business industries in our main analysis. For the estimation of capital service prices, we begin with nominal value-added in the corporate sector and subtract out corporate labor income to estimate the amount of income available to corporate capital. By assuming that the rate of return is constant across ownership classes, we then estimate the value of non-corporate capital income from the rate of return, asset prices, and non-corporate capital stocks. The remaining income in the non-corporate sector is then allocated to self-employed income in the non-corporate sector. This is done individually for each industry in each year. The share of capital income is then scaled in proportion to the BLS estimate of value-added; we keep the quantity from the BEA data and calculate the price residually to match the new value.

d) Issues

The methodology described above is based on a long history of theoretical and empirical work. Despite the widespread success of this work, there are a number of potentially troubling issues relating to the available data and the reasonability of certain assumptions that arise in the implementation of this methodology. This subsection outlines those issues and describes our solutions.

i) Negative Service Prices

The intuition behind our estimation of capital service prices is that the value of capital service flows must exactly exhaust value-added income that is not allocated to labor. The difficulty, however, is that in some years there is very little income available to capital and this leads to negative service prices.

For example, if asset inflation is high and depreciation rates are low relative to the interest rate, negative service prices result. Economically, this is possible and suggests that capital gains were higher than expected, so a small service price is possible in equilibrium. See Berndt and Fuss (1986) for details on this.

Empirically, however, negative service prices make aggregation difficult so we made adjustments for several assets. In some of the 35 business industries, there were cases where certain assets showed negative service prices, most notably inventories, land, and structures in the 1970s when inflation was high. Our first fix was simply to use a smoothed inflation rate from the surrounding years rather than the current inflation in the cost of capital calculation. For land, which showed large capital gains throughout and has no depreciation, we used the economy-wide rate of asset inflation for all years. If this fix didn't work, we used several other methods to shift income from self-employed labor, which was estimated internally, to capital income. As a last resort, we were forced to impute additional income, which added to both capital income and the value of output in a few cases. These imputations added up to about $xxbil. in 1999, so they are a relatively small issue empirically.

ii) Deflators

The methodology described above allows for deflators for each asset to differ across industries. In practice, however, the industry-specific deflators were quite erratic across industries and time. This is possible as different industries have different mixes of component assets in a given year, and also the large discrete nature of some asset categories. The Tangible Wealth Survey reports investment in millions of dollars with no decimal points, so any asset with a very small value and quantity in a given year has a deflator that is not estimated very precisely. As a fix, we simply aggregated each asset across all industries and used the economy-wide average deflator, which removed the noise. Thus, $P_{I,k,j} = P_{I,k}$ for each asset.

A second concern is our reliance on the deflators incorporated in the Tangible Wealth Survey and the NIPA. For most assets this is not a problem, but Jorgenson and Stiroh (2000) argue that the official deflators may not fully account for quality change in software and telecommunications equipment. For these assets, only a small share of investment is associated with constant-quality deflators, which would tend to overstate price increases and understate quantity increases. The software and telecommunications equipment deflators, for example, rose at annual rates of 1.1 and 1.8 percent per year for 1959 to 1999, compared to a decline of 18.8 for computer hardware. We do not address this issue here, but simply raise the point that these data may understate the true quantity of IT capital in all industries.

iii) Depreciation Rates

There has been some debate about the appropriate depreciation rates for assets that are deflated with constant-quality deflators. As first raised by Oliner (1993, 1994) and recently discussed by Whelan (forthcoming), if real investment is constructed with a constant-quality deflator, then one would ideally like to use a depreciation rate obtained from constant-quality data by age of asset. This corresponds to "partial depreciation" in the Oliner terminology. Otherwise, the cost of capital formula in Equation (3) would effectively be double-counting through the asset-specific inflation rate and the asset-specific depreciation term. This is a major issue for computer hardware, which has the most aggressive quality corrections. The BEA depreciation rates currently incorporate the Oliner (1993, 1994) estimates for all computer components except personal computers. According to Herman (2000a), the personal computer depreciation profile is based on a study Lane (1999). Our best geometric approximation to the BEA depreciation rates, however, does not use this new estimate; rather we employ the earlier BEA profile based on the work of Oliner (1993, 1994).

iv) Capital Use Matrix

A final issue is that the detailed investment data by industry and assets are based on a relatively old, and perhaps outdated, view of industry investment. That is, aggregate investment in a given asset is allocated across industries based on a "capital flow table" maintained by BEA (Bonds and Aylor (1998)). This capital-use matrix is created by BEA and estimated every five years or so. The latest capital-use matrix incorporated into our data, however, is from 1992. More recent data would obviously be very valuable, especially in assessing the impact of investment in information technology equipment. We raise the issue as a possible concern.

V. Measuring Labor

The methodology for deriving labor input was introduced by Jorgenson and Griliches (Jorgenson, 1995b) who constructed an index number of aggregate labor input based on data for several categories of labor services. This was extended to the industry level in Gollop and Jorgenson (1980) and Jorgenson, Gollop, and Fraumeni (1987, hereafter JGF). These labor indexes were updated through 1995 with several important modifications in Ho and Jorgenson (1999).

In this section we describe the main points underlying the industry labor input index, including the college educated/non-college educated distinction. We shall be brief since the overall idea is now well known, and concentrate on the methodological changes since JGF. We also contrast our methods with Bureau of Labor Statistics (1993) which employs a similar framework but differs in its implementation.

To avoid common misunderstandings let us first define terms. Following the *United Nations System of National Accounts 1993* (United Nations, 1993) we use the terms volume and constant quality quantity index interchangeably.[18] Similarly, we identify the terms price and constant quality price index. In the UN System the concept of quality is introduced to distinguish the volume index from the often used simple sum of hours worked (or even more simply, employment). This distinction is important given the heterogeneous nature of the work force. The term "constant" refers to the assumption that each type of worker has a constant effectiveness over time, just like the standard unit of investment measured in efficiency units. The volume, or constant quality index of labor input, is an index that takes into account the substitution among different types of workers by weighting the components by their marginal products. The quality of total hours is then an index of the changing composition of the work force, and is defined as the ratio of volume to hours worked.

The concepts of volume and labor quality is useful for avoiding the confusion between substitution and productivity growth. Confusion may arise because the literature on production theory also contains the concept of "factor-augmenting" productivity growth (e.g., labor-augmenting growth). When technical change is labor-augmenting, instead of writing the production function as in (2.1), we have:

$$(5.1) \qquad Y_t = f(K_t, A_t L_t)$$

Some economists would use total hours worked as L_t and calculate the change in A_t from the productivity residual of Equation (5.1). They might then say that labor quality is a "semantic shift" that amounts to relabeling productivity as A_t labor-augmenting change. This confuses two distinct ideas. We use a constant quality labor input index L_t and an index of the quality of hours worked as a measure of compositional change. Productivity change is the residual calculated from L_t using Equation (2.1). There is no separate role for labor-augmenting change and no semantic shift involved.

Our objective is to construct a measure of labor input that accounts for heterogeneity in hours and yet is tractable. We have chosen to classify the workers by sex (2 genders), age (7 classes), educational attainment (6 classes), employment class (2 types), and industry as described in Appendix Table 1. There are thus a total of 2 x 7 x 6 x 2 = 168 types of workers for each of 35 industries.[19] We focus on 35 industries in this paper, but in our labor database we distinguish 51 industries giving a total of

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[18] Price and quantity index number concepts are presented in Chapter XVI, "Price and volume measures," pp. 379-406 (United Nations, 1993). The specific example of labor input is discussed in Paragraph 16.143, p. 403.

[19] This differs from Jorgenson, Gollop and Fraumeni (1987) in three ways. JGF has shown that occupation has little impact when the other dimensions are taken into account and we have thus eliminated it, reducing the size of the matrix to be estimated by a factor of 10. Secondly, we eliminated the 14-15 age group following the official publications of BLS. Thirdly, we disaggregated the educational group "4+ college" into two, "4 years college" and "5+ college" for the years after 1980.

168*51=8568 cells.[20] With this framework in mind, we turn to our notation and empirical implementation.

a) Notation

saecj	subscripts for sex, age, education, class, industry
E_{saecj}	Employment matrix, number of workers in cell s,a,e,c,j
h_{saecj}	Average hours per week in cell s,a,e,c,j
w_{saecj}	Average weeks per year in cell s,a,e,c,j
c_{saej}	Average hourly compensation of employees in cell s,a,e,j
H_{saecj}	hours worked by all workers in cell s,a,e,c,j
H_{lj}	abbreviation for H_{saecj}: *l=1* is *s=1,a=1,e=1,c=1*; *l=2 is s=1,a=1,e=1,c=2......, l=168 is s=2,a=7,e=6,c=2*
$L_{l,j}$	labor input of cell *l* in industry j
$P_{L,l,j}$	price of labor input of cell *l*

b) Methodology

We express the industry *volume of labor input* as a translog index of the individual components as:

$$(5.2) \qquad \Delta \ln L_j = \sum_l \bar{v}_{l,j} \Delta \ln L_{l,j}$$

where:

$$(5.3) \qquad \bar{v}_{l,j,t} = \frac{1}{2}\left(\frac{P_{L,l,j,t} L_{l,j,t}}{\sum_k P_{L,l,j,t} L_{l,j,t}} + \frac{P_{L,l,j,t-1} L_{l,j,t-1}}{\sum_l P_{L,l,j,t-1} L_{l,j,t-1}} \right)$$

where $P_{L,l,j,t}$ is the of price of each type of labor input.

To quantify the impact of substitution among different types of labor input we assume that labor input for each category $\{L_l\}$ is proportional to hours worked $\{H_l\}$:

$$(5.4) \qquad L_{l,j} = Q_l H_{l,j}$$

where the constants of proportionality Q_l transform hours worked into flows of labor services. We assume that labor services for each category of hours worked are the same at all points of time. For

[20] The number of non-zero cells quite a bit less since the self-employed class is zero for many sectors.

example, an hour worked by a self-employed male worker, aged 34, with four years of college education, represents the same labor input in 1958 as in 1999.

The industry labor quantity index in (5.2) may thus be expressed simply as :

$$(5.5) \qquad \Delta \ln L_j = \sum_l \bar{v}_{l,j} \Delta \ln H_{l,j}$$

Observations on the constants Q_l are not required for hours worked or the value shares. The corresponding *price index of labor input* is the ratio of the value of labor compensation to the volume index:

$$(5.6) \qquad P_{L,j} L_j = \sum_l P_{L,l,j} L_{l,j}$$

Finally, the industry industry *labor quality index* measures the contribution of substitution among the components of labor input to the volume obtained from a given number of hours as:

$$(5.7) \qquad Q_{L,j} = \frac{L_j}{H_j}$$

where:

$$(5.8) \qquad H_j = \sum_l H_{l,j}$$

is the *unweighted sum of hours worked*.

To study the relative roles of workers of different educational attainment, we define two further sets of indices. The labor input of college workers is defined as the aggregate over hours of the educational groups {5,6} – "BA" and "more than BA", while the input of non-college workers is defined over the remaining groups – "Grade 0-8", "some high school", "HS diploma", and "some College no BA". That is:

$$(5.9) \qquad \begin{aligned} \Delta \ln L_{CO,j} &= \sum_{s,a,c,e \in \{5,6\}} \bar{v}_{SKsaecj} \Delta \ln H_{saecj} \\ \Delta \ln L_{NC,j} &= \sum_{s,a,c,e \notin \{5,6\}} \bar{v}_{UNsaecj} \Delta \ln H_{saecj} \end{aligned}$$

c) Data

In this study we update and modify the data generation methods used in JGF. The main features of the procedure to construct the H_{saecj} and P_{Lsaecj} matrices are the following.

- Detailed cross-classifications by characteristics of individual workers are taken from the Censuses of Population and the Current Population Survey. These data reflect individual incomes. The total hours worked and compensation paid in each industry are obtained directly from the U.S. National Income and Product Accounts (NIPA). These are based on establishment data and reflect payroll records.

- The observational unit for establishment data is the "job" reflected on a payroll, while the corresponding unit for individual data is the "person." A person may hold more than one job and be classified as a "multiple job-holder." Similarly, a job may be held by more than one person in a given year. To link persons and jobs we assemble four matrices of data for each year -- compensation, hours worked per week, weeks worked per year, and employment -- cross-classified by the characteristics of individual workers.
- The NIPA hours produced by the Bureau of Economic Analysis is adjusted to the BLS's survey of Hours at Work which represent the appropriate concept rather than "hours paid" that is originally recorded in the establishment data.
- Individual data provide estimates of wages, but payroll records also give fringe benefits. Our definition of P_L is the price to employers. The initial estimates derived from individual data are combined with our imputations of benefits and scaled to total labor compensation in each industry given in the NIPA.
- Self-employed individuals are a special problem since their labor and property compensation are not reported separately. In this study capital income in each industry is imputed by assuming that the rate of return after corporate income taxes is the same in corporate and non-corporate sectors. The residual industry labor income of the self-employed is used as a control total. The relative $P_{L,l,j}$'s of the self-employed in each industry is assumed to be equal to that of the employees. BLS (1993) on the other hand treats capital income as a residual and uses the compensation rates for employees.

We begin with the public use tapes from the decennial Censuses of Population for 1990, 1980, and 1970, covering 1 percent of the population (only 0.1% for 1970). We employ these micro data of about 1 million workers to construct benchmark matrices of employment (E_{saecj}), weekly hours (h_{saecj}), weeks per year (w_{saecj}), and labor compensation (c_{saej}). For each worker, we collect data on age, highest grade completed, class of employment, primary industry of employment, weekly hours worked, weeks worked the previous year, and wage and salary income of employees from the previous year. This data set also gives population weights which allow us to derive national totals. These benchmark matrices are adjusted such that they equal the aggregate tables published by the Bureau of the Census, using the method of iterative proportional fitting described in detail by JGF (Chapter 3, pp. 72-75).

Further refinements are made. First, there are multiple job holders working in more than one industry. We use detailed information on this from the May CPS to allocate hours for individual workers among industries and employment classes. Second, information on income is "top-coded."[21] For each industry we fitted a lognormal distribution and used this to estimate the average income for the upper tail of the distribution. Third, the Census of Population for 1990 defined educational attainment as highest degree achieved. We used the March 1990 CPS to construct a bridge table to convert the new Census definition to the JGF definition.

For the benchmarks derived from the 1950 and 1960 Censuses we retained the data and methodology described by JGF (Appendix A, pp. 345-378). All the benchmark matrices here are at the individual level, as opposed to establishment level that is constructed later.

In the next step, for the years after 1990, we employ the Current Population Survey (CPS) Annual Demographic File from the March surveys to estimate employment hours, and compensation matrices for each year, again at the individual level. These have sample sizes of about 80,000 workers, only a tenth of the Census data. We therefore do not use this to fill the whole matrix of 8568 cells directly, but instead use it to estimate matrices that are of smaller dimension. For example, for employment we estimate a matrix with sex, class, age and education, another with industry and class. For weekly hours and annual weeks we cross-classify by sex, class, age and 10 industries. For hourly compensation of employees we have sex, age and education. The first step is to scale these matrices based on the March CPS to the BLS annual tabulations that are based on the CPS of every month. These matrices with the marginal totals are then used to extrapolate the full dimensioned $E_{saecj}, h_{saecj}, w_{saecj}, c_{saej}$ matrices starting from the 1990 benchmarks.

For the years prior to 1990 we employ the simpler approach of JGF, using the information tabulated by BLS from the CPS giving the employment cross classified by the various categories, e.g. sex-age-class and sex-age-education.[22] The initial guess matrix derived from the nearest two Census is adjusted such that the marginal totals equal these BLS national estimates, e.g. we sum over industry and class to get the sex-age-education categories in the BLS tables.

The CPS covers only the civilian population. For data on military workers we turn to data from the Defense Manpower Data Center.[23] This consists of the number of workers and their compensation cross classified by sex, 7 age groups and 5 educational groups. This fits exactly into our framework.

With this time series of matrices on employment, hours, weeks and compensation based on individual data, $E_{saecj}, h_{saecj}, w_{saecj}, c_{saej}$, we generate a set that is based on establishment data that is

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[21]Since 1996 the CPS provides the average of the top-coded wages. Prior to that we have to estimate it ourselves.
[22]A list of these BLS reports are given in Appendix A of JGF. These include *Employment and Earnings, Special Labor Force Reports,* and *BLS Bulletins*. Other unpublished tabulations like *Educational Attainment of Workers* and *Unpaid family workers* are kindly provided by Tom Hale and Tom Nardone of the BLS.
[23]We thank Mike Dove and Scott Segerman of the DMDC for making this data available to us.

given in the National Income and Product Accounts. The NIPA gives the total number of employees and self-employed for detailed industries.[24] The total for unpaid family workers are from a separate BLS tabulation. The establishment based employment matrix, denoted EE, is derived by scaling each (c,j) part of E_{saecj} equally:

$$E_{saecj} \rightarrow EE_{saecj} \ni \sum_{sae} EE_{saecj} = NIPA(c, j)$$

For hours, the NIPA gives the total hours worked by employees for 15 industry groups.[25] Using the hours and weeks matrices above we generate the establishment based hours on a 52 weeks per year basis by scaling to this control total for each industry group:

$$h_{saecj}, w_{saecj} \rightarrow HE_{saecj} \ni \sum_{sae, j \in IND} 52 * EE_{saecj} HE_{saecj} = NIPA(IND); \qquad c = employee$$

For the self-employed and unpaid class, the BLS Division of Productivity Research provides their estimate of total non-farm hours of this group. We scaled the *HE(c=2)* part such that the sum over all non-farm sectors equal this BLS total. For agriculture hours the ERS of USDA estimates total hours of this class.[26]

Finally, we control the compensation matrix to the NIPA's "Compensation of Employees by Industry" and "Wage and Salary by Industry."[27] We first adjust the c_{saej} matrix (employees only) to the "Wage and Salary" totals for each industry. We then impute other compensation supplements and rescale to the "Compensation" totals to get the establishment-based matrix, denoted *CE*:

$$c_{saej} \rightarrow CE_{saecj} \ni \sum_{sae} 52 * EE_{saecj} HE_{saecj} CE_{saecj} = NIPA(j) \qquad c = employee$$

For the self-employed and unpaid workers, we initialize relative wages to those of employees in each industry. We then control these wages to our estimate of proprietor's labor income as described in item (5) above.

Finally, we note one more adjustment to the NIPA data. The Bureau of Economic Analysis revised the industry classification in NIPA from the 1972-SIC to the 1987-SIC. To obtain a consistent time series we transformed all the data prior to 1987 to the new basis using the 1987 data for which both classifications were provided by the BEA.

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[24] *Survey of Current Business*, August 2001, Tables 6.4C, 6.7C, 6.8C give the most recent data. The whole time series is available at www.bea.gov.
[25] *Survey of Current Business*, August 2001, Table 6.9C. Kurt Kunze kindly provided separate information for total military hours.
[26] We thank Larry Rosenblum of the BLS, and Eldon Ball of the ERS for generously sharing their data with us.
[27] *Survey of Current Business*, August 2001, Table 6.2C, 6.3C

d) Issues

i) Level of Classification

How detailed a classification to use is a key question in using the index number approach. Our classification system gives us a total of 8568 different types of civilian labor. On one hand, other ignored characteristics of individual workers may be important in assessing labor quality, for example, geographical location, occupation, race, work experience, and health status. On the other hand, it may be objected that our system is too detailed to be implemented satisfactorily. For example, we employ data from the Current Population Survey, which currently includes records for about 80,000 households in each year. If these were distributed over 8568 categories of workers, on average each cell would contain about ten workers only.

For the first objection we should point out that our characteristics have been used in other studies and have proven to be able to capture the main features of the data at the aggregate level.[28] The size of the CPS sample makes further refinement difficult to make reliable.

For the second objection that too many categories are used, we should first remind the reader that we also make use of the decennial Census which provides about 1 million observations of workers. The sample size issue arises in the annual CPS with only a tenth of that number of observations. In this case we made use of simplifying "independence" assumptions, in essence assuming a smaller matrix to be estimated. This means that we do not have 168 independent cells for each industry every year, and the change from Census to Census is assumed to occur smoothly. That is, while we do not capture year-to-year variation in great detail, the use of the decennial Census should provide the long run change in the detail as advertised.

In contrast, the BLS (as described in BLS (1993)) uses sex, age, educational attainment and class of employment like us, but drops industry and includes an experience dimension. This results in a much smaller matrix to be estimated but unable to give sectoral estimates that many wish to see.

Another example of the problem with small sample size is the number of self-employed workers in many industries. In some industries the NIPA estimate that the national total is merely a couple of thousands, essentially invisible in the CPS sample. This may seem like a small problem but recall that we multiply it by our estimate of self-employed labor compensation, which may be large. To deal with these problem sectors we collapse the industry dimension for self-employed workers and use the total Manufacturing estimate as our control total.

An issue that has vexed labor economists in the U.S. is the change in educational classification in the CPS in 1992 and in the 1990 Census. Jaeger (1997) has carefully discussed this problem and we

[28] For example, BLS (1993) and Young (1995).

make use of his Tables to construct a bridge to link the new classification to the old. That is, we take the 1992 CPS, bridged it to the old classification, and estimated the change in labor quality between 1991-92. For 1992 onwards we use the new categories only.

ii) Critiques of the Index Number Approach

The index number approach to measuring labor input has been subjected to a number of criticisms. One is that a proper measure of labor input should account for intensity of effort as emphasized by Becker (1985). Unfortunately, intensity, unlike hours, is not observable in the data.[29] If differences in the intensity of hours worked among workers distinguished by educational attainment, class of employment, and industry, however, then this may account for some of the observed differences in rates of labor compensation, and is thus implicitly included in our measures.

The second, more serious, objection the index number approach is the identification of rates of labor compensation with marginal products. What if these rates reflect "market power" by trade unions rather than productivity of workers? A conceptual approach to this issue is based on the observation that market power is exercised on the supply side of the labor market by excluding individuals from jobs for which they would otherwise be qualified. This is still consistent with price-taking by producers demanding labor services and, therefore, with the identification of wages with marginal products. A similar issue arises in discrimination by groups of workers who choose to segregate themselves by age, sex, race, or institution of undergraduate origin. Again, firms can be viewed as price takers, as required in modeling producer behavior.[30]

A more subtle criticism of equating compensation with marginal products arises from the "signaling" hypothesis of Spence (1973). The signaling hypothesis has a number of testable empirical implications. Tests like those reported by Kroch and Sjoblom (1994) have provided support for the human capital approach rather than the hypothesis of asymmetric information about ability. For example, Kroch and Sjoblom use two measures of education in modeling wages for individual workers -- years of schooling completed and rank in the educational distribution, a proxy for unobserved ability under the signaling hypothesis. Using longitudinal data for individuals, years of schooling clearly dominates rank, which gives some confidence that the distortion due to signaling is small.

VI. Empirical Results

We now present results from our analysis of the sources of U.S. economic growth at the industry level using the methodology described above. The contributions of capital and labor inputs and gains in aggregate productivity discussed in Section I ultimately reflect the evolution of the production structure at

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[29]Basu, Fernald, and Shapiro (2001) argue that intensity can be proxied for by energy utilization.
[30]These "market imperfections" are discussed BLS (1993), pp. 42-43.

the industry level. Changes in this production structure cumulate into the determinants of economic growth as technologies evolve and economic incentives are altered accordingly. We first develop appropriate concepts of industry output and input and then describe aggregation over industries to obtain results for the economy as a whole.

In Section I (Tables 1-2 and Figures 1-3), we have demonstrated that investment in information technology (IT) and other tangible assets are the most important sources of U.S. economic growth. Investments in IT have provided the primary force behind the recent American growth resurgence. However, complementary investments in tangible assets are almost equally important in the resurgence and remain the most substantial component of capital input growth. The rush of investment in tangible assets has been the most striking feature of the U.S. economy since 1995.

Although investments in tangible assets greatly preponderate as sources of U.S. economic growth, investments in human capital have also contributed significantly to growth and have played a vital role in the recent growth revival. Although investments in college-educated workers have predominated over investments in non-college workers as a source of growth, the contribution of non-college workers is almost equal in magnitude. Perhaps surprisingly, non-college workers have been much more important in the surge of U.S. economic growth since 1995. This at least partially reflects the declining unemployment rate that pulled many less educated workers into the labor force.

Investments in tangible assets and investments in human capital have both made sustained contributions to U.S. economic growth. Aggregate total factor productivity (TFP) gains were also significant during the period 1958-1973, but nearly disappeared after 1973. These gains have recently shown some modest signs of revival. A very important issue to be resolved in this section is to identify the sources of this productivity revival at the industry level. In Section I, we have already identified the information technology industries as the main locus of sustained productivity growth for the economy as a whole since 1973.

a) Industry Growth Accounting Results

We allocate production in the U.S. economy among the thirty-seven industries listed in Table 3. This table gives the value of output and value-added for each industry for 1999, together with the industry's definition in the Standard Industrial Classification (SIC) system. Note that we take a broad view of the economy and include a Private Household industry and a General Government industry, two industries that are often excluded from productivity analysis.[31]

[31]These two industries have only primary inputs and output is measured somewhat differently. In Private Households, output equals the capital service flow from residential structures and consumers' durables. In General Government, output equals an index of labor input and capital services. In both cases, productivity is zero by construction.

In order to identify the impact of production of information technology, we focus specifically on Industrial Machinery and Equipment (SIC #35), containing computers (SIC #357), and Electronic and Electrical Equipment (SIC #36), containing semi-conductors (SIC #3674) and telecommunications equipment (SIC #366). Production of computer software takes place in our Services industry (SIC #70-87), but we do not break it out here.

Our initial decomposition of industry output growth for the full period 1958-1999 is given in Table 4 and Figure 4. Labor productivity is defined simply as output per hour worked, so the rate of growth of output is the sum of the rates of growth of labor productivity and hours worked. The two high-technology industries, Industrial Machinery and Equipment and Electronic and Electrical Equipment, have the highest growth rates of labor productivity for the period 1958-1999. Agriculture, Coal Mining, Instruments, and Communications also have relatively high labor productivity growth rates. Only Construction has a negative rate of labor productivity growth. This industry has long been a puzzle to productivity analysts, e.g., Baily and Gordon (1988).

Labor productivity growth exceeds the growth of output for any industry with negative growth in hours worked. This occurs in fourteen industries of the thirty-six industries with labor inputs, led by Leather Products, Tobacco Products, Coal Mining, Agriculture, and Metal Mining. Note that the Private Households industry has zero labor input by definition, and produces output only with residential capital. For the remaining twenty-two industries the growth of hours worked is positive. This vast reallocation of hours worked among industries is reflected in Table 2 and Figure 2.

In modeling production for each industry we employ the methodology outlined in Section II. The growth of industry output and its sources, i.e., the contribution of capital, labor, and intermediate inputs, and productivity growth, for the period 1958-1999 are presented in Table 5 and Figure 5. Output growth is strongest for Industrial Machinery and Equipment and Electronic and Electrical Equipment, the industries that supply computers, semi-conductors, and telecommunications equipment. Leather Products is the only industry with negative output growth for the full period, but Tobacco Products, Petroleum and Gas Extraction, Primary Metals and Gas Utilities have had very slow growth by comparison with the rest of the U.S. economy.

An important feature of the methodology presented in Section II is the explicit role provided for intermediate inputs. Consider, for example, the output of the semi-conductor industry. Most of this output is invisible at the aggregate level, because semi-conductor products are mainly inputs into other industries rather than deliveries to final demand as consumption and investment goods. Semi-conductor inputs, however, play a key role in the improvements in the quality and performance of computers, telecommunications equipment, instruments, and a host of other products.[32]

More specifically, semi-conductors are an output of Electronic and Electrical Machinery, but appear as intermediate inputs into Industrial Machinery and Equipment, Instruments, and other industries. Price declines resulting from improvements in semi-conductor technology are reflected in the large contributions of intermediate inputs in the computer industry and other industries that consume semi-conductors. By accurately accounting for intermediate inputs through the use of inter-industry transactions tables we can allocate the sources of U.S. economic growth among industries.

The considerable impact of intermediate inputs on the growth of industry output is strikingly apparent in the sources of growth represented in Table 5 and Figure 5. Intermediate input is the key contributor to the growth of output in Industrial Machinery and Equipment, containing computers, as well as Electronic and Electrical Equipment, Motor Vehicles, Instruments, Communications, and many other industries. Leather Products, the only industry with negative output growth over the period 1958-1999, is also the only industry with a negative contribution of intermediate input. The important role of intermediate inputs is entirely missed if one were to use a value-added concept for industry analysis.

Investments in tangible assets and human capital are also very important contributors to the growth of output. The contributions of capital input are positive for all thirty-seven industries. The largest contribution of capital input is for Private Households, reflecting the fact that the output of this industry consists entirely of capital inputs from housing and consumers' durables, which are rapidly growing. The contributions of capital input are also particularly significant in capital intensive industries, such as Communications and Electric Utilities, as well as in FIRE (Finance, Insurance, and Real Estate).

Services and General Government, two labor-intensive industries, have the highest contributions of labor input, while Leather Products, the only industry with declining output, has the largest negative contribution of labor input. However, eleven of the thirty-six industries with labor input, i.e., excluding Private Households, have negative labor input contributions to the growth of output. Labor input is an important source of aggregate economic growth, so these are outweighed by the positive contributions from the remaining twenty-five industries. Obviously, this is reflected in the reallocations of labor input among industries represented in Table 2 and Figure 2.

Moving to productivity growth in Table 5, Electronic and Electrical Equipment, containing semi-conductors and telecommunications equipment, has the highest productivity growth rate, but Industrial Machinery and Equipment and Instruments also have comparatively high productivity growth rates. However, productivity does not preponderate in the growth of output in these rapidly growing industries.

[32]See Triplett (1996) for details.

Agriculture, Coal Mining, Textile Mill Products, Apparel and Textiles, Petroleum Refining, on the other hand, are the five industries with productivity growth as the predominant source of output growth. These industries have comparatively modest growth rates and negative contributions of labor input.

Private Households and General Government have zero productivity growth by definition. Seven of the thirty-five remaining industries with productivity growth have negative growth rates for the period 1958-1999. While a number of these industries have very low rates of growth of output, it seems paradoxical that Services, an industry with relatively rapid output growth, has a slightly negative productivity growth rate. The perplexing phenomenon of negative productivity growth at the industry level was a primary motivation for the path breaking research of Corrado and Slifman (1999) and Gullickson and Harper (1999).

One possible interpretation of negative productivity growth is a failure to account for changes in quality in the measurement of output. If price increases were systematically overstated due to a failure to hold quality constant, the growth of output and productivity would be correspondingly understated. An alternative and equally plausible explanation is that growth cannot be identified with changes in technology, but rather reflects the growth of inputs. In this view negative productivity growth reflects worsening productive efficiency due to rising barriers to entry and/or growing inflexibility in the allocation of labor.

Section II also outlined a methodology for analyzing the sources of labor productivity growth at the industry level in Equation (2.4). Capital deepening is defined in the same way as at the aggregate level – the product of the value share of capital and the growth rate of capital input per hour worked. The definition of intermediate deepening is analogous to capital deepening. The contribution of labor quality to labor productivity growth is the product of the value share of labor and the growth rate of labor input per hour worked. Finally, productivity growth contributes point-for-point to labor productivity growth.

The sources of labor productivity growth are given in Table 6 and Figure 6. Labor productivity growth exceeds the growth of productivity for all industries, even Construction, a industries with negative productivity growth. The contribution of intermediate deepening to labor productivity growth is positive for all industries with intermediate input. Capital deepening is positive for all industries. The contribution of labor quality reflects increases in the proportion of workers with higher marginal products and is negative for only Nonmetallic Mining. We have analyzed the role of productivity growth as a source of industry output growth in detail above.

Table 7 and Figure 7 provide output growth rates for all thirty-seven industries for the sub-periods 1958-1973, 1973-1990, 1990-1995, and 1995-1999. During the period of resurgent aggregate growth in 1995-1999, the two high-technology industries – Industrial Machinery and Equipment and Electronic and Electrical Equipment – achieved double-digit growth rates. These were also the most rapidly growing industries during the period 1990-1995, when aggregate economic growth reached a nadir. Petroleum and Gas extraction, Apparel and Textiles, Petroleum Refining, and Primary Metals declined after 1995, reflecting the slowing natural resources and competition from low-tech imports.

The contributions of capital input to industry output growth by sub-period are given in Table 8, where our methodology for measuring capital was described in Section III. Private Households have the highest contributions of capital input for all four sub-periods. Communications have the next highest contribution for all sub-periods, except during 1973-1990, when Petroleum and Gas extraction had a higher contribution. Although these contributions are positive for every industry for the period 1958-1999 as a whole and for the sub-period 1958-1973, negative growth rates occurred for Petroleum and Gas extraction, Tobacco Products, Leather Products, Stone, Clay and Glass, and Other Transportation Equipment during the period 1990-1995.

The contributions of labor input to industry output growth by sub-period are given in Table 9, where are methodology for measuring labor input was described in Section IV. Coal Mining and Petroleum Refining had negative contributions for all four sub-periods. While only five industries had negative growth rates before 1973, the number rose to fifteen industries after 1973. General Government had the highest contribution of labor input before 1973, but Services had the highest contribution after 1973, reflecting the rapid growth of the labor-intensive service industry. Construction and Communications had especially high growth rates during the period 1995-1999, while Coal Mining and Apparel showed large negative growth.

The contributions of intermediate input to industry output growth by sub-period are given in Table 10.[33] The intermediate input contributions are greatest for Rubber and Plastic products, Industrial Machinery and Equipment, Electronic and Electrical Equipment, Motor Vehicles, Instruments, and Communications for the period 1958-1999 as a whole. For the period 1995-1999, Construction, Tobacco Products, Furniture and Fixtures, Industrial Machinery and Equipment, and Electronic and Electrical Equipment head the list. However, Petroleum and Gas extraction, Textile Mill Products, Apparel and Textile, Paper Products, Petroleum Refining, and Primary Metals all had negative growth rates during this period.

Productivity growth rates by industry and by sub-period are given in Table 11, completing our analysis of the sources of industry output growth by sub-periods. There is steady acceleration in productivity growth in the two high-technology industries – Industrial Machinery and Equipment and Electronic and Electrical Equipment – after 1973, reflecting the rising importance of semi-conductors, as well as computers and telecommunications equipment, as outputs of these industries. Jorgenson (2001), for example, identified fundamental structural changes in the semi-conductor industry as a key change in the mid-1990s. Construction is the only industry with negative productivity growth rates for all four sub-periods and there is a steady decline in productivity growth in this industry.

The evolving patterns of productivity growth at the industry level are inconsistent with an explanation of negative productivity growth rates that relies solely on persistent errors of measurement. Rather, negative productivity growth rates appear to be a pervasive feature of industry performance in the U.S. economy. Only Agriculture, Coal Mining, Food Products, Textile Mill Products, Apparel and Textiles, Furniture and Fixtures, Petroleum Refining, Rubber and Plastics, Stone, Clay and Glass, Instruments, and the two high technology industries have positive productivity growth rates throughout the period. With the sole exception of Construction the remaining industries have both positive and negative growth rates of productivity, which makes the mismeasurement story less tenable.

Productivity growth rates have increased in twenty industries during the period 1995-1999 relative to 1990-1995, but twelve of the thirty-five industries for which we measure productivity had negative productivity growth rates during this period. Perhaps surprisingly, the list includes Communications, one of the most important consumers of high-technology products. It also includes the two of the largest and most heterogeneous industries – Trade and FIRE (finance, insurance, and real estate). The wide definitions for these industries is a concern, because it likely masks important underlying variation. We will also see later that these industries are very substantial investors in high-technology capital.

Labor productivity growth rates by industry and by sub-period are given in Table 12. There is the same steady acceleration in labor productivity growth in Industrial Machinery and Equipment and Electronic and Electrical Equipment, the two high-technology industries, as in the productivity growth of these industries shown in Table 11. Construction exhibits a decline in labor productivity growth, starting from a positive growth before 1973, but becoming negative after 1973. These data have been the focus of much attention, since they are readily available in official publications.

Growth rates of hours worked by industry and by sub-period are given in Table 13, completing our analysis of output growth at the industry level by sub-period. We have already pointed out that the growth of hours worked is negative for fourteen industries for the period 1958-1999. This number falls to nine before 1973, rises to eighteen for the period 1973-1990, twenty for 1990-1995, and then falls to sixteen for 1995-1995. Growth rates of hours worked are negative for all periods for Coal Mining, Tobacco Products, Petroleum Refining, and Leather Products.

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[33]Figure 8 compares the contribution of intermediate inputs to the sum of the remaining components (capital, labor, and productivity) for the full period.

b) Aggregation across Industries

An important feature of our methodology is that we are able to identify the contributions of individual industries to aggregate economic growth. The first step in this process of identification is to measure flows of goods and services among industries as intermediate inputs reflected in the inter-industry transactions tables. We have completed this step in Tables 5 and 10. The second step is to aggregate output, capital, labor, and productivity over industrial industries, using the methodology outlined in Section V. We now turn our attention to this second step.

Triplett (1996) has quantified the role of semi-conductors as an input into the computer industry. Under some reasonable assumptions, falling semi-conductor prices account for virtually all of the price declines in computers. Building on this observation, Oliner and Sichel (2000) have constructed a model of the U.S. economy with three industries – computers, semi-conductors, and all other products. Our framework for aggregation over industries, originated by Jorgenson, Gollop, and Fraumeni (1987), extends the principles underlying the results of Triplett (1996) and Oliner and Sichel (2000) to all products and all industries.

An ingenious weighting scheme originated by Domar (1961) plays a key role in the framework for aggregation over industries introduced by Jorgenson, Gollop, and Fraumeni (1987). In this scheme (Equation (2.17)) the growth rate of each industry's output is weighted by the ratio of two proportions. The first is the proportion of each industry's value-added in value-added for the U.S. economy as a whole. The second is the proportion of value-added in the industry's output. The ratio of these two proportions – the so-called "Domar-weights" – captures both the relative importance of the industry in value-added for the economy as a whole and the relative importance of value-added in the industry's output. Note that the sum of the Domar weights exceeds unity.

Table 14 gives industry contributions to aggregate value-added and aggregate total factor productivity. For value-added, we have weighted the growth rates of value-added by industry by the industry's share of value-added for the U.S. economy as a whole (Equation (2.9)). Note that these shares sum to one. Although the two high-technology industries – Industrial Machinery and Equipment and Electronic and Electrical Equipment – have the highest rates of growth of value-added at the industry level, the contributions of these industries to value-added for the whole economy is relatively modest, reflecting the small proportion of value-added originating in these industries. We discuss the Domar-weighted growth rates of productivity below.

We aggregate over capital inputs at the industry level in Table 15 and Figure 9. We have allocated the contribution of capital input to the growth of industry output between information technology (IT) and non-information technology (Non-IT), in the same way as in Table 1 and Figure 1. We have then applied the Domar weights given in Table 15 to obtain the contribution of each industry's investment in tangible assets to aggregate economic growth. These weights capture the impact of this investment on the industry where it takes place, as well as the industries that purchase the output of this industry as intermediate inputs.

Although Communications has the largest contribution of IT to industry output, the contributions to economy-wide economic growth from investments in IT are much larger for Trade, FIRE, Services, and Private Households. This reflects the comparatively large Domar weights for these industries, as well as the considerable importance of IT contributions to the growth of output. Private Households are by far the leading investors in Non-IT tangible assets (largely reflecting residential structures), but FIRE, Services, Trade, and General Government are also important investors in these assets.

Similarly, we aggregate over labor inputs at the industry level in Table 16 and Figure 10. We have allocated the contribution of labor input to the growth of industry output between college-educated and non-college workers in the same way as for the economy as a whole. We have then applied Domar weights to obtain the contribution of each industry's investments in human capital to economic growth. These weights capture the impact of investment in human capital on all industries, not only the industry where the investments take place.

The greatest contributions of investments in college-educated workers to industry output are in Services and General Government and these are also the industries where this investment has the largest impact on economic growth. Printing and Publishing, Trade, and FIRE are other industries with large contributions of investments in college-educated workers, but these investments have a more considerable impact on economic growth in Construction than in Printing and Publishing, because Construction has a much bigger Domar weight.

All the industries with important contributions to economic growth from investments in college-educated workers also have important contributions from investments in non-college workers. These workers predominate in Trade and Construction, are nearly equal in importance in Services, and are dominated by college-educated workers only in General Government and FIRE. Another notable development is the large-scale exodus of non-college workers from Agriculture and smaller-scale declines in the contributions of these workers in Metal Mining, Coal Mining, and Leather Products, as well as nine other industries.

Finally, we aggregate productivity at the industry level in Table 14 and Figure 11. We applied Domar weights to obtain the contribution of each industry's productivity to economic growth. Note that these Domar-weights sum to more than one in Table 14. The three largest contributors are Electronic and Electric Equipment, Trade, Industrial Machinery. The two high-tech industries reflect strong productivity growth and modest weights, while the Trade reflects modest productivity growth and a relatively large weight. Note that seven industries made negative contributions as discussed above, while 28 industries made positive contributions.

c) Comparison with BLS Estimates

The Bureau of Labor Statistics (2001) also estimates productivity growth (called multifactor productivity (MFP) by BLS) for 2-digit manufacturing industries based on methodologies described by Gullickson (1995) and BLS (1997). As our study uses similar data and reports similar estimates, it is instructive to compare productivity figures in order to highlight any methodological and data differences.

Table 17 reports the BLS estimates of MFP growth for the period 1958-1999 (BLS, column 1) and our estimate of productivity growth (J-H-S, column 3). One important methodological difference is that the BLS estimates are based on hours worked, while ours adjust for compositional changes in the work force, i.e., the contribution of labor quality. Therefore, we also report adjusted BLS MFP estimates (Adj BLS, column 2) that subtract our labor quality contribution from the official BLS estimates.[34]

The first observation is that there is some divergence in industry coverage. For example, we report estimates for Tobacco Products and Leather Products, two very small industries for which BLS feels data quality is insufficient. In addition, we break out Transportation Equipment into Motor Vehicles and Other Transportation Equipment, making comparisons with BLS less transparent. The second observation is that for the 17 industries with comparable coverage, many of the estimates are very close, e.g., the simple correlation is 0.884 between our productivity growth estimates and the official BLS MFP growth estimates and 0.881 between our estimate and the adjusted BLS estimates.

Industries where we have very close correspondence after labor quality adjustments are Paper Products, Chemicals, Stone, Clay, and Glass, Primary Metals, Industrial Machinery and Equipment, Electronic and Electric Equipment, and Miscellaneous Manufacturing. Industries with large divergences include Textile Mills, Lumber and Wood, Rubber and Plastic, Fabricated Metals, and Instruments.

A closer examination of the output growth, capital and labor input growth reveals some explanations for the differences. In the case of Fabricated Metals, for example, we find that our output growth rates are much higher than BLS (2001). This is somewhat puzzling because this is a well-defined industry, and likely due to the different classifications or price indices used by the Office of Employment Projections (that provided our data) versus those used in the official BLS estimates. A similar but smaller difference holds for Printing & Publishing. In Textile Mills, the small number of self-employed workers makes estimating labor compensation and quality difficult.

[34]Note that since we subtract our labor quality contribution, we are implicitly using our labor share and our labor quality growth rate. To the extent that labor share's differ across the studies, this also falls into the adjustment. Our labor quality contribution is reported in column (4).

d) U.S. Growth Resurgence at the Industry Level

Our final set of results examines the contributions of each industry to the resurgence of U.S. economic growth after 1995. In Section I we have shown that IT capital was the most important single source of this resurgence. In Figure 12 compare Domar-weighted growth rates of IT capital input for the periods 1973-1995 and 1995-1999. The contribution of greater investment in IT is concentrated in a relatively small number of industries – FIRE, Services, Private Households, Trade, Communications, and General Government, although these industries are relatively large in size and play an important role in the aggregate. Smaller increases are evident in Electronic and Electrical Equipment, Industrial Machinery and Equipment, Transportation and Warehousing, and Printing and Publishing, as well as many other industries.

In Section I we have also shown that investments in college-educated workers are the most important source of growth during the period 1995-1999, other than investments in tangible assets. In Figure 13 we have compared Domar-weighted growth rates of labor input from college-educated workers for the same periods as in Figure 13. While there was a surge in the contribution of these workers in Services after 1995, the rise in these contributions in FIRE and Construction was comparatively modest. The augmentations in the contributions in General Government and Trade fell short of increases over the period 1973-1995.

Finally, Domar-weighted growth rates of productivity are given in Figure 14 for the same periods as in Figures 12-13. The combined increases in the two high technology industries, Industrial Machinery and Equipment and Electronic and Electrical Equipment are nearly equal to the increase in productivity for the economy as a whole. However, it would be seriously misleading to attribute the entire aggregate increase to the two industries. The contribution of renewed productivity growth in Services, for example, is comparable in magnitude as a source of the resurgence of total factor productivity growth and there are many industries that show increases and others that show declines.

Sizeable increases in productivity occurred in Paper Products, Fabricated Metals, Electric Utilities, Other Transportation Equipment, Government Enterprises, Chemical Products, Primary Metals, and Rubber and Plastics, and Petroleum and Gas extraction, as well as Services. Taken together, these equal the increases in the two high technology industries. However, there were noticable declines in Food Products, Agriculture, Instruments, Transportation and Warehousing, Communications, Trade, FIRE, and Construction.

We conclude that attributions of total factor productivity growth to individual industries are highly arbitrary. It is far easier and much more important to allocate the contributions of capital and labor inputs to individual industries, as we have done above. Industrial Machinery and Equipment, containing computers, and Electronic and Electrical Equipment, including semi-conductors and telecommunications equipment, stand out as rapidly increasing in relative importance during the period 1958-1973. This is driven by rising investment in IT, resulting from rapid price declines and high rates of productivity growth in the two high technology industries.

Greenwood, Hercowitz, and Krussell (1997), Hercowitz (1998), and Greenwood, Hercowitz, and Krussell (2000) have attributed some sixty percent of postwar U.S. economic growth to investment-specific or embodied productivity growth which, following Solow (1960), they distinguish from disembodied productivity growth. As evidence, they note that the relative price of equipment has fallen three percent per year. Our decomposition of U.S. economic growth attributes this to disembodied productivity growth at the industry level, specifically, productivity growth in the two high technology industries that produce IT investment goods, which allows investment goods prices to fall.

Proper aggregation over industries reveals that the dichotomy between embodied and disembodied productivity growth can be false and misleading. There is no separate role for investment-specific productivity growth after productivity growth at the industry level has been taken into account. Investment goods are produced by industries and must be priced as industry outputs. The declining prices of IT investment goods are the consequence of productivity growth in the production of these investment goods. As Ho and Stiroh (2001) have pointed out, only when aggregation has been carried out inappropriately is there a role for embodied productivity growth.

VII. Conclusions

This paper presents new data for understanding the sources of the post-1995 resurgence of U.S. economic growth. We develop and present detailed estimates of output, inputs, and productivity for 37 industries and highlight the critical importance, and heterogeneity, of information technology investment and productivity across U.S. industries.

We also present the methodology for appropriate aggregation across industries using the production possibility frontier. This approach reduces the stringent assumption necessary for the aggregate production frontier. Our aggregate estimates that are built up from the detailed industry data support earlier aggregate work and show an important role for the both the production and the use of information technology in the resurgence of U.S. economic growth.

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Table 1: Growth in Aggregate Value-Added and its Sources

	1958-99	1958-73	1973-90	1990-95	1995-99
Contributions					
Value-Added	3.38	4.09	2.86	2.48	4.02
IT	0.32	0.26	0.27	0.41	0.69
Non-IT	3.05	3.83	2.60	2.07	3.33
Capital Input	1.59	1.67	1.51	1.16	2.12
IT	0.41	0.22	0.41	0.50	1.04
Non-IT	1.17	1.46	1.10	0.65	1.07
Labor Input	1.19	1.23	1.16	1.07	1.33
College	0.68	0.55	0.77	0.73	0.72
Non-college	0.51	0.68	0.39	0.34	0.61
Aggregate TFP	0.60	1.18	0.19	0.25	0.58
Addendum					
Contr K Quality	0.55	0.45	0.55	0.57	0.91
Contr K Stock	1.04	1.22	0.97	0.59	1.21
Contr L Quality	0.29	0.33	0.25	0.43	0.17
Contr L Hours	0.90	0.90	0.91	0.64	1.16
Growth Rates					
Value-Added	3.38	4.09	2.86	2.48	4.02
IT	8.66	6.62	6.87	12.45	19.11
Non-IT	3.18	3.99	2.70	2.14	3.45
Capital Input	3.87	4.09	3.71	2.85	4.97
IT	15.12	15.03	15.24	11.36	19.68
Non-IT	3.05	3.70	2.89	1.79	2.87
Labor Input	2.03	2.09	1.97	1.80	2.31
College	4.21	4.73	4.36	3.11	2.96
Non-college	1.24	1.45	0.99	0.97	1.83

Notes: All figures are average annual percentages. The contribution of an output or input is the growth rate multiplied by the average value share. IT in value-added includes SIC #35 and #36. IT in capital input includes computer hardware, computer software, and telecommunications equipment.

Table 2: Decomposition of Aggregate Labor Productivity and TFP

	1958-99	1958-73	1973-90	1990-95	1995-99
		Contributions			
Average Labor Productivity	1.85	2.56	1.32	1.40	2.00
Capital Deepening	0.96	1.04	0.88	0.73	1.25
IT	0.37	0.20	0.36	0.45	0.94
Non-IT	0.59	0.85	0.51	0.27	0.31
Labor Quality	0.29	0.33	0.25	0.43	0.17
College	-0.01	-0.01	-0.03	0.04	-0.02
Non-college	0.12	0.16	0.07	0.20	0.07
Reallocation of Hours	0.19	0.18	0.21	0.19	0.11
Aggregate TFP	0.60	1.18	0.19	0.25	0.58
		Productivity and Reallocations			
Aggregate TFP	0.60	1.18	0.19	0.25	0.58
Reallocation of Capital Input	0.04	0.07	0.01	0.02	0.04
IT	0.00	-0.01	0.01	0.00	0.01
Non-IT	0.03	0.07	0.01	0.03	0.04
Reallocation of Labor Input	-0.01	0.11	-0.04	-0.15	-0.11
College	-0.01	0.00	-0.01	-0.04	-0.04
Non-college	0.01	0.11	-0.02	-0.12	-0.07
Domar-Weighted Productivity	0.56	1.00	0.21	0.38	0.64
IT	0.22	0.10	0.20	0.35	0.56
Non-IT	0.34	0.90	0.01	0.03	0.08
		Addendum			
Unweighted Value-Added	3.26	3.93	2.73	2.34	4.12
IT	0.31	0.24	0.26	0.40	0.69
Non-IT	2.95	3.69	2.47	1.94	3.43
Reallocation of Value-Added	-0.12	-0.16	-0.13	-0.14	0.10
IT	-0.01	-0.02	-0.01	-0.01	0.00
Non-IT	-0.11	-0.13	-0.13	-0.12	0.10
Hours Growth	1.53	1.53	1.54	1.08	2.02

Notes: Notes: All figures are average annual percentages. The contribution of an output or input is the growth rate multiplied by the average value share. IT in value-added includes SIC #35 and #36. IT in capital input includes computer hardware, computer software, and telecommunications equipment. Aggregate TFP is from the production possibility frontier and Domar-weighted productivity is from aggregation across sectors.

Table 3: Industry Output and Valued-Added, 1999

Code	Industry Name	Output	Value-Added	SIC
1	Agriculture	360,344	187,356	01-02, 07-09
2	Metal Mining	13,763	5,490	10
3	Coal Mining	23,984	14,167	11-12
4	Petroleum and Gas	118,070	60,374	13
5	Nonmetallic Mining	18,433	10,575	14
6	Construction	930,814	379,989	15-17
7	Food Products	457,043	145,975	20
8	Tobacco Products	43,443	16,866	21
9	Textile Mill Products	61,064	21,440	22
10	Apparel and Textiles	89,250	32,098	23
11	Lumber and Wood	115,923	43,220	24
12	Furniture and Fixtures	78,231	35,736	25
13	Paper Products	163,760	68,038	26
14	Printing and Publishing	221,662	129,235	27
15	Chemical Products	408,794	180,406	28
16	Petroleum Refining	139,807	19,769	29
17	Rubber and Plastic	166,665	75,943	30
18	Leather Products	11,104	3,995	31
19	Stone, Clay, and Glass	102,323	49,107	32
20	Primary Metals	158,386	51,081	33
21	Fabricated Metals	267,116	123,978	34
22	Industrial Machinery and Equipm	436,956	183,141	35
23	Electronic and Electric Equipmer	374,264	177,390	36
24	Motor Vehicles	380,832	81,451	371
25	Other Transportation Equipment	169,822	99,432	372-379
26	Instruments	170,893	104,421	38
27	Miscellaneous Manufacturing	54,052	22,112	39
28	Transport and Warehouse	531,537	265,835	40-47
29	Communications	398,351	217,491	48
30	Electric Utilities	241,115	160,723	491, %493
31	Gas Utilities	89,743	26,981	492, %493, 496
32	Trade	1,805,632	1,113,581	50-59
33	FIRE	1,862,003	1,168,044	60-67
34	Services	3,284,062	2,040,742	70-87, 494-495
35	Goverment Enterprises	237,104	152,389	
36	Private Households	1,302,840	1,302,840	88
38	General Government	1,140,945	1,140,945	

Notes: All figures in millions of current dollars. % indicates part of an SIC code.

Table 4: Industry Output, Hours, and Labor Productivity, 1958-1999

	Output	Hours	Labor Productivity
Agriculture	1.98	-1.54	3.52
Metal Mining	1.46	-1.51	2.97
Coal Mining	2.40	-1.61	4.01
Petroleum and Gas	0.47	-0.08	0.54
Nonmetallic Mining	1.78	-0.07	1.84
Construction	1.68	2.23	-0.55
Food Products	2.08	-0.21	2.30
Tobacco Products	0.31	-1.98	2.29
Textile Mill Products	2.13	-1.25	3.38
Apparel and Textiles	1.88	-1.08	2.96
Lumber and Wood	2.26	0.78	1.48
Furniture and Fixtures	3.36	1.07	2.29
Paper Products	2.78	0.40	2.38
Printing and Publishing	2.47	1.50	0.98
Chemical Products	3.39	0.64	2.74
Petroleum Refining	1.74	-1.42	3.16
Rubber and Plastic	5.19	2.36	2.83
Leather Products	-1.16	-3.60	2.43
Stone, Clay, and Glass	2.09	0.19	1.91
Primary Metals	0.86	-0.89	1.75
Fabricated Metals	2.61	0.62	1.99
Industrial Machinery and Equipme	6.00	1.03	4.97
Electronic and Electric Equipment	7.28	1.26	6.02
Motor Vehicles	3.73	1.28	2.45
Other Transportation Equipment	1.56	-0.39	1.95
Instruments	5.06	1.06	4.00
Miscellaneous Manufacturing	2.66	0.38	2.29
Transport and Warehouse	3.20	1.32	1.88
Communications	5.33	1.50	3.84
Electric Utilities	3.63	0.54	3.09
Gas Utilities	0.91	-0.49	1.41
Trade	3.70	1.53	2.17
FIRE	4.23	2.64	1.60
Services	4.61	3.27	1.34
Goverment Enterprises	2.86	1.47	1.39
Private Households	3.87	0.00	3.87
General Government	1.86	1.32	0.54

Notes: All figures are average annual growth rates.

Table 5: Sources of Growth of Industry Output, 1958-1999

		Input Contributions			
	Output	Capital	Labor	Intermediate	Productivity
Agriculture	1.98	0.13	-0.26	0.62	1.49
Metal Mining	1.46	0.59	-0.35	1.40	-0.18
Coal Mining	2.40	0.69	-0.53	0.77	1.47
Petroleum and Gas	0.47	1.02	0.15	0.55	-1.25
Nonmetallic Mining	1.78	0.80	-0.06	0.59	0.45
Construction	1.68	0.17	0.99	1.39	-0.86
Food Products	2.08	0.21	0.02	1.15	0.69
Tobacco Products	0.31	0.69	-0.24	1.00	-1.14
Textile Mill Products	2.13	0.14	-0.24	0.73	1.49
Apparel and Textiles	1.88	0.19	-0.19	0.84	1.04
Lumber and Wood	2.26	0.27	0.31	1.52	0.15
Furniture and Fixtures	3.36	0.30	0.49	1.70	0.88
Paper Products	2.78	0.46	0.25	1.51	0.56
Printing and Publishing	2.47	0.65	0.79	1.20	-0.17
Chemical Products	3.39	0.74	0.22	1.75	0.67
Petroleum Refining	1.74	0.20	-0.06	0.66	0.94
Rubber and Plastic	5.19	0.49	0.85	2.33	1.52
Leather Products	-1.16	0.05	-0.86	-0.60	0.24
Stone, Clay, and Glass	2.09	0.34	0.19	1.06	0.50
Primary Metals	0.86	0.12	-0.08	0.47	0.34
Fabricated Metals	2.61	0.33	0.30	1.36	0.62
Industrial Machinery and Equipmen	6.00	0.63	0.47	2.68	2.21
Electronic and Electric Equipment	7.28	0.84	0.57	2.54	3.32
Motor Vehicles	3.73	0.28	0.26	3.10	0.09
Other Transportation Equipment	1.56	0.24	0.01	0.69	0.62
Instruments	5.06	0.61	0.68	2.07	1.71
Miscellaneous Manufacturing	2.66	0.34	0.31	1.32	0.69
Transport and Warehouse	3.20	0.28	0.64	1.42	0.85
Communications	5.33	2.03	0.67	2.22	0.42
Electric Utilities	3.63	1.36	0.25	1.44	0.57
Gas Utilities	0.91	0.53	-0.01	0.89	-0.49
Trade	3.70	0.93	0.99	1.25	0.54
FIRE	4.23	1.57	0.83	1.59	0.24
Services	4.61	0.91	1.89	1.98	-0.17
Goverment Enterprises	2.86	0.86	0.77	1.19	0.04
Private Households	3.87	3.87	0.00	0.00	0.00
General Government	1.86	0.61	1.25	0.00	0.00

Notes: Output and productivity are average annual growth rates. Capital, labor, and intermediate inputs are average annual contributions (share-weighted growth rates).

Table 6: Sources of Growth in Industry Labor Productivity, 1958-1999

	ALP	Capital Deepening	Intermediate Deepening	Labor Quality	Productivity
Agriculture	3.52	0.41	1.50	0.12	1.49
Metal Mining	2.97	1.13	1.93	0.09	-0.18
Coal Mining	4.01	0.78	1.54	0.21	1.47
Petroleum and Gas	0.54	0.86	0.85	0.09	-1.25
Nonmetallic Mining	1.84	0.82	0.63	-0.05	0.45
Construction	-0.55	0.05	0.14	0.13	-0.86
Food Products	2.30	0.22	1.33	0.06	0.69
Tobacco Products	2.29	1.26	2.06	0.11	-1.14
Textile Mill Products	3.38	0.23	1.58	0.08	1.49
Apparel and Textiles	2.96	0.29	1.50	0.13	1.04
Lumber and Wood	1.48	0.15	1.06	0.12	0.15
Furniture and Fixtures	2.29	0.19	1.10	0.12	0.88
Paper Products	2.38	0.40	1.28	0.14	0.56
Printing and Publishing	0.98	0.45	0.50	0.20	-0.17
Chemical Products	2.74	0.61	1.38	0.08	0.67
Petroleum Refining	3.16	0.29	1.90	0.03	0.94
Rubber and Plastic	2.83	0.25	0.96	0.10	1.52
Leather Products	2.43	0.46	1.60	0.13	0.24
Stone, Clay, and Glass	1.91	0.28	0.99	0.14	0.50
Primary Metals	1.75	0.20	1.13	0.08	0.34
Fabricated Metals	1.99	0.25	1.01	0.10	0.62
Industrial Machinery and Equipmen	4.97	0.49	2.12	0.15	2.21
Electronic and Electric Equipment	6.02	0.69	1.87	0.15	3.32
Motor Vehicles	2.45	0.12	2.16	0.08	0.09
Other Transportation Equipment	1.95	0.25	0.91	0.17	0.62
Instruments	4.00	0.50	1.56	0.24	1.71
Miscellaneous Manufacturing	2.29	0.30	1.10	0.20	0.69
Transport and Warehouse	1.88	0.09	0.81	0.13	0.85
Communications	3.84	1.53	1.70	0.19	0.42
Electric Utilities	3.09	1.19	1.17	0.16	0.57
Gas Utilities	1.41	0.63	1.25	0.03	-0.49
Trade	2.17	0.69	0.70	0.25	0.54
FIRE	1.60	0.58	0.67	0.10	0.24
Services	1.34	0.44	0.77	0.31	-0.17
Goverment Enterprises	1.39	0.54	0.60	0.21	0.04
Private Households	3.87	3.87	0.00	0.00	0.00
General Government	0.54	0.19	0.00	0.35	0.00

Notes: Average labor productivity and productivity are average annual growth rates. Capital deepening, intermediate deepening, and labor quality are average annual contributions (share-weighted growth rates).

Table 7: Growth of Industry Output by Sub-Period

	1958-99	1958-73	1973-90	1990-95	1995-99
Agriculture	1.98	1.97	2.03	1.87	1.97
Metal Mining	1.46	2.29	0.89	1.68	0.50
Coal Mining	2.40	2.45	3.24	-0.01	1.71
Petroleum and Gas	0.47	2.60	-0.61	-1.13	-0.94
Nonmetallic Mining	1.78	3.60	-0.10	1.60	3.15
Construction	1.68	2.86	0.51	-0.07	4.41
Food Products	2.08	2.59	1.92	2.19	0.78
Tobacco Products	0.31	1.35	-0.74	0.44	0.76
Textile Mill Products	2.13	3.59	1.08	2.68	0.39
Apparel and Textiles	1.88	4.18	0.28	3.13	-1.48
Lumber and Wood	2.26	4.01	1.60	0.97	0.06
Furniture and Fixtures	3.36	4.60	1.59	2.79	6.96
Paper Products	2.78	4.72	1.80	1.62	1.08
Printing and Publishing	2.47	3.41	2.54	-0.05	1.83
Chemical Products	3.39	6.29	1.58	1.36	2.72
Petroleum Refining	1.74	3.36	1.55	0.53	-2.02
Rubber and Plastic	5.19	8.29	2.67	5.28	4.13
Leather Products	-1.16	-0.48	-2.71	-3.09	5.28
Stone, Clay, and Glass	2.09	3.73	0.11	1.19	5.52
Primary Metals	0.86	4.08	-2.21	2.49	-0.21
Fabricated Metals	2.61	4.42	0.04	3.18	6.06
Industrial Machinery and Equipment	6.00	5.46	4.21	8.94	11.96
Electronic and Electric Equipment	7.28	7.16	4.33	11.87	14.53
Motor Vehicles	3.73	6.21	0.59	6.08	4.83
Other Transportation Equipment	1.56	2.04	2.56	-5.43	4.28
Instruments	5.06	6.65	5.19	1.46	3.08
Miscellaneous Manufacturing	2.66	4.98	0.38	2.71	3.64
Transport and Warehouse	3.20	4.15	2.29	3.55	3.06
Communications	5.33	5.92	4.78	4.34	6.69
Electric Utilities	3.63	5.71	2.62	1.19	3.20
Gas Utilities	0.91	5.25	-1.83	-2.24	0.24
Trade	3.70	4.63	3.24	2.87	3.16
FIRE	4.23	4.08	4.51	3.14	4.98
Services	4.61	5.83	3.72	3.09	5.71
Goverment Enterprises	2.86	3.75	2.14	1.63	4.10
Private Households	3.87	4.29	3.65	2.77	4.61
General Government	1.86	2.74	1.55	1.07	0.85

Notes: All figures are average annual growth rates.

Table 8: Contribution of Industry Capital Input by Sub-Period

	1958-99	1958-73	1973-90	1990-95	1995-99
Agriculture	0.13	0.20	0.01	0.10	0.39
Metal Mining	0.59	0.81	0.35	0.64	0.71
Coal Mining	0.69	0.61	0.77	0.42	0.97
Petroleum and Gas	1.02	0.87	1.75	-0.57	0.51
Nonmetallic Mining	0.80	1.05	0.53	0.26	1.71
Construction	0.17	0.20	0.06	0.10	0.54
Food Products	0.21	0.16	0.19	0.28	0.43
Tobacco Products	0.69	0.72	1.01	-0.21	0.33
Textile Mill Products	0.14	0.20	0.05	0.20	0.20
Apparel and Textiles	0.19	0.25	0.16	0.26	0.04
Lumber and Wood	0.27	0.45	0.18	0.04	0.23
Furniture and Fixtures	0.30	0.40	0.25	0.10	0.37
Paper Products	0.46	0.52	0.49	0.26	0.33
Printing and Publishing	0.65	0.61	0.68	0.38	0.99
Chemical Products	0.74	0.86	0.62	0.66	0.93
Petroleum Refining	0.20	0.22	0.23	0.20	-0.06
Rubber and Plastic	0.49	0.65	0.29	0.46	0.75
Leather Products	0.05	0.21	0.02	-0.25	-0.01
Stone, Clay, and Glass	0.34	0.43	0.26	-0.10	0.82
Primary Metals	0.12	0.26	-0.01	0.00	0.30
Fabricated Metals	0.33	0.40	0.27	0.16	0.54
Industrial Machinery and Equipment	0.63	0.71	0.60	0.36	0.80
Electronic and Electric Equipment	0.84	0.68	0.73	0.86	1.92
Motor Vehicles	0.28	0.49	0.08	0.20	0.43
Other Transportation Equipment	0.24	0.19	0.34	-0.12	0.51
Instruments	0.61	0.64	0.59	0.47	0.82
Miscellaneous Manufacturing	0.34	0.40	0.29	0.24	0.48
Transport and Warehouse	0.28	0.27	0.16	0.24	0.92
Communications	2.03	2.67	1.55	1.42	2.45
Electric Utilities	1.36	1.97	1.38	0.25	0.43
Gas Utilities	0.53	0.77	0.33	0.42	0.60
Trade	0.93	0.96	0.84	0.81	1.33
FIRE	1.57	1.79	1.41	1.04	2.06
Services	0.91	1.13	0.76	0.67	1.06
Goverment Enterprises	0.86	0.93	0.85	0.77	0.78
Private Households	3.87	4.29	3.65	2.77	4.61
General Government	0.61	0.81	0.56	0.42	0.33

Notes: All figures are average annual contributions (share-weighted growth rates).

Table 9: Contribution of Industry Labor Input by Sub-Period

	1958-99	1958-73	1973-90	1990-95	1995-99
Agriculture	-0.26	-0.59	-0.23	0.12	0.44
Metal Mining	-0.35	0.28	-0.74	-0.32	-1.09
Coal Mining	-0.53	-0.02	-0.11	-2.31	-1.97
Petroleum and Gas	0.15	-0.09	0.66	-0.48	-0.29
Nonmetallic Mining	-0.06	0.16	-0.05	-0.31	-0.66
Construction	0.99	0.98	0.93	0.50	1.85
Food Products	0.02	0.05	-0.03	0.15	0.01
Tobacco Products	-0.24	0.05	-0.31	-0.74	-0.38
Textile Mill Products	-0.24	0.26	-0.48	-0.14	-1.13
Apparel and Textiles	-0.19	0.57	-0.41	-0.21	-2.07
Lumber and Wood	0.31	0.58	0.04	0.46	0.29
Furniture and Fixtures	0.49	0.98	0.08	0.36	0.56
Paper Products	0.25	0.58	0.04	0.33	-0.22
Printing and Publishing	0.79	0.35	1.66	0.04	-0.26
Chemical Products	0.22	0.40	0.28	-0.05	-0.36
Petroleum Refining	-0.06	-0.08	-0.04	-0.01	-0.13
Rubber and Plastic	0.85	1.61	0.25	1.08	0.23
Leather Products	-0.86	0.02	-1.46	-0.79	-1.67
Stone, Clay, and Glass	0.19	0.73	-0.33	0.24	0.36
Primary Metals	-0.08	0.38	-0.48	-0.05	-0.09
Fabricated Metals	0.30	0.82	-0.24	0.50	0.41
Industrial Machinery and Equipment	0.47	1.05	0.07	0.29	0.24
Electronic and Electric Equipment	0.57	1.25	0.25	0.00	0.16
Motor Vehicles	0.26	0.62	-0.18	0.75	0.20
Other Transportation Equipment	0.01	-0.03	0.69	-2.73	0.68
Instruments	0.68	1.25	0.75	-0.96	0.23
Miscellaneous Manufacturing	0.31	0.62	0.01	0.54	0.12
Transport and Warehouse	0.64	0.42	0.54	1.46	0.84
Communications	0.67	0.97	0.37	0.41	1.15
Electric Utilities	0.25	0.38	0.36	-0.12	-0.16
Gas Utilities	-0.01	0.08	-0.03	-0.05	-0.27
Trade	0.99	1.10	0.94	0.95	0.80
FIRE	0.83	0.86	0.93	0.44	0.81
Services	1.89	1.68	2.16	1.52	1.93
Goverment Enterprises	0.77	1.04	0.85	0.28	0.05
Private Households	0.00	0.00	0.00	0.00	0.00
General Government	1.25	1.93	0.99	0.65	0.52

Notes: All figures are average annual contributions (share-weighted growth rates).

Table 10: Contribution of Industry Intermediate Input by Sub-Period

	1958-99	1958-73	1973-90	1990-95	1995-99
Agriculture	0.62	1.66	-0.22	0.47	0.47
Metal Mining	1.40	2.17	1.14	0.14	1.19
Coal Mining	0.77	0.82	1.46	-1.51	0.50
Petroleum and Gas	0.54	0.59	1.49	-2.00	-0.49
Nonmetallic Mining	0.59	1.20	-0.40	0.46	2.65
Construction	1.39	1.92	0.42	0.71	4.36
Food Products	1.15	1.64	1.00	1.09	0.08
Tobacco Products	1.00	-0.04	0.72	-0.96	8.49
Textile Mill Products	0.73	2.63	-0.63	0.85	-0.72
Apparel and Textiles	0.84	2.36	-0.50	2.45	-1.22
Lumber and Wood	1.52	3.26	0.11	2.32	0.02
Furniture and Fixtures	1.70	2.48	0.47	1.56	4.18
Paper Products	1.51	2.57	1.29	1.65	-1.73
Printing and Publishing	1.20	1.97	0.96	0.02	0.78
Chemical Products	1.75	3.08	1.00	0.87	1.09
Petroleum Refining	0.66	2.00	0.93	-1.41	-2.94
Rubber and Plastic	2.33	4.15	0.84	2.67	1.44
Leather Products	-0.60	-0.02	-1.53	-2.38	3.39
Stone, Clay, and Glass	1.06	1.97	-0.20	0.72	3.45
Primary Metals	0.47	3.10	-1.67	2.01	-2.19
Fabricated Metals	1.36	2.24	0.06	1.51	3.39
Industrial Machinery and Equipment	2.68	3.11	1.23	4.37	5.12
Electronic and Electric Equipment	2.54	3.33	0.70	5.11	4.19
Motor Vehicles	3.10	4.36	1.04	5.62	3.97
Other Transportation Equipment	0.69	0.83	1.25	-2.26	1.48
Instruments	2.07	2.71	1.68	1.54	1.95
Miscellaneous Manufacturing	1.32	2.54	-0.26	1.62	3.05
Transport and Warehouse	1.43	1.91	0.97	1.31	1.65
Communications	2.22	2.13	1.99	1.92	3.92
Electric Utilities	1.44	2.15	1.23	0.26	1.15
Gas Utilities	0.89	3.83	-1.42	-0.45	1.35
Trade	1.25	1.76	0.91	0.97	1.13
FIRE	1.59	1.43	1.66	1.09	2.49
Services	1.98	2.46	1.51	1.62	2.67
Goverment Enterprises	1.19	1.44	0.86	1.11	1.70
Private Households	0.00	0.00	0.00	0.00	0.00
General Government	0.00	0.00	0.00	0.00	0.00

Notes: All figures are average annual contributions (share-weighted growth rates).

Table 11: Growth of Industry Productivity by Sub-Period

	1958-99	1958-73	1973-90	1990-95	1995-99
Agriculture	1.49	0.70	2.48	1.18	0.67
Metal Mining	-0.18	-0.98	0.15	1.22	-0.31
Coal Mining	1.47	1.05	1.11	3.39	2.20
Petroleum and Gas	-1.25	1.23	-4.50	1.92	-0.67
Nonmetallic Mining	0.45	1.18	-0.18	1.19	-0.55
Construction	-0.86	-0.25	-0.90	-1.37	-2.34
Food Products	0.69	0.73	0.76	0.68	0.26
Tobacco Products	-1.14	0.61	-2.16	2.35	-7.70
Textile Mill Products	1.49	0.50	2.15	1.77	2.04
Apparel and Textiles	1.04	0.99	1.03	0.64	1.78
Lumber and Wood	0.15	-0.28	1.27	-1.84	-0.48
Furniture and Fixtures	0.88	0.75	0.80	0.76	1.85
Paper Products	0.56	1.05	-0.02	-0.62	2.70
Printing and Publishing	-0.17	0.48	-0.76	-0.49	0.32
Chemical Products	0.67	1.95	-0.32	-0.12	1.06
Petroleum Refining	0.94	1.22	0.42	1.75	1.11
Rubber and Plastic	1.52	1.88	1.29	1.08	1.70
Leather Products	0.24	-0.69	0.26	0.33	3.58
Stone, Clay, and Glass	0.50	0.60	0.38	0.32	0.90
Primary Metals	0.34	0.33	-0.05	0.52	1.77
Fabricated Metals	0.62	0.97	-0.05	1.01	1.72
Industrial Machinery and Equipment	2.21	0.58	2.30	3.92	5.80
Electronic and Electric Equipment	3.32	1.90	2.64	5.90	8.27
Motor Vehicles	0.09	0.74	-0.35	-0.49	0.24
Other Transportation Equipment	0.62	1.05	0.28	-0.32	1.61
Instruments	1.71	2.05	2.17	0.40	0.07
Miscellaneous Manufacturing	0.69	1.42	0.34	0.31	-0.02
Transport and Warehouse	0.85	1.54	0.62	0.53	-0.36
Communications	0.42	0.16	0.88	0.60	-0.83
Electric Utilities	0.57	1.22	-0.35	0.80	1.79
Gas Utilities	-0.49	0.57	-0.72	-2.16	-1.44
Trade	0.54	0.82	0.55	0.15	-0.09
FIRE	0.24	-0.01	0.51	0.57	-0.38
Services	-0.17	0.55	-0.71	-0.72	0.06
Goverment Enterprises	0.04	0.34	-0.42	-0.54	1.57
Private Households	0.00	0.00	0.00	0.00	0.00
General Government	0.00	0.00	0.00	0.00	0.00

Notes: All figures are average annual growth rates.

Table 12: Growth of Industry Labor Productivity by Sub-Period

	1958-99	1958-73	1973-90	1990-95	1995-99
Agriculture	3.52	5.02	3.41	1.92	0.39
Metal Mining	2.97	2.06	2.97	3.45	5.78
Coal Mining	4.01	3.00	3.56	6.35	6.78
Petroleum and Gas	0.54	3.74	-3.17	2.66	1.71
Nonmetallic Mining	1.84	3.73	-0.17	2.20	2.85
Construction	-0.55	0.45	-1.39	-0.75	-0.46
Food Products	2.30	2.64	2.46	1.72	1.03
Tobacco Products	2.29	1.97	1.67	4.27	3.65
Textile Mill Products	3.38	3.05	3.59	3.43	3.62
Apparel and Textiles	2.96	2.66	1.91	4.62	6.49
Lumber and Wood	1.48	2.55	1.84	-0.79	-1.23
Furniture and Fixtures	2.29	2.51	1.39	2.13	5.50
Paper Products	2.38	3.05	2.04	1.68	2.22
Printing and Publishing	0.98	2.59	-0.49	-0.12	2.54
Chemical Products	2.74	4.77	1.06	2.17	3.00
Petroleum Refining	3.16	4.70	2.70	2.14	0.61
Rubber and Plastic	2.83	3.51	1.92	3.28	3.60
Leather Products	2.43	0.50	1.90	1.21	13.49
Stone, Clay, and Glass	1.91	2.30	1.15	1.29	4.43
Primary Metals	1.75	2.76	0.76	3.33	0.21
Fabricated Metals	1.99	2.32	0.93	2.43	4.77
Industrial Machinery and Equipment	4.97	2.64	4.42	8.76	11.29
Electronic and Electric Equipment	6.02	3.86	4.25	12.13	14.04
Motor Vehicles	2.45	3.26	1.48	2.39	3.61
Other Transportation Equipment	1.95	2.62	1.33	1.42	2.77
Instruments	4.00	4.21	4.02	4.17	2.92
Miscellaneous Manufacturing	2.29	3.81	0.86	1.81	3.26
Transport and Warehouse	1.88	3.58	1.10	0.24	0.92
Communications	3.84	3.64	4.31	3.63	2.82
Electric Utilities	3.09	4.33	1.22	3.27	6.15
Gas Utilities	1.41	4.84	-1.37	-1.14	3.53
Trade	2.17	3.08	1.64	1.66	1.64
FIRE	1.60	0.90	1.73	2.72	2.19
Services	1.34	3.16	-0.15	0.44	2.01
Goverment Enterprises	1.39	1.34	0.75	1.49	4.16
Private Households	3.87	4.29	3.65	2.77	4.61
General Government	0.54	0.40	0.51	1.08	0.48

Notes: All figures are average annual growth rates.

Table 13: Growth of Industry Hours by Sub-Period

	1958-99	1958-73	1973-90	1990-95	1995-99
Agriculture	-1.54	-3.05	-1.39	-0.04	1.57
Metal Mining	-1.51	0.23	-2.08	-1.77	-5.28
Coal Mining	-1.61	-0.55	-0.33	-6.36	-5.07
Petroleum and Gas	-0.08	-1.14	2.56	-3.80	-2.65
Nonmetallic Mining	-0.07	-0.14	0.07	-0.60	0.30
Construction	2.23	2.41	1.90	0.68	4.88
Food Products	-0.21	-0.05	-0.55	0.47	-0.26
Tobacco Products	-1.98	-0.62	-2.41	-3.83	-2.89
Textile Mill Products	-1.25	0.53	-2.51	-0.75	-3.23
Apparel and Textiles	-1.08	1.52	-1.63	-1.49	-7.96
Lumber and Wood	0.78	1.47	-0.24	1.75	1.29
Furniture and Fixtures	1.07	2.09	0.20	0.66	1.45
Paper Products	0.40	1.68	-0.24	-0.06	-1.14
Printing and Publishing	1.50	0.82	3.03	0.07	-0.71
Chemical Products	0.64	1.51	0.52	-0.81	-0.28
Petroleum Refining	-1.42	-1.34	-1.15	-1.61	-2.63
Rubber and Plastic	2.36	4.78	0.75	2.01	0.54
Leather Products	-3.60	-0.98	-4.61	-4.30	-8.21
Stone, Clay, and Glass	0.19	1.43	-1.04	-0.10	1.09
Primary Metals	-0.89	1.33	-2.97	-0.84	-0.42
Fabricated Metals	0.62	2.10	-0.88	0.75	1.29
Industrial Machinery and Equipme	1.03	2.82	-0.21	0.18	0.67
Electronic and Electric Equipment	1.26	3.30	0.08	-0.26	0.49
Motor Vehicles	1.28	2.95	-0.89	3.69	1.22
Other Transportation Equipment	-0.39	-0.58	1.23	-6.85	1.52
Instruments	1.06	2.44	1.18	-2.72	0.15
Miscellaneous Manufacturing	0.38	1.17	-0.48	0.90	0.37
Transport and Warehouse	1.32	0.58	1.19	3.30	2.14
Communications	1.50	2.28	0.48	0.71	3.87
Electric Utilities	0.54	1.38	1.39	-2.08	-2.95
Gas Utilities	-0.49	0.41	-0.45	-1.10	-3.29
Trade	1.53	1.56	1.61	1.21	1.52
FIRE	2.64	3.17	2.78	0.42	2.80
Services	3.27	2.67	3.88	2.65	3.71
Goverment Enterprises	1.47	2.41	1.39	0.14	-0.06
Private Households	0.00	0.00	0.00	0.00	0.00
General Government	1.32	2.33	1.04	-0.01	0.37

Notes: All figures are average annual growth rates.

Table 14: Industry Contributions to Aggregate Value-Added and TFP Growth, 1958-1999

	Value-Added			Productivity		
	V-A Weight	Growth	Contribution to Aggregate V-A	Domar Weight	Growth	Contribution to Aggregate TFP
Agriculture	0.031	2.87	0.08	0.065	1.49	0.09
Metal Mining	0.001	0.60	0.00	0.002	-0.18	0.00
Coal Mining	0.003	2.78	0.01	0.005	1.47	0.01
Petroleum and Gas	0.015	0.10	-0.02	0.027	-1.25	-0.08
Nonmetallic Mining	0.002	2.18	0.00	0.003	0.45	0.00
Construction	0.051	0.72	0.04	0.118	-0.86	-0.09
Food Products	0.018	3.85	0.07	0.075	0.69	0.05
Tobacco Products	0.002	-1.17	0.00	0.004	-1.14	0.00
Textile Mill Products	0.004	4.58	0.02	0.013	1.49	0.02
Apparel and Textiles	0.007	2.94	0.03	0.020	1.05	0.02
Lumber and Wood	0.005	2.08	0.01	0.015	0.15	0.00
Furniture and Fixtures	0.003	3.77	0.01	0.008	0.88	0.01
Paper Products	0.008	3.23	0.03	0.022	0.56	0.01
Printing and Publishing	0.012	2.45	0.03	0.023	-0.17	0.00
Chemical Products	0.019	4.04	0.08	0.047	0.67	0.03
Petroleum Refining	0.005	7.88	0.04	0.031	0.94	0.03
Rubber and Plastic	0.006	6.82	0.04	0.015	1.52	0.02
Leather Products	0.001	-1.34	0.00	0.004	0.24	0.00
Stone, Clay, and Glass	0.007	2.08	0.01	0.014	0.50	0.01
Primary Metals	0.011	1.11	0.01	0.038	0.34	0.01
Fabricated Metals	0.015	2.83	0.04	0.035	0.62	0.02
Industrial Machinery and Equipment	0.022	7.48	0.15	0.048	2.21	0.10
Electronic and Electric Equipment	0.017	10.13	0.17	0.036	3.32	0.12
Motor Vehicles	0.011	2.20	0.03	0.041	0.09	0.01
Other Transportation Equipment	0.012	1.86	0.02	0.026	0.62	0.02
Instruments	0.010	5.46	0.05	0.017	1.71	0.03
Miscellaneous Manufacturing	0.003	3.22	0.01	0.007	0.70	0.01
Transport and Warehouse	0.034	3.21	0.11	0.062	0.85	0.05
Communications	0.020	4.92	0.10	0.033	0.42	0.01
Electric Utilities	0.015	3.47	0.05	0.025	0.57	0.01
Gas Utilities	0.005	-1.15	-0.01	0.018	-0.49	-0.01
Trade	0.124	3.80	0.47	0.193	0.54	0.11
FIRE	0.087	4.07	0.35	0.134	0.24	0.03
Services	0.134	4.13	0.55	0.213	-0.17	-0.05
Goverment Enterprises	0.013	2.75	0.03	0.021	0.04	0.00
Private Households	0.134	3.87	0.52	0.134	0.00	0.00
General Government	0.132	1.86	0.25	0.132	0.00	0.00
Sum	1.000		3.378	1.724		0.569

Notes: All figures are annual averages. Value-added weights are industry value-added as a share of aggregate value-added. Domar weights are industry output as a share of aggregate value-added. A contribution is a share-weighted growth rate.

Table 15: Industy Contributions to Capital Input Growth, 1958-1999

		Capital			IT Capital			Non-IT Capital		
	Domar Weight	Industry Contribution	Contribution to Aggregate	Share of Aggregate	Industry Contribution	Contribution to Aggregate	Share of Aggregate	Industry Contribution	Contribution to Aggregate	Share of Aggregate
Agriculture	0.065	0.126	0.009	0.005	0.010	0.001	0.001	0.116	0.008	0.007
Metal Mining	0.002	0.589	0.002	0.001	0.067	0.000	0.000	0.522	0.002	0.001
Coal Mining	0.005	0.686	0.004	0.003	0.049	0.000	0.000	0.638	0.004	0.003
Petroleum and Gas	0.027	1.022	0.045	0.028	0.096	0.003	0.008	0.926	0.042	0.035
Nonmetallic Mining	0.003	0.801	0.003	0.002	0.063	0.000	0.000	0.738	0.002	0.002
Construction	0.118	0.165	0.019	0.012	0.028	0.003	0.006	0.138	0.017	0.014
Food Products	0.075	0.213	0.015	0.009	0.046	0.003	0.007	0.167	0.012	0.010
Tobacco Products	0.004	0.693	0.003	0.002	0.127	0.000	0.001	0.567	0.002	0.002
Textile Mill Products	0.013	0.138	0.002	0.001	0.056	0.001	0.001	0.083	0.001	0.001
Apparel and Textiles	0.020	0.194	0.004	0.003	0.043	0.001	0.002	0.151	0.003	0.003
Lumber and Wood	0.015	0.267	0.005	0.003	0.040	0.001	0.002	0.227	0.004	0.003
Furniture and Fixtures	0.008	0.296	0.002	0.002	0.060	0.001	0.001	0.236	0.002	0.002
Paper Products	0.022	0.458	0.010	0.006	0.060	0.001	0.003	0.398	0.009	0.007
Printing and Publishing	0.023	0.649	0.015	0.009	0.275	0.007	0.016	0.375	0.009	0.007
Chemical Products	0.047	0.741	0.035	0.022	0.107	0.005	0.012	0.635	0.030	0.025
Petroleum Refining	0.031	0.196	0.007	0.004	0.029	0.001	0.002	0.167	0.006	0.005
Rubber and Plastic	0.015	0.490	0.008	0.005	0.083	0.001	0.003	0.407	0.006	0.005
Leather Products	0.004	0.054	0.001	0.000	0.051	0.000	0.000	0.003	0.000	0.000
Stone, Clay, and Glass	0.014	0.335	0.005	0.003	0.107	0.001	0.004	0.229	0.004	0.003
Primary Metals	0.038	0.121	0.006	0.004	0.039	0.001	0.003	0.082	0.005	0.004
Fabricated Metals	0.035	0.328	0.012	0.007	0.077	0.002	0.006	0.251	0.010	0.008
Industrial Machinery and Equipment	0.048	0.631	0.032	0.019	0.293	0.014	0.035	0.339	0.017	0.014
Electronic and Electric Equipment	0.036	0.844	0.031	0.019	0.278	0.010	0.024	0.566	0.021	0.017
Motor Vehicles	0.041	0.278	0.013	0.008	0.040	0.002	0.004	0.239	0.011	0.009
Other Transportation Equipment	0.026	0.245	0.006	0.004	0.123	0.003	0.007	0.122	0.004	0.003
Instruments	0.017	0.614	0.010	0.006	0.247	0.005	0.011	0.368	0.006	0.005
Miscellaneous Manufacturing	0.007	0.342	0.003	0.002	0.094	0.001	0.002	0.250	0.002	0.002
Transport and Warehouse	0.062	0.283	0.017	0.011	0.107	0.006	0.015	0.176	0.011	0.009
Communications	0.033	2.029	0.065	0.040	1.316	0.042	0.101	0.713	0.023	0.019
Electric Utilities	0.025	1.365	0.033	0.020	0.151	0.004	0.011	1.214	0.028	0.024
Gas Utilities	0.018	0.528	0.009	0.006	0.129	0.002	0.005	0.400	0.007	0.006
Trade	0.193	0.927	0.178	0.110	0.290	0.055	0.131	0.637	0.124	0.102
FIRE	0.134	1.567	0.210	0.129	0.497	0.073	0.176	1.069	0.136	0.113
Services	0.213	0.913	0.191	0.118	0.258	0.062	0.149	0.655	0.129	0.107
Goverment Enterprises	0.021	0.861	0.018	0.011	0.245	0.006	0.013	0.617	0.013	0.011
Private Households	0.134	3.872	0.517	0.319	0.539	0.073	0.175	3.333	0.444	0.368
General Government	0.132	0.611	0.080	0.050	0.205	0.027	0.064	0.404	0.054	0.044
Total			1.62	1.00		0.42	1.00		1.21	1.00

Notes: Industry contribution refers to the share-weighted growth rate of the input in each industry. Contribution to aggregate weights the industry contribution by the Domar-weight. Share of aggregate is the industry contribution to aggregate as a share of the sum across industries ofall industry contributions to aggregate.

Table 16: Industy Contributions to Aggregate Labor Input Growth, 1958-1999

		Total Labor			College Educated Labor			Non-college Educated Labor		
	Domar Weight	Industry Contribution	Contribution to Aggregate	Share of Aggregate	Industry Contribution	Contribution to Aggregate	Share of Aggregate	Industry Contribution	Contribution to Aggregate	Share of Aggregate
Agriculture	0.065	-0.256	-0.021	-0.018	0.117	0.007	0.011	-0.373	-0.028	-0.055
Metal Mining	0.002	-0.351	-0.001	-0.001	0.036	0.000	0.000	-0.386	-0.001	-0.002
Coal Mining	0.005	-0.526	-0.002	-0.002	0.084	0.000	0.000	-0.610	-0.002	-0.004
Petroleum and Gas	0.027	0.154	0.007	0.006	0.118	0.004	0.006	0.036	0.002	0.005
Nonmetallic Mining	0.003	-0.064	0.000	0.000	0.084	0.000	0.001	-0.148	0.000	-0.001
Construction	0.118	0.986	0.115	0.097	0.284	0.032	0.047	0.702	0.083	0.160
Food Products	0.075	0.023	0.001	0.001	0.073	0.005	0.008	-0.050	-0.004	-0.008
Tobacco Products	0.004	-0.235	-0.001	-0.001	0.033	0.000	0.000	-0.268	-0.001	-0.002
Textile Mill Products	0.013	-0.235	-0.002	-0.002	0.031	0.001	0.001	-0.266	-0.002	-0.005
Apparel and Textiles	0.020	-0.191	0.001	0.000	0.063	0.002	0.003	-0.253	-0.002	-0.003
Lumber and Wood	0.015	0.314	0.005	0.004	0.123	0.002	0.003	0.191	0.003	0.005
Furniture and Fixtures	0.008	0.492	0.004	0.003	0.195	0.002	0.002	0.296	0.002	0.005
Paper Products	0.022	0.247	0.006	0.005	0.133	0.003	0.004	0.115	0.003	0.005
Printing and Publishing	0.023	0.794	0.018	0.015	0.408	0.009	0.014	0.386	0.009	0.017
Chemical Products	0.047	0.221	0.011	0.009	0.178	0.009	0.013	0.043	0.002	0.004
Petroleum Refining	0.031	-0.060	-0.002	-0.002	0.015	0.000	0.001	-0.075	-0.002	-0.004
Rubber and Plastic	0.015	0.845	0.013	0.011	0.251	0.004	0.006	0.595	0.009	0.017
Leather Products	0.004	-0.860	-0.002	-0.001	-0.030	0.000	0.001	-0.830	-0.002	-0.004
Stone, Clay, and Glass	0.014	0.195	0.003	0.003	0.150	0.002	0.003	0.045	0.001	0.002
Primary Metals	0.038	-0.075	0.000	0.000	0.055	0.002	0.004	-0.130	-0.003	-0.005
Fabricated Metals	0.035	0.302	0.011	0.009	0.142	0.005	0.007	0.160	0.006	0.012
Industrial Machinery and Equipment	0.048	0.474	0.022	0.019	0.260	0.012	0.019	0.214	0.010	0.019
Electronic and Electric Equipment	0.036	0.575	0.022	0.018	0.305	0.011	0.017	0.270	0.011	0.020
Motor Vehicles	0.041	0.264	0.013	0.011	0.102	0.004	0.007	0.162	0.008	0.016
Other Transportation Equipment	0.026	0.011	0.000	0.000	0.246	0.007	0.010	-0.236	-0.006	-0.012
Instruments	0.017	0.676	0.010	0.009	0.418	0.007	0.010	0.258	0.003	0.006
Miscellaneous Manufacturing	0.007	0.312	0.003	0.002	0.216	0.002	0.003	0.096	0.001	0.002
Transport and Warehouse	0.062	0.640	0.037	0.031	0.303	0.018	0.027	0.338	0.019	0.036
Communications	0.033	0.669	0.021	0.018	0.313	0.011	0.016	0.355	0.011	0.021
Electric Utilities	0.025	0.255	0.006	0.005	0.153	0.004	0.006	0.102	0.002	0.004
Gas Utilities	0.018	-0.013	0.000	0.000	0.032	0.001	0.001	-0.045	-0.001	-0.001
Trade	0.193	0.986	0.189	0.160	0.406	0.078	0.117	0.580	0.112	0.214
FIRE	0.134	0.835	0.110	0.093	0.518	0.070	0.105	0.318	0.040	0.078
Services	0.213	1.887	0.407	0.343	0.955	0.209	0.314	0.932	0.198	0.381
Goverment Enterprises	0.021	0.770	0.016	0.013	0.354	0.007	0.011	0.416	0.008	0.016
Private Households	0.134	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
General Government	0.132	1.246	0.167	0.141	1.014	0.136	0.204	0.232	0.032	0.061
Total			1.19	1.00		0.67	1.00		0.52	1.00

Notes: Industry contribution refers to the share-weighted growth rate of the input in each industry. Contribution to aggregate weights the industry contribution by the Domar-weight. Share of aggregate is the industry contribution to aggregate as a share across industries of the sum of all industry contributions to aggregate.

Table 17: Comparison of J-H-S Manufacturing Productivity Growth to BLS MFP Growth 1959-1999

	Productivity			Labor Quality
	BLS	Adj BLS	J-H-S	J-H-S
Food Products	0.43	0.38	0.69	0.06
Tobacco Products			-1.14	0.11
Textile Mill Products	2.32	2.24	1.49	0.08
Apparel and Textiles	0.85	0.72	1.04	0.13
Lumber and Wood	1.10	0.99	0.15	0.12
Furniture and Fixtures	0.65	0.53	0.88	0.12
Paper Products	0.72	0.58	0.56	0.14
Printing and Publishing	-0.36	-0.56	-0.17	0.20
Chemical Products	0.86	0.77	0.67	0.08
Petroleum Refining	0.34	0.31	0.94	0.03
Rubber and Plastic	0.92	0.82	1.52	0.10
Leather Products			0.24	0.13
Stone, Clay, and Glass	0.74	0.60	0.50	0.14
Primary Metals	0.36	0.28	0.34	0.08
Fabricated Metals	0.28	0.17	0.62	0.10
Industrial Machinery and Equipment	2.31	2.17	2.21	0.15
Electronic and Electric Equipment	3.32	3.17	3.32	0.15
Transportation	0.85			
Motor Vehicles			0.09	0.08
Other Transportation Equipment			0.62	0.17
Instruments	1.38	1.14	1.71	0.24
Miscellaneous Manufacturing	0.73	0.54	0.69	0.20
Correlation with J-H-S Productivity	0.884	0.881		

Notes: BLS productivity from BLS (2000). Adjusted BLS subtracts estimates of J-H-S labor quality contribution from Table 6. J-H-S productivity growth from Table 11.

Figure 1: Sources of U.S. Economic Growth

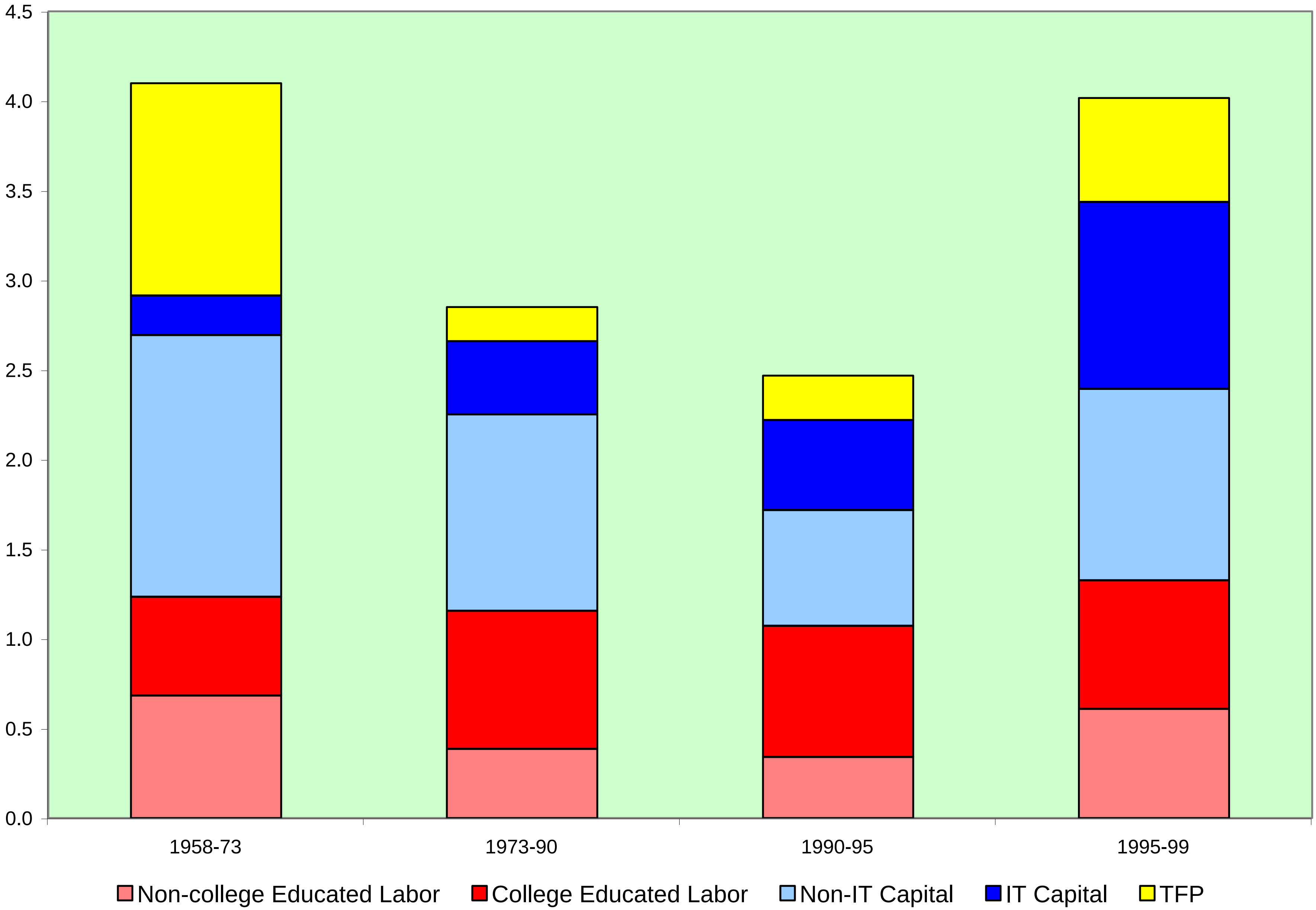


Figure 2: Sources of U.S. Labor Productivity Growth

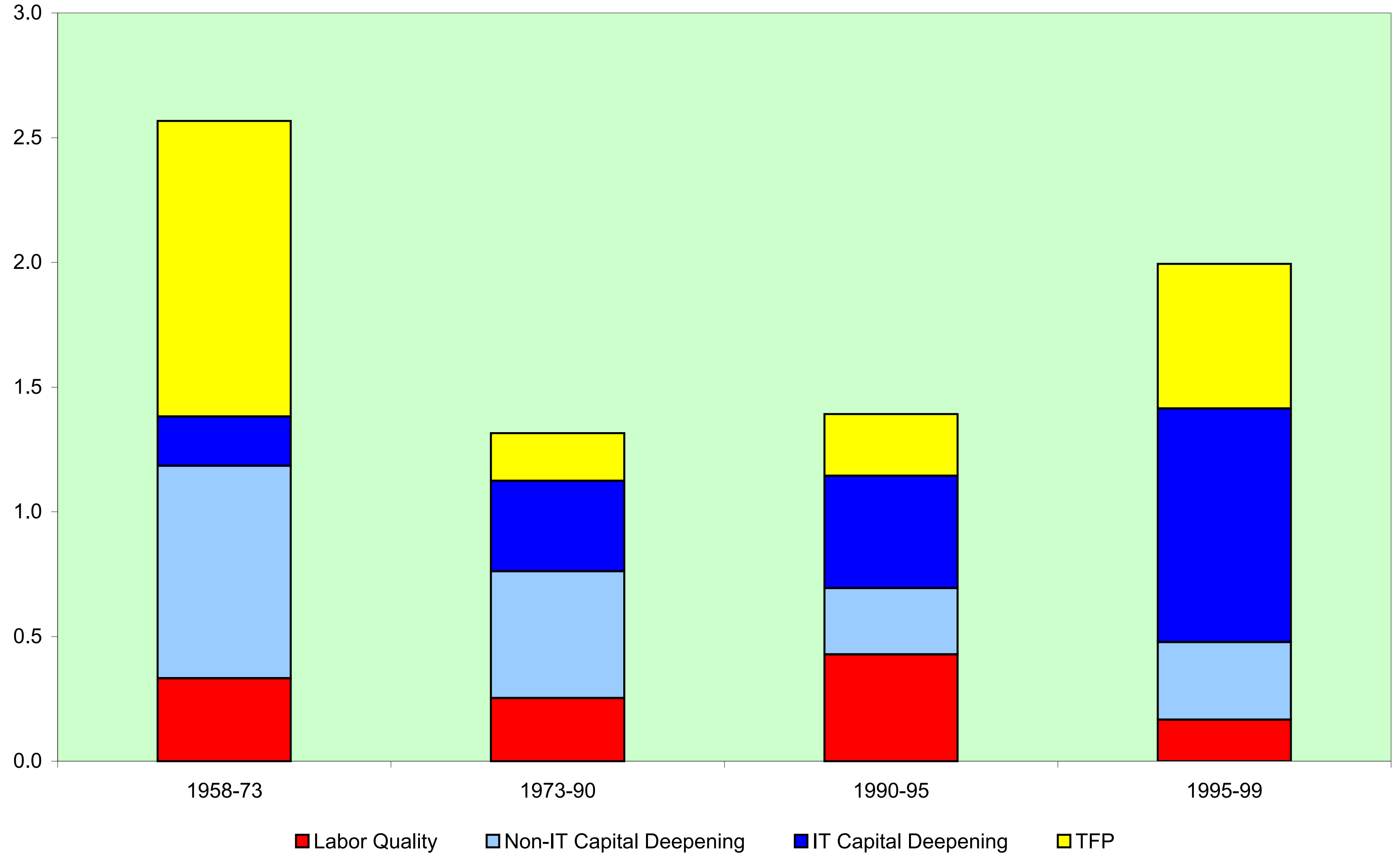


Figure 3: Sources of U.S. TFP Growth

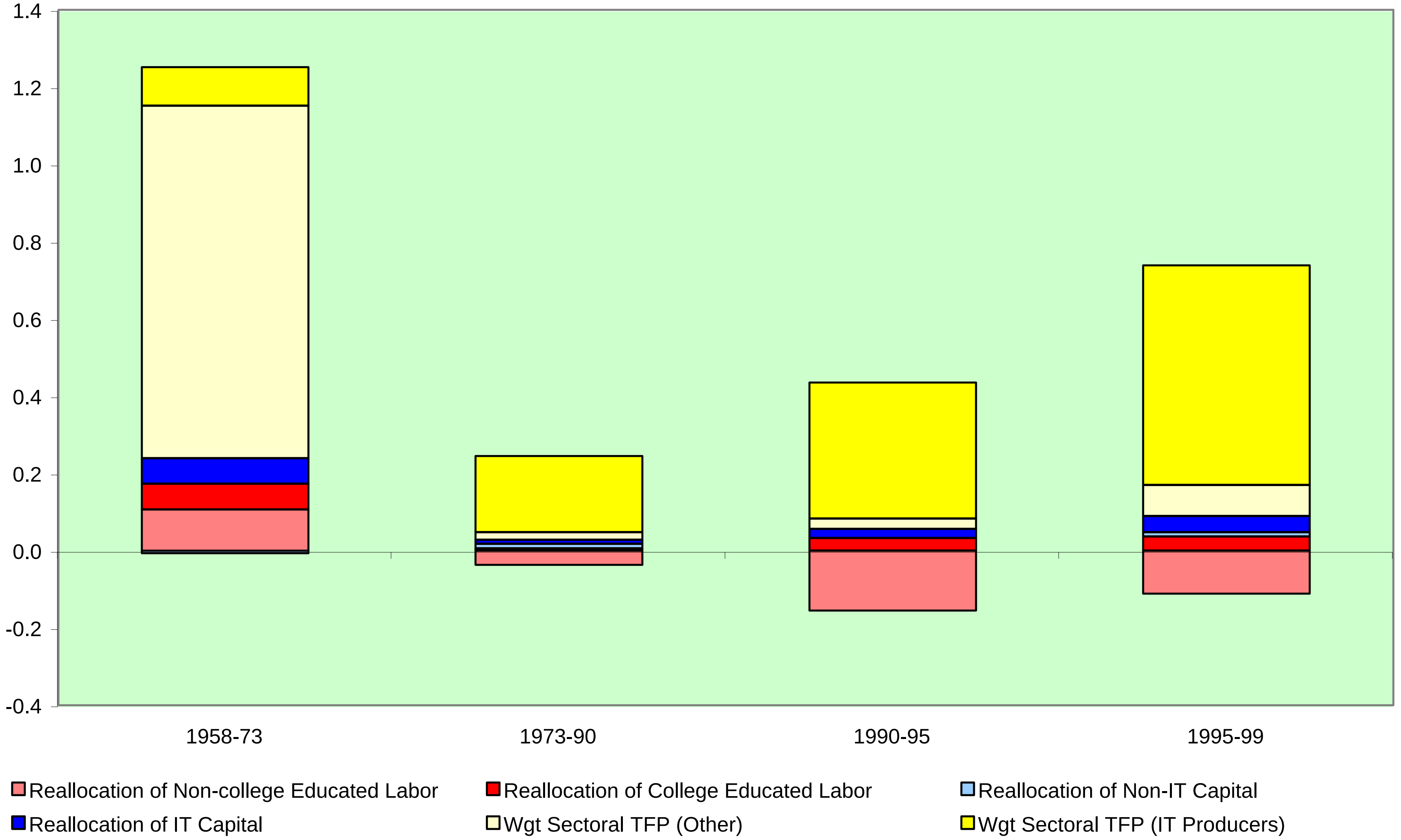


Figure 4: Industry Hours and Labor Productivity Growth, 1958-1999

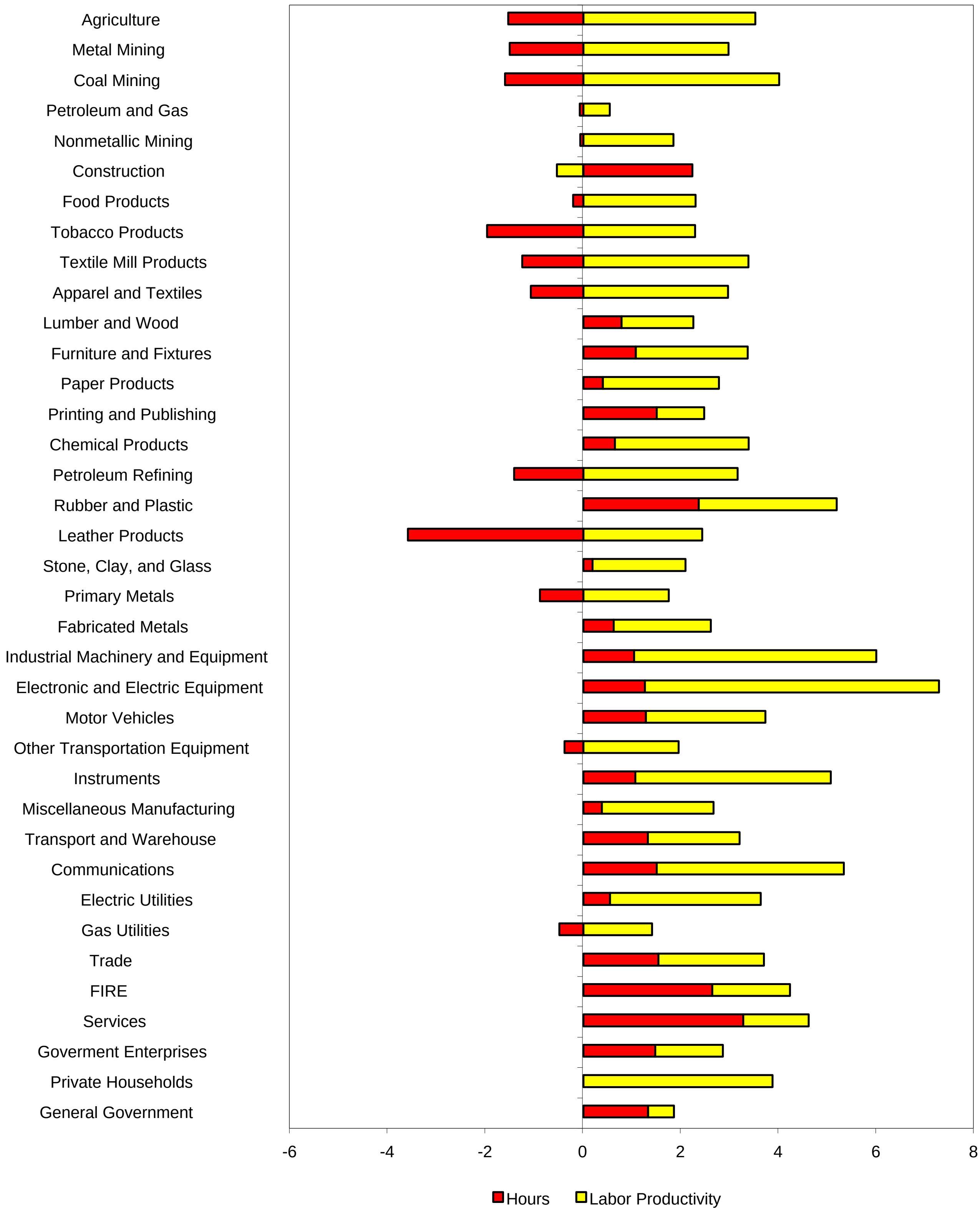


Figure 5: Sources of Growth in Industry Output, 1958-1999

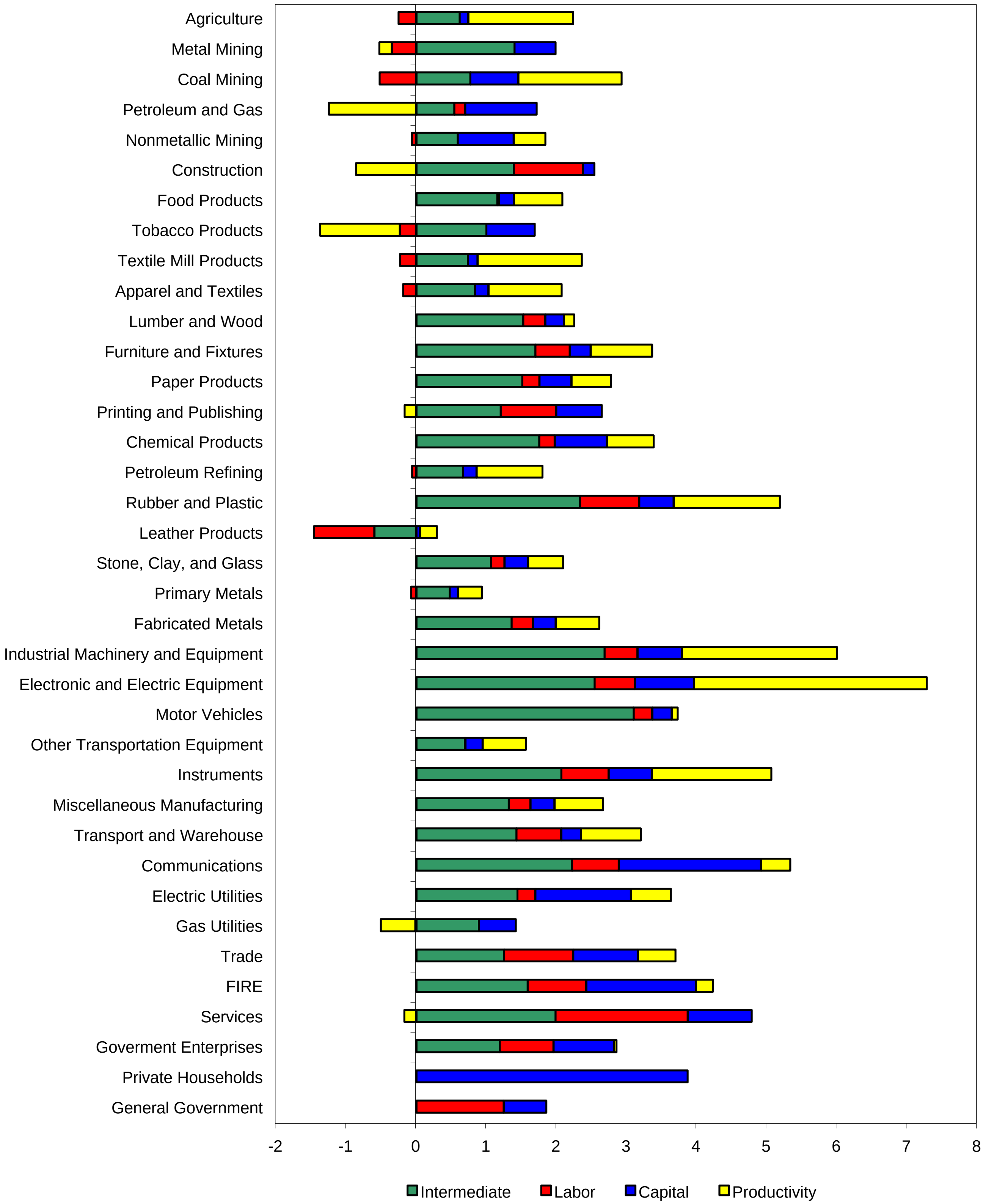


Figure 6: Sources of Growth in Industry Labor Productivity, 1958-1999

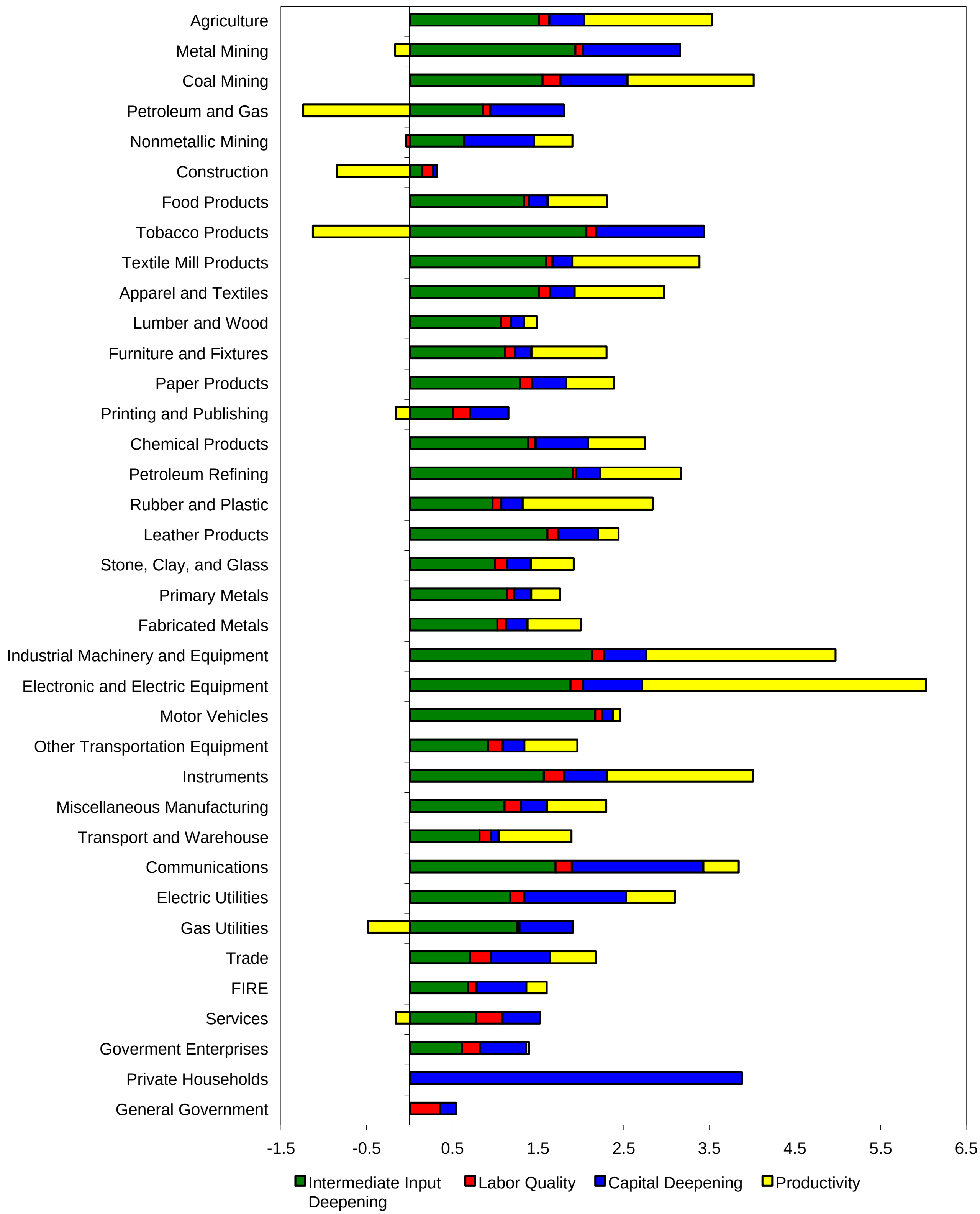


Figure 7: Growth of Industry Output by Sub-Period

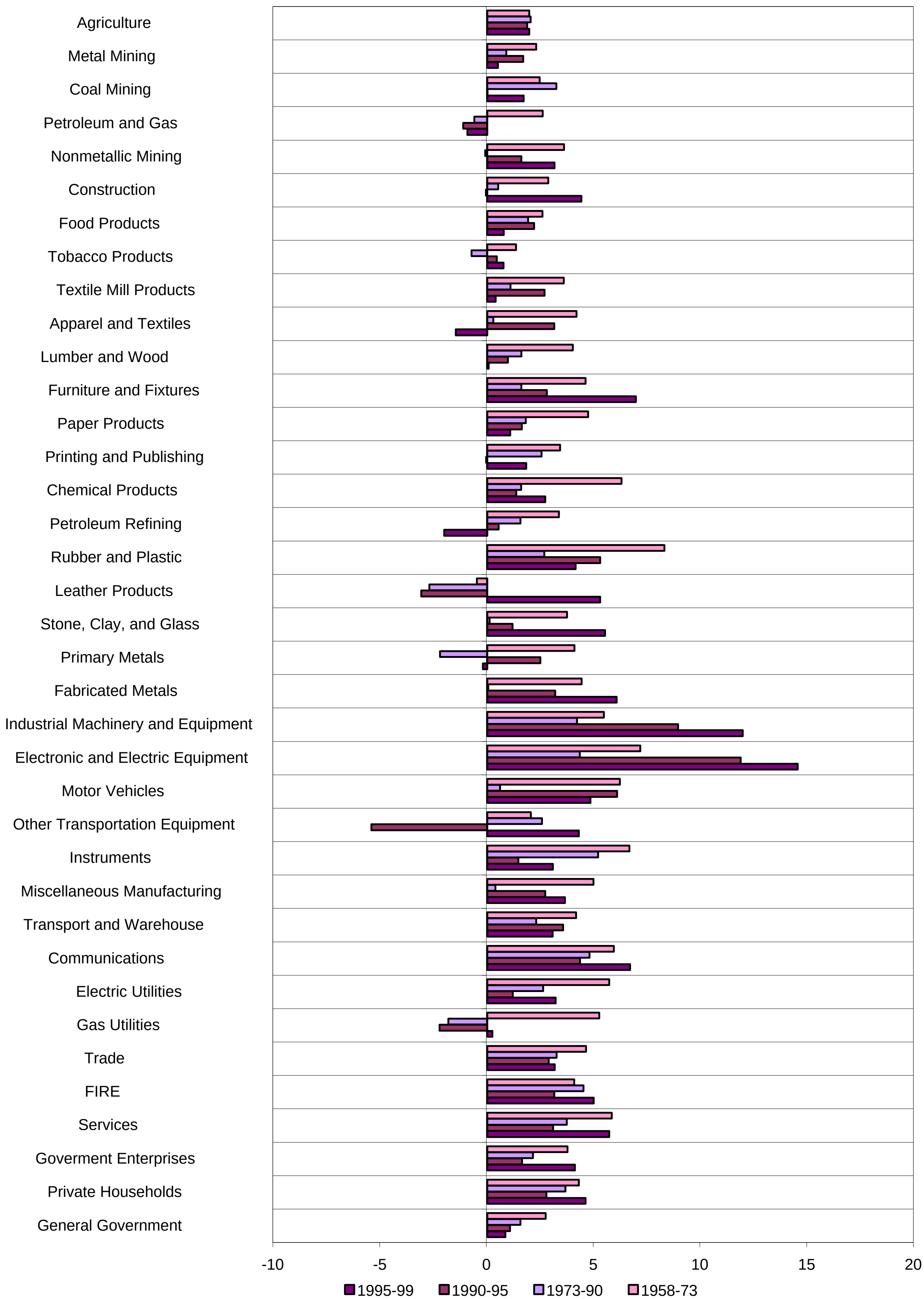
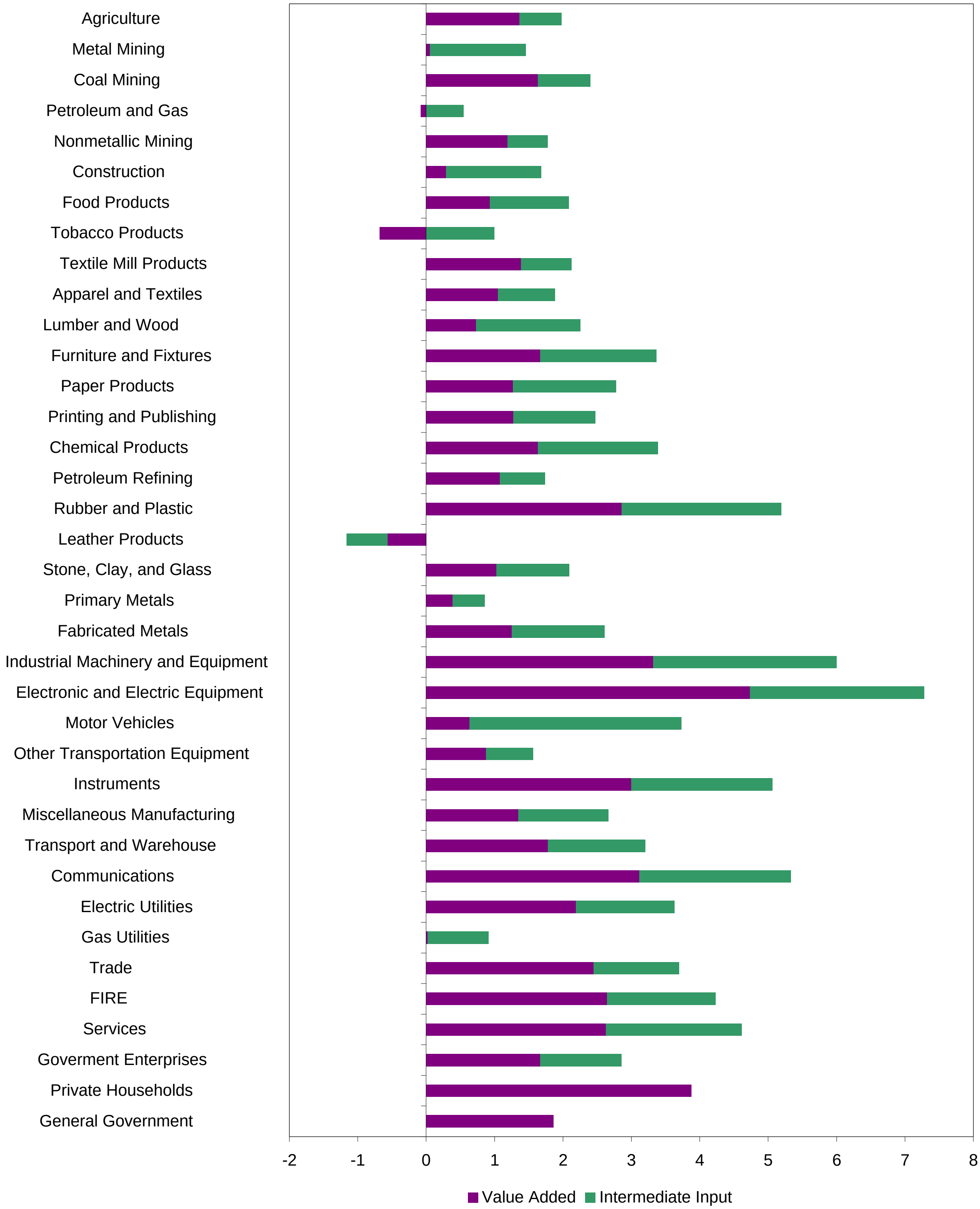
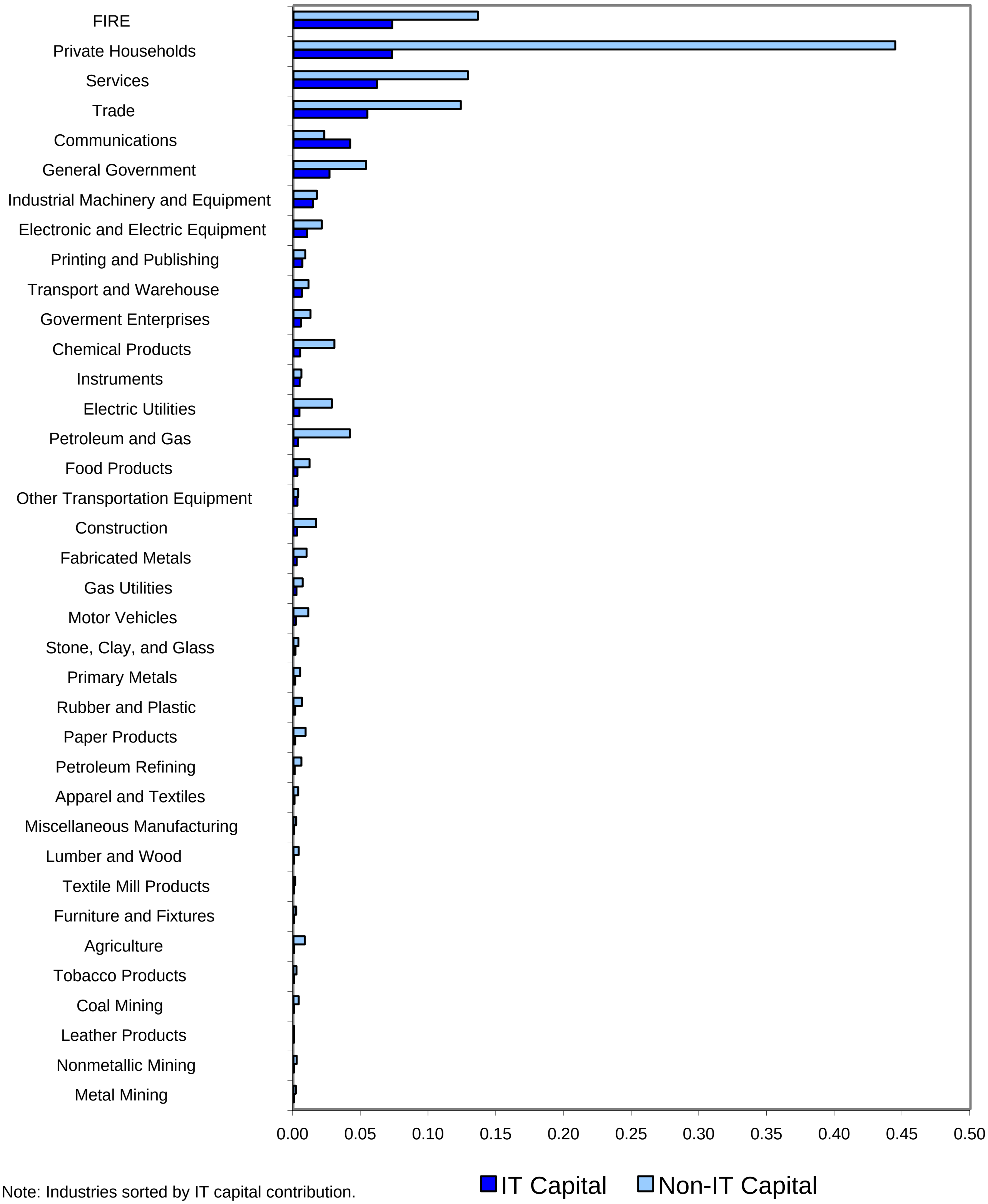


Figure 8: Value-Added and Intermediate Contributions to Output Growth, 1958-1999



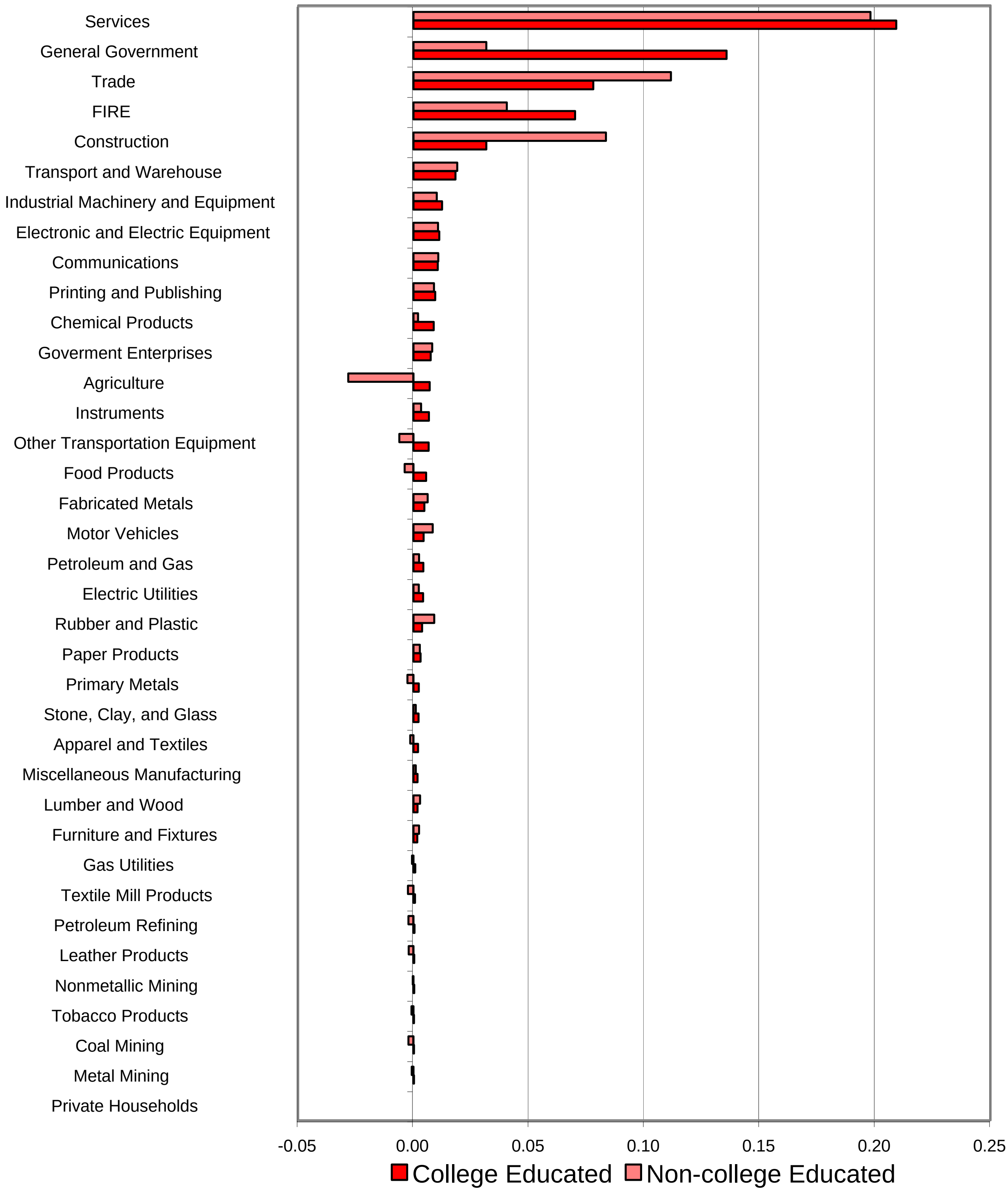
Contribution of value-added includes capital, labor, and

Figure 9: Domar-Weighted Contributions of Capital Input, 1958-1999



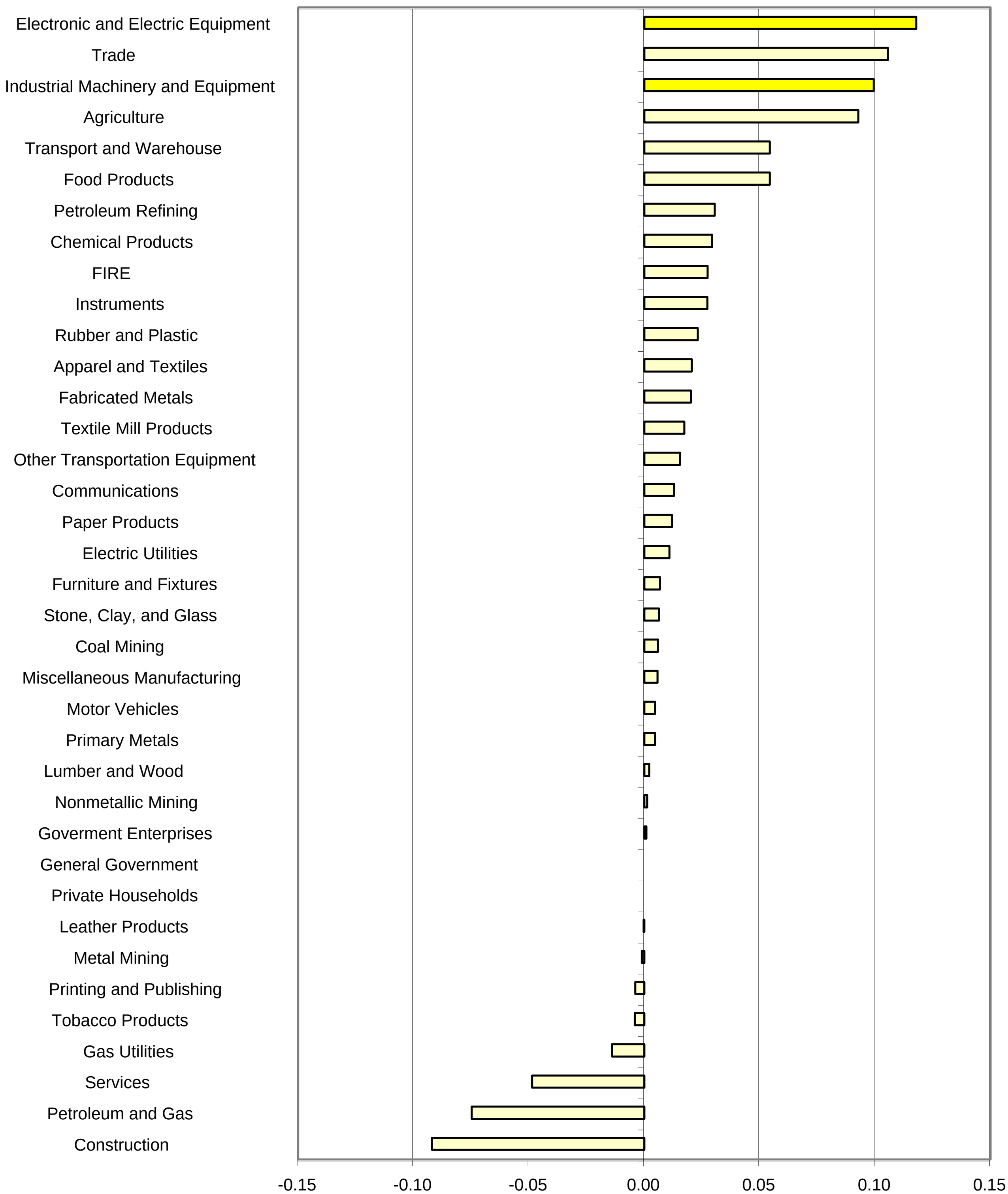
Note: Industries sorted by IT capital contribution.

Figure 10: Domar-Weighted Contributions of Labor Input, 1958-1999



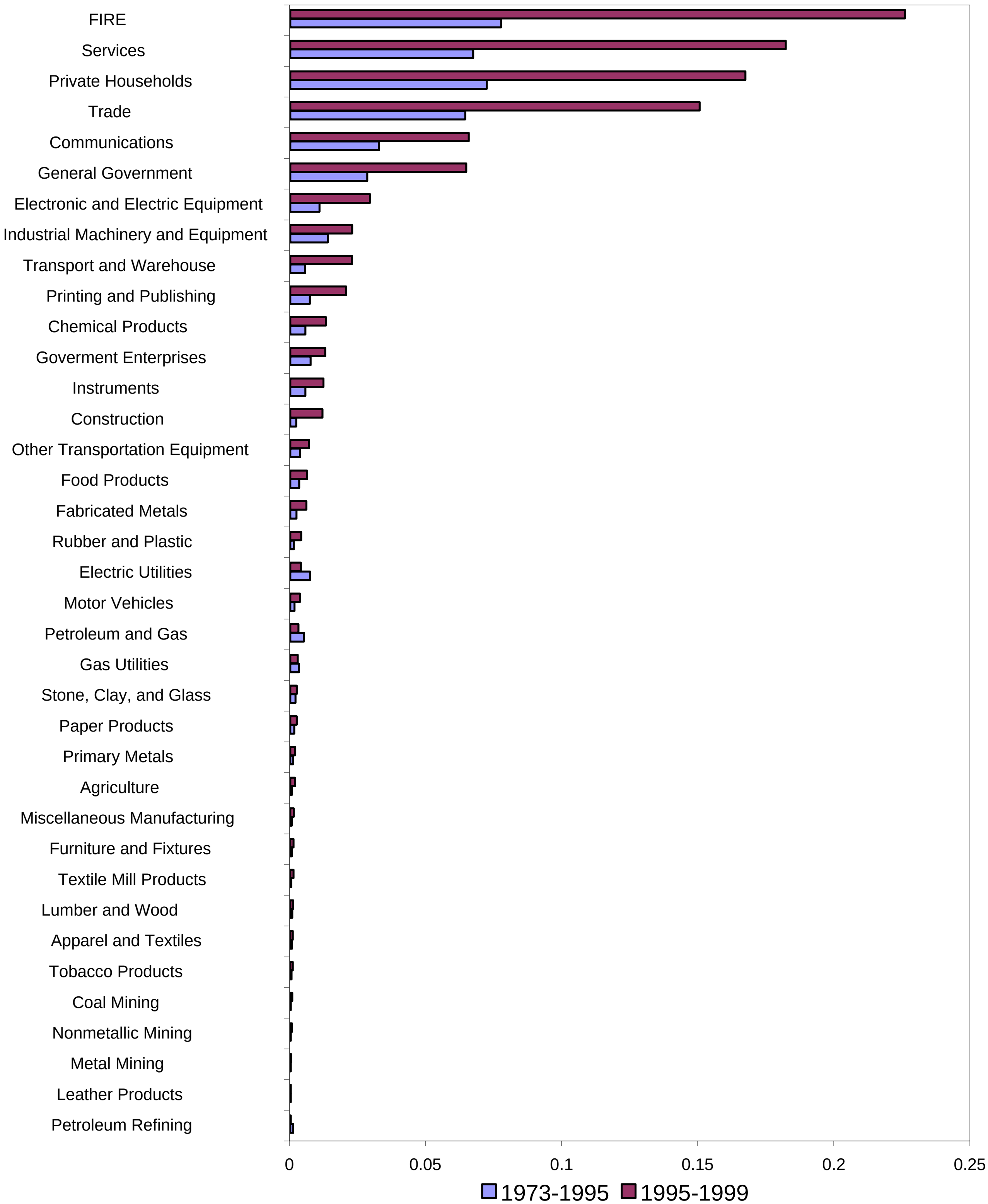
Note: Industries sorted by college educated contribution.

Figure 11: Domar-Weighted Contributions of Productivity, 1958-1999



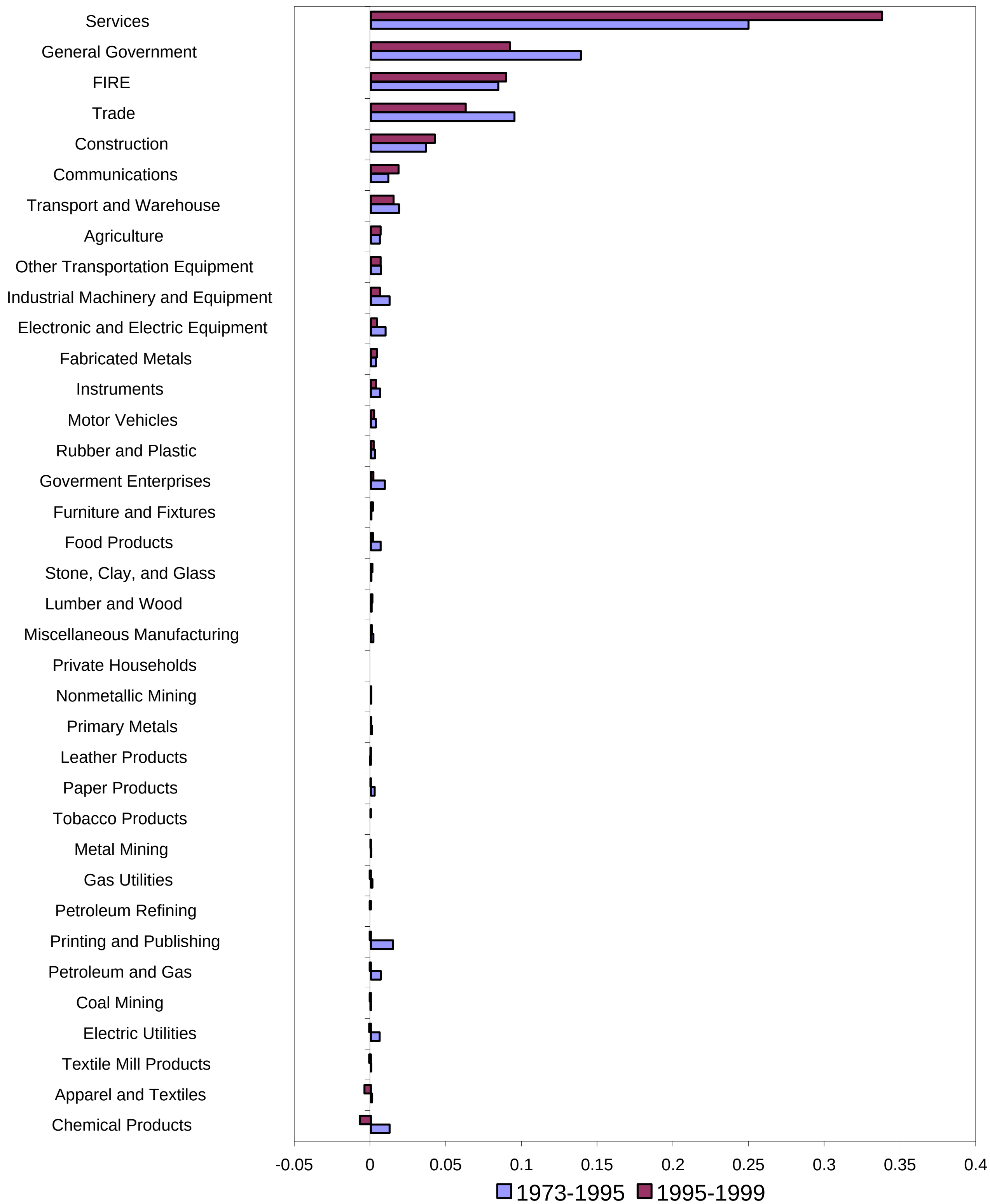
Note: Industries sorted by productivity contribution.

Figure 12: Domar-Weighted Contributions of IT Capital 1995-1999 versus 1973-1995



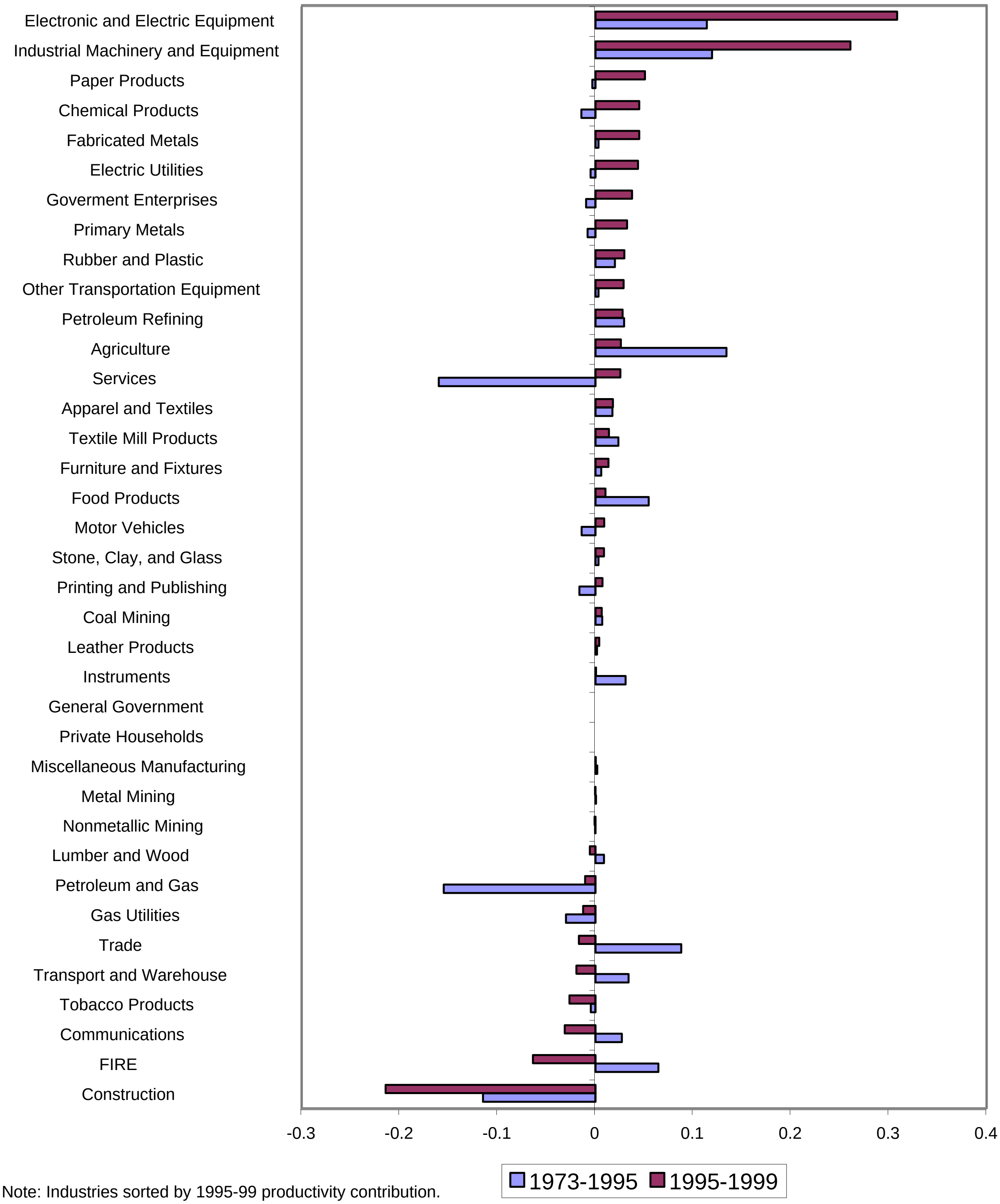
Note: Industries sorted by 1995-99 IT capital contribution.

Figure 13: Domar-weighted Contributions of College Educated Labor 1995-1999 versus 1973-1995



Note: Industries sorted boy 1995-99 college educated contribution.

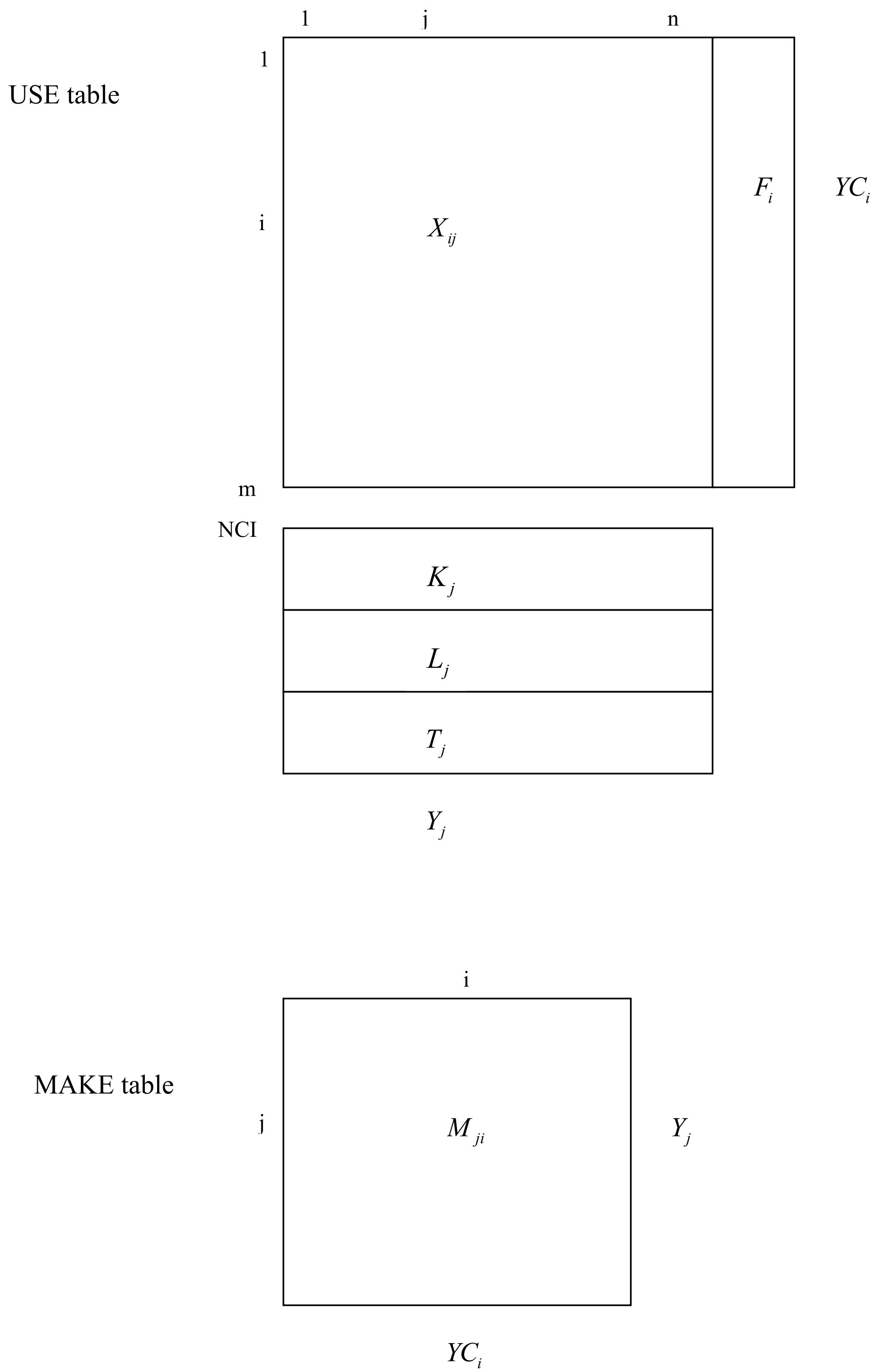
Figure 14: Domar-Weighted Productivity Contributions 1995-1999 versus 1973-1995



Note: Industries sorted by 1995-99 productivity contribution.

Appendix Table 1. Classification of civilian labor force

Sex	Male; Female
Class	Employees; Self-employed and unpaid
Age	16-17; 18-24; 25-34; 35-44; 45-54; 55-64; 65+
Education	
1980-92	0-8 years grade school; 1-3 years High School; 4 years High School;
	1-3 years College; 4+ years College
1980-92	0-8 years grade school; 1-3 years High School; 4 years High School;
	1-3 years College; 4 years College; 5+ years College
1992+	0-8 years grade school; grade 9-12 no diploma; High School graduate
	some College no BA; Bachelors degree; more than BA degree
Industry	(51 2-digit industries)



Appendix Figure 1. Use and Make input output tables.