

**Where did the Productivity Growth Go?  
Inflation Dynamics and the Distribution of Income\***

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## ABSTRACT

A basic tenet of economic science is that productivity growth is the source of growth in real income per capita. But our results raise doubts. This paper creates a direct link between macro productivity growth and the evolution of the income distribution at the micro level. Our most surprising result is that over the entire period 1966-2001, as well as over 1997-2001, *only the top 10 percent of the income distribution enjoyed a growth rate of real wage and salary income equal to or above the average rate of economy-wide productivity growth.* Growing inequality is not just a matter of the rich having more capital income; the increasing skewness in wage and salary income is what drives our results.

As fascinating as are the micro data conclusions of this paper, the macro analysis provides an important advance along several dimensions in the longstanding literature on inflation and wage dynamics. An acceleration or deceleration of the productivity growth trend alters the inflation rate by at least one-for-one in the opposite direction. Our “mainstream” inflation equation is extremely stable and easily passes Chow tests for instability more than two decades after it was originally specified. We provide strong evidence that the slope of the Phillips curve has *not* shifted, and that any such conclusion claimed by other researchers is based on fitting naive equations with missing lags and missing supply shock variables.

This paper revives research on wage adjustment. Rather than interpreting price and wage equations separately, they are specified to allow joint feedback between price and wage equations and to produce a model that explains movements of labor’s share of income in terms of variables known to explain wages and prices, including the change in the productivity growth trend. This motivates a possible explanation for the rise in labor’s share in the 1960’s, and the fall over the past 4 years.

The paper concludes with a review of issues related to income mobility, consumption inequality, and the sources of growing income inequality. We argue that economists in their explanations of growing income inequality have placed too much emphasis on “skill-biased technical change” and too little attention to the “economics of superstars,” i.e., the pure rents earned by the top CEOs, sports stars, and entertainment stars. This source of divergence at the top, combined with the role of deunionization, immigration, and free trade in pushing down incomes at the bottom, have led to the wide divergence between the growth rates of productivity, average compensation, and median compensation.

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“Workers have been so cowed by an environment in which they are so obviously dispensable that they have been afraid to ask for the raises they deserve, or for their share of the money derived from the remarkable increases in worker productivity over the past few years.”

– Bob Herbert (2005)

“There is no question that a huge gap has opened up between productivity and living standards . . . . Not since World War II have productivity and income diverged so sharply.”

– Louis Uchitelle (2005)

### I. Introduction

The first half of the current decade offers an unprecedented dichotomy of macroeconomic glow and gloom. The 2001 U. S. recession was so mild that the four-quarter growth rate of real GDP never turned negative; output growth since 2001 has been sufficient to widen the gap significantly between American and European per-capita income; and inflation has remained sufficiently tame to allow the Fed to cut short-term real interest rates to negative values for an unprecedented length of time.<sup>1</sup> The primary source of this benign macroeconomic environment, so envied by other rich nations, was the 2001-04 explosion in U. S. labor productivity growth. Any statistical representation of the underlying productivity growth trend in 2003-04 reached growth rates that exceeded 3 percent per year, higher than registered by similar statistical trends for any earlier sub-period of the postwar era, even the previous record rates achieved in the Kennedy Administration years of the early 1960s.

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1. Using 2.0 percent per year as a rough measure of expected inflation, the real Federal Funds rate was negative for three straight years between late 2001 and late 2004.

Yet who received the benefits of this productivity growth explosion? Median family income fell by 3.8 percent from 1999 to 2004 and grew cumulatively from 1995 to 2004 at an annual rate of only 0.9 percent per year, much slower than the growth rate of nonfarm private business (NFPB) output per hour over the same period of 2.9 percent.<sup>2</sup> Similarly, the median real wage for all workers grew over 1995-2003 at 1.4 percent per year, less than half the rate of productivity growth.<sup>3</sup> Not only did median real incomes and wages fail to come close to the gains in productivity, but jobs at any wage were hard to find. Total payroll employment in July 2005 was only 0.9 percent above its previous peak in February, 2001. The unemployment rate at 5.0 percent in July, 2005 seemed low by historical standards but was held down by a drop in the labor force participation rate from 67.1 percent in 2000 to 66.1 percent in June, 2005, a result of a substantial “discouraged worker” effect of people, especially young people, unable to find jobs.<sup>4</sup>

The failure of the productivity growth revival proportionately to boost the real incomes and wages of the median family and median worker calls into question the standard view that productivity growth translates automatically into rising living standards, as in this quote from Paul Krugman (1990, p. 9), commenting on the pre-1995 period of slow productivity growth:

Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability

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2. Mishel *et. al.* (2005), Table 1.1, p. 42. Median household income updated from 2003 to 2004 from Leonhardt (2005).

3. Mishel *et. al.* (2005), Table 2.6, p. 122. Measures of real income and real wages from this source deflate nominal values by the CPI-U-RS back to 1978.

4. The labor-force participation rate of those aged 16-24 declined from 65.8 percent in the year 2000 to 61.1 percent in July, 2005.

to raise its output per worker . . . the essential arithmetic says that long-term growth in living standards . . . depends almost entirely on productivity growth.

This paper should be read in the spirit of a detective novel, “The Case of the Missing Productivity – Where Did It Go?” By definition, if the share of labor income in total income is constant, then growth in labor productivity (real income per hour) must be equal to growth in real labor compensation per hour. A constant income share of labor implies that an acceleration in productivity growth as occurred after 1995 must show up in some combination of a slowdown of the inflation rate and a speedup in growth of nominal labor compensation sufficient in combination to raise the growth rate of real compensation per hour growth by the same proportion by which productivity growth has increased. If real compensation does not respond in proportion, then by definition labor’s share must decline and the benefits of the faster rate of productivity growth must spill over disproportionately to real nonlabor income per hour, i.e., corporate profits.

But our topic goes far beyond the dry facts of labor compensation per hour as opposed to productivity growth in the macro data. This paper is unique in its interplay of macro and micro questions and data. Even if labor’s share of income in the macro data was constant, who actually earned that labor income? The micro data tell a shocking story of gains accruing disproportionately to the top one percent and 0.1 percent of the income distribution. The median Federal taxpayer has hardly had any real income gain at all over the full span of the IRS micro tax data covering 1966 to 2001! How could the macro and micro data on labor income be so “out of synch” in the U. S. economy over the entire period since the 1960s?

## Macro and Micro

Our detective story is divided into two parts, macro and micro. The macro part asks how the post-1995 productivity growth acceleration enters into the econometrics of price and wage dynamics. In past incarnations of dynamic Phillips curves, productivity growth has been a minor side show if mentioned at all, and much of the recent Phillips curve literature examines reduced-form inflation equations that exclude wages entirely. In the subset of the older literature that enters the wage rate into the price equation, traditionally wages would enter divided through by the productivity trend, with the ratio of the wage rate to trend productivity defined as “trend unit labor cost.” In this framework faster productivity growth would indirectly hold down trend unit labor cost and thus reduce inflation unless and until nominal wage growth was pushed up by the same amount as productivity growth. Any lag of wage adjustment behind the productivity growth acceleration would cause labor’s share to decline and cause the non-labor, i.e., profit, share to increase.

The macro part of the paper provides a new look at econometric inflation dynamics in order to assess the causes of low inflation in the decade after 1995. In light of high demand in the late 1990s, why was inflation so low? What role was played by the revival of trend productivity growth as contrasted to other sources of beneficial supply shocks? Our analysis is not just about the past decade, but represents an attempt to provide a consistent interpretation over the entire interval since the early 1960s. What role did the productivity growth slowdown of 1965-79 play in creating high inflation in the 1970s?

We find that, while changes in the productivity trend have a strong and consistent role in the reduced-form inflation equation when wage feedback is omitted, the response of wage changes to productivity trend changes is much murkier. Wage equations are not as stable in post-sample simulations as the reduced-form inflation equations. Puzzles about the responses of wages have their counterpart in differences between model-simulated changes in the labor and profit shares as compared to the behavior of these shares in the data.

Some of these puzzles may involve the significant discrepancy in the time series behavior of the two leading macro indexes of wage changes, the employment cost index (ECI) and the BLS quarterly index of compensation per hour (CPH). While the CPH is by construction consistent with the behavior of labor's income share in the national accounts (NIPA), the ECI is not. CPH growth rose rapidly in the late 1990s, even faster than the productivity trend, so trend unit labor cost changes increased, whereas trend unit labor cost based on the ECI slowed markedly.

Two sets of puzzles bring us to the micro section of the detective story. First is the conflict between rising productivity and *average* compensation growth with the relative stagnation of *median* real household income and real wages. Second is the conflict between the CPH and ECI. A possible resolution to both puzzles is that a disproportionate part of measured labor compensation in the past decade has gone to the top part of the income distribution, e.g., the top 1 percent or top 10 percent, accounting for the stagnation of real gains for the median household and median worker. Similarly, outsized gains at the top would explain why the ECI,

a fixed-weighted market-basket of wage rates, would lag behind any measure of average compensation that is pushed up by extreme skewness toward the top wage and salary earners.

The micro section of the paper examines the behavior of labor and non-labor income as recorded in the IRS micro data files of the Statistics of Income covering the years 1966-2001. The total amounts of real labor income change can be compared between the NIPA and IRS sources, and then the IRS micro files can be used to determine how much of the real income gain over various periods, e.g., 1966-2001 or 1997-2001, accrue to the median taxpayer and to those at the 20, 80, 90, 95, 99, and 99.9 percentiles. While the NIPA data on non-labor income cannot be so neatly linked to IRS data on non-labor income, we analyze the IRS micro data to determine the distribution of real income gains for non-labor income and total income, not just for labor income.

Taken together, the macro and micro parts of our detective story allow us to allocate the cumulative increase in real GDP attributable to the post-1995 acceleration in productivity growth. The macro section allows us to determine how much of the cumulative increase was broadly allocated to all income groups through lower inflation, how much went to nominal labor income, and how much went to nominal non-labor income. The micro section allows us to look within the increased amount of real labor income to determine how much went to the top, middle, and bottom of the income distribution. In the end, we find that only the top 10 percent of taxpayers had gains in real labor income per hour or in total income per hour that kept pace with productivity growth over either the 1966-2001 or 1997-2001 periods.



### Plan of the Paper

The paper begins in Part II with a simple model that introduces notation and assigns parameter values that can produce any mix of three extreme responses of the macroeconomy to a change in trend productivity growth, namely entirely a response of the inflation rate, entirely nominal labor income, or entirely profit income. Part III provides an introduction to the macro data, examining the behavior of labor's share, and the relative growth rates of productivity and different components of real and nominal income over the postwar period. Then in Part IV we begin the macro section with the econometric specification of what Gordon (1982, 1998) has previously called the "mainstream" model determining price and wage changes, including the role of trend unit labor cost in transmitting wage changes to price changes and vice-versa. Estimates of the reduced-form inflation equation (which omits wages) are presented in a form that allows an estimate of the direct impact of changes in the productivity growth trend. The reduced form equation is evaluated in dynamic simulations, is tested for structural stability, and is compared to simpler approaches containing fewer variables and shorter lag lengths.

Part V examines the econometric determination of wage changes, with a primary focus on the channels by which an acceleration in wage changes, trend productivity growth, and trend unit labor cost feed back to the inflation rate, and symmetrically how inflation affects wage changes. This section uncovers anomalies in the behavior of the wage determination process. Nevertheless, simulations of the two-equation price-wage model with fully endogenous feedback delivers reasonable simulation errors and plausible counterfactual effects

of the 1965-80 productivity slowdown and 1995-2005 productivity revival on inflation, trend unit labor cost, and trend labor's share.

Part VI contains the micro section of the paper based on a new analysis that creates aggregates and percentile slices of IRS micro data files and compares them with NIPA aggregates. We take each IRS aggregate, restate it on a per-taxpayer basis, and look at levels and growth rates across quantiles ranging from 0-20 to 99.9-100. We can subdivide growth in real labor and in real total income across any time interval into the share earned by each subgroup of the income distribution. Part VII discusses questions posed by the micro analysis. Does income mobility dilute the meaning of median income? Has inequality in consumption spending remained flat, somehow avoiding the marked increase of income equality? Finally, what are the leading explanations of the marked increase of income inequality? Part VIII concludes.

## **II. A Simple Model of Responses to a Change in Trend Productivity Growth**

We begin by introducing the identities that link the level and growth rate of labor productivity with the shares of labor and non-labor income. We then develop a simple dynamic model that determines the response of price and wage changes to changes in productivity growth. This allows us to explore a set of possible outcomes following an acceleration or deceleration in trend productivity growth. Our exploration of the model shows how a mix of outcomes could emerge from plausible parameters. The productivity trend acceleration might

affect inflation, wage change, and profit change with different alternative dynamic adjustment paths.

Our initial focus is on the relationship between labor's share and productivity, both levels and growth rates. Henceforth we will define labor productivity, or output per hour ( $Y/H$ ) by  $\Theta$ . Nominal GDP ( $PY$ ) is the GDP deflator ( $P$ ) times real GDP ( $Y$ ). Total labor compensation ( $WH$ ) equals nominal hourly labor compensation ( $W$ ) times the aggregate number of hours of labor input ( $H$ ). Labor's share is thus defined as

$$S = (WH)/(PY) = (W/P)/\Theta \quad (1)$$

The remaining share of nominal GDP ( $PY$ ) goes to non-labor income, including corporate profits, proprietors' income, rent, and interest. The aggregate of nominal corporate profits ( $RK$ ) is the rate of return on corporate capital ( $R$ ) times the nominal value of corporate capital ( $K$ ). Taking into account the residual value of nominal non-labor non-profit income ( $I$ ), the non-labor share can be written:

$$1-S = RK/PY + I/PY = 1 - (W/P)/\Theta \quad (2)$$

We use lower case letters for the corresponding logarithmic growth rates of labor productivity and of labor's share:

$$\theta = y - h \quad (3)$$

$$s = w - p - \theta \quad (4)$$

In a steady state where the level of labor's share is fixed, productivity growth must equal real wage growth, i.e. if productivity growth accelerates then there must be some combination of

accelerating nominal wage growth and declining inflation. If the acceleration in real wage growth falls short of the acceleration in productivity growth, then the growth rate of labor's share ( $s$ ) is negative ( $s < 0$ ) and the growth rate of the non-labor share is positive. The *level* of labor's share ( $S$ ) falls and the level of the non-labor share ( $1-S$ ) rises.

We assume that in equilibrium, when productivity growth is fully anticipated, labor's share is constant ( $s=0$ ).<sup>5</sup> The dynamic effect of a productivity shock then can be modeled with a simple system of equations describing the paths of prices and wages.

Suppose prices and wages both depend only on their own lagged values and a shock to the productivity growth rate ( $\theta$ ). Assume all agents set wages and prices based on their expectations for productivity growth. We begin by modeling their expectations with a simple backward looking rule where the respective growth rates of expected productivity change, wage change, and price change all equal the first lagged value of the actual series,  $\theta^e_t = \theta_{t-1}$ ,  $p^e_t = p_{t-1}$ , and  $w^e_t = w_{t-1}$ , and  $L$  is the lag operator. The dependence of prices and wages on shocks to the productivity growth rate is motivated from a wage aspiration perspective, in the sense that workers' wage demands do not react immediately to changes in productivity.<sup>6</sup>

$$p_t = p_{t-1} - a(L)(\theta_t - \theta_{t-1}) \tag{5}$$

$$w_t = w_{t-1} + b(L)(\theta_t - \theta_{t-1}) \tag{6}$$

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5. Thus we are implicitly assuming a Cobb-Douglas technology.

6. See Ball and Moffitt (2001)

In order to capture the stylized fact that labor's share stays constant over long periods of time, we could temporarily impose the constraint that the  $a$  coefficients plus the  $b$  coefficients equal unity. This implies a simple law of motion for the growth rate ( $s$ ) of labor's share:

$$s_t = s_{t-1} + (a+b)(L)(\theta_t - \theta_{t-1}) - (\theta_t - \theta_{t-1}) \quad (7)$$

Now we have the tools necessary to model a permanent one percent rise in productivity growth. In reaction to such a hypothetical change in the rate of productivity growth, wage growth and price growth will shift over the length of the lag terms summarized by the lag operator ( $L$ ). The permanent changes in the growth rates of wages and prices will equal the sums of the coefficients on the productivity shock multiplied by the value of the shock. With our constraint that  $a+b = 1$ , this implies labor's share will end up with a zero growth rate again. If, over time, the  $\theta$  shocks are just as often positive as they are negative, labor's share will tend to be constant. Notice that without the constraint on the productivity shock coefficients, any productivity shock would cause a permanent change in the growth rate of labor's share of income.

In order to find the change in the level of labor's share, we need to know the structure of the coefficients on the lags of the productivity shock. Suppose for the sake of simplicity that  $a(L)$  in equation (5) equals zero – a productivity shock only affects wages – and that the productivity shock enters the wage equation for four periods, with a coefficient of 0.25 in each period. Then if there is a one percent increase in the productivity growth rate, wage growth will increase by a quarter percentage point for four periods, and in the first three periods will be

growing slower than productivity, implying that  $s$  is negative. Given this structure of coefficients, an unexpected acceleration in productivity growth will permanently *reduce* the level of labor's share, and a productivity deceleration (such as that which occurred during 1965-79) will *raise* it.

On the other hand,  $b(L)$  could equal zero and productivity could feed entirely into prices. The outcome of this alternative case would be identical to the case analyzed above, in that if the shock enters for four periods, prices will not decelerate rapidly enough for real wages to keep up with productivity. Again, for three periods the growth rate of labor's share ( $s$ ) would be negative, and in the fourth period it would reach a new equilibrium at a lower level of  $S$ .

The two cases outlined so far assume that eventually wages and prices shift so that labor's share moves to a stable equilibrium. It is possible, though, that productivity has no effect on either prices or wages, and feeds entirely into corporate profits. That would be the case where both  $a(L)$  and  $b(L)$  equal zero. An increase in trend productivity growth then leads to a permanent decline in the *growth rate* of labor's share ( $s$ ). If  $s$  starts at zero and productivity growth accelerates by one percentage point, the law of motion for  $s$  shows that  $s$  will move to negative one ( $s = -1$ ) permanently, an implausible outcome, since it would cause the level of labor's share ( $S$ ) to reach zero within a finite number of years.

The result that labor's share is unstable after any productivity shock occurs for any values of  $a(L)$  and  $b(L)$  whose sum is not unity. Labor's share is clearly stable, though, in the

national income accounts (NIPA) data that we will examine in the next section of the paper. In order to account for this feature of the real world, a feedback term can be added to the model. The rate of change of both prices and wages may both react to the lagged change in labor's share:

$$p_t = p_{t-1} - a(L)(\theta_t - \theta_{t-1}) + cs_{t-1} \quad (8)$$

$$w_t = w_{t-1} + b(L)(\theta_t - \theta_{t-1}) - ds_{t-1} \quad (9)$$

Independent of the size of the “ $a$ ” coefficient in the inflation equation (8), an increase in productivity growth that causes a negative growth rate in labor's share ( $s$ ) would create a positive response in the inflation rate, i.e., the inflation rate would decline. Similarly, independent of the size of the “ $b$ ” coefficient in the wage change equation (9), an increase in productivity growth would create a negative response in the rate of wage change, i.e., the rate of wage change would increase. The feedback terms represented by the coefficients  $c$  and  $d$  are more general than the  $a$  and  $b$  coefficients, since they would apply even in the absence of a change in productivity growth. They imply that any autonomous jump in the rate of wage change that increases labor's share would create extra inflation in equation (8) and would tend to reduce future wage changes in equation (9). The inclusion of the “ $s$ ” feedback term in equations (8) and (9), as we will see below, makes the change in labor's share an independent source of changes in the inflation rate, analogous to the other supply shocks that appear in our general model of inflation dynamics discussed below in Part IV of this paper.

The adjustment hypothesis summarized in equations (8) and (9) implies a new law of motion for  $s$ :

$$s_t = (1-c-d)s_{t-1} + (a+b)(L)(\theta_t - \theta_{t-1}) - (\theta_t - \theta_{t-1}) \quad (10)$$

If a negative shift in labor's share should occur, caused by the initial effects of an increase in productivity growth, this should cause the growth rate  $s$  to become positive in the next period if  $c+d < 1$ .

Equations (8), (9) and (10) give a concise summary of the response of prices, wages, and labor's share to changes in trend productivity growth. Most importantly, it is clear that the price and wage equations play equal roles in equation (10). If productivity affects only prices, i.e.  $b=0$ , labor's share will be affected in exactly the same way as if  $a=0$  and only wages react to productivity shocks. Additionally, if  $1-c-d$  is between plus and minus one, equation (10) will be stable, and labor's share will always reach a level equilibrium. In other words, the situation described where a shock causes a permanent fall in  $s$ , cannot occur within this framework;  $s$  will always eventually reach zero. All of the coefficients in equation (10) are easily estimated in the context of standard Phillips curve models, and estimated real-world price and wages equations will be manipulated exactly as above to produce an equation for labor's share analogous to equation (10).



### III. Issues Raised by Macro Data on Productivity and Labor's Share

The previous section introduced notation and described alternative scenarios in the reaction of prices, wages, and labor's share to a change (positive or negative) in the trend growth of labor productivity, or output per hour. This section examines the data. How large was the post-1995 acceleration in productivity growth? Did real wages accelerate fully in response, leaving labor's income share intact, or did labor's share decline as in several scenarios in the model of Part II above? How large was the difference among alternative macro measures of real wage growth?

To highlight the discrepancies that are discussed in this section, nonfarm private labor productivity over the four years ending in 2005:Q1, according to the official data as of July, 2005, registered an annual growth rate of 3.89 percent per year. In contrast, average real hourly earnings in the total private economy increased at an annual rate over the same period of only 0.49 percent. Casual observers might conclude from these two numbers that there had been a massive shrinkage of labor's income share over these four years. The data comparisons in this section reduce but do not eliminate this gap, for indeed labor's income share actually did decline, although by much less than suggested by the stark comparison between these two numbers, 3.89 and 0.49. Here we provide a complete decomposition of the data for the four-year interval 2001:Q1 to 2005:Q1, treating six topics to explain the difference between these two numbers: (a) data revisions, (b) the actual performance of productivity vs. the underlying

productivity growth trend, (c) the nonfarm private business (NFPB) sector conventionally used to measure productivity growth vs. the total economy, (d) the difference between productivity and real compensation growth, (e) the difference between hourly compensation and average hourly earnings, and (f) the impact of alternative price deflators used to calculate real wage growth from data on nominal wages.

### **Data Revisions**

The annual revisions of the National Income and Product Accounts (NIPA) in July, 2005, reduced the growth rate of real GDP over the last few years and raised the rate of inflation as registered by the GDP and PCE deflators. The complementary revisions of the BLS productivity data, largely because of NIPA output revisions but also reflecting small revisions in BLS data on hours of work, reduced the annual growth rate of NFPB productivity over the four year interval 2001:Q1 to 2005:Q1 from 3.89 percent per annum to 3.44 percent per annum. Corresponding to this revision, statistical trends fit to the BLS productivity data, which in 2003-04 had been running at close to 3.5 percent per annum, are now reduced to close to 3.0 percent, as we will see in the next section.

### **Productivity Growth: Actual Data and Alternative Trends**

The distinction between actual and trend productivity growth is illustrated in the top frame of Figure 1, which displays actual and trend productivity growth rates from 1950:Q1 to 2005:Q2. The grey-shaded line plots the eight-quarter rate of change of NFPB output per hour, and this series remains above 3.0 percent for all but a single quarter from 2002:Q1 to 2005:Q2,

briefly exceeding 4.0 percent in 2003:Q3. The solid line is a Hodrick-Prescott (HP) trend.<sup>7</sup> The recent data revisions have had a marked effect on the behavior of the trend. Prior to the revisions, the HP trend reached 3.5 percent per year during the 2003-04 period. Now it barely scrapes 3.0 percent.

### **Total Economy vs. Non-farm Private Business (NFPB) Sector**

The bottom frame of Figure 1 displays as a solid line the same HP trend for the NFPB sector, copied from the top frame. This starts at 3.3 percent in 1950, reaches an interim high point of 3.1 percent in early 1962, declines to a low point of 1.0 percent in 1979, gradually recovers in the 1980s, rises through 2.0 percent in early 1997 and exceeds 3.0 percent briefly in 2002-03. In contrast the grey line shows the trend, constructed in exactly the same way, for the entire economy. This tracks the NFPB trend quite closely until the late 1980s and then grows at lower rates after that. The total economy trend rises above 2.0 percent in 1999, two years after the NFPB trend, and it only slightly exceeds 2.5 percent during 2002-05.

The separate black line labeled "Difference" in the bottom frame of Figure 1 displays the difference between the two trends, that is the NFPB trend minus the total economy trend. The difference is very close to zero on average during 1950-85 but then begins to rise, reaching a maximum of 0.58 in 2001:Q1 before declining to a value of 0.19 percent in the most recent quarter, 2005:Q2. Subsequently we look more closely at the data to locate the sectoral origins for this growing spread between the productivity growth trends in the total economy compared

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7. The smoothing parameter used for the Hodrick-Prescott filter is 6400 and was chosen in Gordon (2003,

to that for the NFPB sector. Understanding this difference is important for at least two reasons. First, labor's income share in the total economy depends on growth in the economy wide real wage relative to productivity growth for the total economy, not just productivity growth in the NFPB sector. Second, calculations of current potential output growth and forecasts of future potential output growth require forecasts of productivity growth for the total economy, not just for the NFPB sector.<sup>8</sup>

The top section of Table 1 displays growth rates of output per hour for the total economy, for the NFPB sector, and for the four sectors that make up the "residual" part of the economy outside of the NFPB sector, namely farms, government, households, and institutions.<sup>9</sup> Growth rates are displayed not according to the NBER business cycle chronology, but between "benchmark quarters" which are judged to have similar cyclical characteristics. These quarters are defined as those when the actual unemployment rate is equal to the NAIRU and is declining through the NAIRU, i.e., during the phase of the expansion when actual real GDP is growing faster than potential real GDP. We take the most recent quarter (2005:Q2) to be a benchmark quarter, even though the average unemployment rate was still about 0.3 percentage points *below* the time-varying NAIRU that we develop in the next section of the paper.<sup>10</sup> The first six

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pp. 220-1) to avoid too much "bending" of the trend in response to the deep recession of 1981-82.

8. In such forecasts Gordon (2003, Table 10, p. 270) assumed that the sectoral productivity difference would average 0.50 percentage points per year over the next 20 years.

9. The source of the output data in the top section of Table 1 is NIPA Table 1.3.6. The source of the hours data is a set of unpublished BLS data in billions of hours provided to us by Phyllis Otto. Output per hour is calculated as the ratio of the level of NIPA value added in billions of \$2000 to billions of BLS hours.

10. Benchmark quarters in Table 1 for the period up through 1987 are the same or within one quarter of the benchmark quarters used in Gordon (2003) and in earlier papers. Because our new estimates of the

columns of Table 1 show annual growth rates between benchmark quarters, the next column shows the average growth rate over the entire 1954-2005 interval, and the final two columns break the 1997-2005 period at 2001:Q1, in order to focus on differences between the 1997-2001 period when the economy was enjoying its extraordinary expansion and 2001-05 when the economy was in recession or recovering from recession.

In the top section of Table 1, we can see that residual sector productivity growth was slower than in the NFPB sector in all sub-intervals except for 1954-63 and 1979-87. After 1987 residual productivity growth slowed down while NFPB productivity growth increased, accounting for the growing gap between the total economy and the NFPB sector displayed in the bottom frame of Figure 1 and in the bottom section of Table 1. In the first four periods covering 1954-87, the difference between the total economy growth rate and the NFPB growth rate was miniscule, 2.02 vs. 2.10 percent per year, with residual sector productivity growth at a respectable rate of 1.80 percent. However in the final two periods between 1987 and 2005, the total economy growth rate began to fall significantly behind the NFPB growth rate, with rates of 1.81 and 2.22 percent respectively, due to the sharp slowdown in residual productivity growth to 0.54 percent per year.

Which sectors accounted for this slowdown in residual productivity growth? Breaking the history at 1987:Q4, we calculate these productivity growth rates for the four residual sectors:

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NAIRU are lower in the 1990s than in earlier papers, the mid-1990s benchmark quarter has been shifted from 1994:Q4 to 1997:Q4. The use of 2005:Q1 as the terminal quarter in this draft of the paper, rather

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	<i>1954:Q4-1987:Q4</i>	<i>1987:Q4-2005:Q1</i>
Farm	5.26	3.42
Government	0.22	0.15
Households	4.78	4.46
Institutions	0.81	0.17

While all four sectors experienced a post-1987 productivity growth slowdown, the slowdown in the farm sector was the largest in absolute magnitude, and the top section of Table 1 shows that the slowdown in farm productivity growth mainly occurred in 2001-05. There was little difference before and after 1987 in productivity growth in the government and institutions sector, and there was a slight slowdown in the household sector. The household sector is an anomaly, in that productivity consists of the ratio of two unrelated series; the numerator is largely imputed rent on owner-occupied housing, and the denominator consists of hired workers in households. Some idea of the heterogeneity of the residual sector is provided by the average value of \$2000 output per hour in 2005:Q1. For the total economy productivity was \$43 per hour, for NFPB \$45 per hour, for the residual sector \$38 per hour. But within the residual sector the highly variable levels of productivity were \$16 for farms, \$30 for government, \$562 for households, and \$25 for institutions. Doubtless there are significant measurement issues in each of the residual sectors that make any measure of productivity problematic, and this is why the BLS publishes productivity data for the business and NFPB sectors but not for the total economy.

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than 2005:Q2, reflects the fact that full data on the income side of GDP were not released until late

## Productivity, Real Compensation, and Labor's Income Share

Before looking at the detailed comparisons of sectoral productivity and compensation growth in Table 1, we first examine the postwar behavior of labor's income share in Figure 2. The lower line displays the ratio of NIPA employee compensation in the total economy to NIPA domestic income, i.e., GDP minus capital consumption and indirect business taxes. Contrary to the widespread impression that labor's share has been squeezed, there was no change in labor's share from 1996:Q3 to 2005:Q1, with a substantial increase in the boom of the late 1990s followed by a reversal in the early years of the current decade.

Over a longer period, labor's share has fluctuated over a wider range. There were two big step increases in 1952-54 and especially in 1966-70. The data underlying Figure 2 indicate that labor's income share rose markedly from 67.5 percent in 1966:Q1 to 73.7 percent in 1970:Q4. Labor's income share then fluctuated around a mean of 71.2 percent between early 1984 and early 2005. The average during the past decade (1996:Q2-2005:Q1) was almost exactly the same, 70.8 percent. Thus our preliminary examination of the data reveals substantial fluctuations in labor's income share prior to 1984 but little movement since then. In particular, the cycle of rising and falling labor's share during 1996-2005 averaged out with the same labor's share as the longer period 1984-2005.

The top line in Figure 2 adds to NIPA employee compensation the labor component of proprietors' income, as estimated by the Employment Policy Institute.<sup>11</sup> Because the share of proprietors' income in total domestic income has declined over the years, and because the labor share of that income has also declined, the overall behavior of labor's income share looks more stable in the upper line in Figure 2. Over the entire interval plotted, labor's share defined by the ratio of employee compensation to domestic income rises from 65.1 percent in 1950:Q1 to a level 4.4 points higher at 69.5 percent in 2005:Q1. In contrast, labor's share that includes the labor component of proprietor's income barely rises at all over the same time interval, from 71.8 percent in 1950:Q1 to 72.5 percent in 2005:Q1.

Overall there seems little air of crisis in the data on labor's share displayed in Figure 2. Especially when the labor component of proprietors' income is included, the share of labor in domestic income has floated up and down over the decades with no clear trend. The biggest event was the increase in labor's share in the 1966-70 period, which might in our subsequent analysis be partially explained by the productivity growth slowdown that began in the mid-1960s.

### **Components of Non-Labor Compensation**

Figure 3 displays the components of the non-labor, i.e., capital share of domestic income. The top line by definition is unity minus the labor's share concept plotted as the lower line in Figure 2. That is, in Figure 3 all of Proprietors' income is included in non-labor, i.e., capital

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11. See Mishel *et. al* (2005), Table 1.24, p. 95. The fraction of total proprietors' income that we use from



income. In Figure 2 the lower line treats all of proprietor's income as capital income, and the upper line treats a fraction (ranging from 0.41 to 0.29) of proprietors' income as part of labor income.

Figure 3 "stacks" the five components of non-labor income, expressed as a share of domestic income. From bottom to top, they are the small component called "Government enterprises and transfer payments," then income from rent, above it proprietors' income (including its labor component), then interest, and finally at the top corporate profits. The arrangement of Figure 3 is to place the more stable components at the bottom and the more volatile components at the top. The sum of rent and proprietors' income declined in the first part of the postwar era and then recovered modestly. The combined share of these two components of capital income in domestic income was a very high 20.1 percent in the first quarter plotted in Figure 3, that is, 1950:Q1. Then the combined share declined gradually to a low point of 8.0 percent in 1983:Q3, and then gradually increased to a terminal value of 11.1 percent in 2005:Q1.

If this major component of non-labor income declined so much in the postwar era, what emerged to take its place? Something else must have boosted the non-labor share of income, in light of the relative constancy of labor's share displayed in Figure 2. Perhaps the biggest change over the postwar era, and more than sufficient to offset the decline in proprietors' income and rent, was the huge increase in the share of interest income, which evolved slowly during 1960-

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the Mishel table is linearly interpolated between the selected years that they display.

1980 and then jumped suddenly from 1980 to 1985. The data plotted in Figure 3 are based on a share of interest of merely 1.4 percent in 1950:Q1, then a slow increase to 6.5 percent in 1979:Q1, then a sharp increase to 10.9 percent in 1986:Q2, and finally a slow slide to 7.2 percent in 2005:Q1.

Without further research it is not straightforward to explain the behavior of the interest share, which inherently combines the share of debt in GDP, times the effective nominal interest rate in each time period. Presumably the increase in the interest income share from 1950 to 1986 combines the gradual increase in the use of debt in the economy, multiplied by a sharp increase in interest rates in the late 1960s, and especially between 1978 and 1981-82.

Much of the current discussion of the failure of productivity gains to spill over to labor income focuses on the buoyant behavior of corporate profits in the past several years.

However, it is immediately clear from Figure 3 that the share of before-tax corporate profits declined from about 13 percent of domestic income in 1950 to about 11 percent in 2005:Q1. The following in-text table shows a succession of low and high points for the pre-tax profit share in domestic income over the past 55 years.

<i>Low Point (Quarter)</i>	<i>High Point (Quarter)</i>
13.1 (1950:Q1)	15.4 (1950:Q4)
10.6 (1953:Q4)	14.0 (1955:Q1)
10.0 (1958:Q1)	13.7 (1959:Q2)
10.8 (1961:Q1)	14.3 (1966:Q1)
8.8 (1970:Q4)	-----
6.6 (1982:Q4)	11.6 (1997:Q3)
6.9 (2001:Q3)	11.4 (2005:Q1)

These profit shares place some perspective on recent debates about whether productivity gains have gone disproportionately to profits. First, it is clear in inspecting both the “low” and “high” columns above that there has been a long-term decline in the profit share. The decline from the first to last “low point” was 4.2 percentage points and the decline from the first to last “high point” was 4.0 percentage points, hardly any difference. Thus historical perspective does not find anything unusual in the profit share of domestic income in the post-recession period of 2001-05.

Labor’s share, of course, may evolve differently in each separate sector of the economy. The middle section of Table 1 displays the growth rate of real compensation per hour, deflated by the GDP deflator. Any differences between real wage growth (in the middle section) and productivity growth (in the top section) imply changes in labor’s income share, as displayed in the bottom section.

Over the entire period 1954-2005, differences between real wage growth and productivity growth in the total economy were minimal, with an average growth of real compensation of 2.03 percent per year compared with 1.92 percent for productivity, implying a slight increase in labor’s share of 0.11 points over the 51 years. Somewhat surprisingly, in light of comments about labor “losing out” from the productivity growth upsurge, labor’s share in the total economy actually increased at an annual rate of 0.25 percent over the period 1997-2005, during which labor’s share increased sharply in the boom years 1997-2001 and declined somewhat less sharply between early 2001 and early 2005.

In the NFPB sector labor's share exhibited a gradual decline relative to the total economy. The share declined in each period over the entire 1954-2005 interval, with an average annual growth rate of the share of -0.26 percent. As in the total economy, there was a sharp increase in labor's share during 1997-2001 and for NFPB an equally rapid and sharp decrease in labor's share during 2001-05. A notable aspect of Table 1 is that compensation in the "residual" sector increased much faster than productivity, implying a marked increase in labor's income share at an annual rate of 1.28 percent over the full 1954-2005 period.

Why did the residual and private business sectors behave so differently? The residual sector has measured productivity growth which is much lower, albeit not zero, in comparison with the private business sector. An ancient law of economics often called "Baumol's Law" states that labor mobility causes wages to increase uniformly across sectors, so that those sectors with below-average productivity growth (the proverbial "haircuts" and "string quartets") will have real wage growth (when deflated by economy-wide rather than sectoral price increases) faster than productivity growth, and hence a positive growth rate of labor's share. This phenomenon can explain why labor's income share increased in the residual sector much more than in the total economy or the NFPB sector over the past five decades.

### **Alternative Wage Indexes and the Role of Price Deflators**

Further evidence on the relationship between productivity growth, compensation growth, and the growth rate of other wage indices is provided in Table 2. The columns display growth rates across the same time intervals as in Table 1. The top row displays business sector

productivity, the same index as displayed in the top section of Table 1. The next three rows display three alternative measures of annual growth in the real wage, all deflated by the GDP deflator. The first is real Compensation per Hour (CPH) in the private business economy, the same index as displayed in the middle section of Table 1. Next is the Employment Cost Index (ECI), which is a CPI-like index of a market basket of wages which controls for shifts in mix across industries and occupations, both of which plague the CPH. Because the ECI is only available back to 1978, several blank cells appear in Table 2, but we are able to track the growth rate of the ECI measure of the real wage over our sub-intervals starting in 1979. The third wage index summarized in Table 2 is the BLS index of average hourly earnings (AHE) for production and nonsupervisory workers, which extends back to the 1940s. Because the real AHE growth rate is often deflated by the CPI in official government publications, e.g., the *Economic Report of the President 2005*, Table B-47, we include the bottom rows of Table 2 that allow us to translate different systems of deflation for the alternative wage indexes.

Three themes emerge from Table 2. First, the growth rate of the real CPH is modestly below the growth rate of private sector business productivity over the entire 1954-2005 period and also over the shorter 1997-2005 period, but these respective growth rates imply a continuous decline in labor's income share that is not evident in the NIPA income distribution data plotted in Figure 2. Figure 2 displays labor's share for the total economy, and indeed the bottom section of Table 1 shows that the implied change in labor's share for the total economy is

positive over 1954-2005 while the same data sources imply that the change in labor's share for the private business sector is negative.

The shortfall of CPH growth relative to productivity growth in the private business sector is minor compared to the shortfall of the other wage indexes displayed in Table 2. For the 1954-2005 interval, over which only the CPH and AHE wage data are available, the annual growth rate of the shortfall of the real CPH is only -0.25 percent per year, but the shortfall for the AHE is -1.49 percent per year (i.e., 0.80 minus 2.29). As officially presented by the BLS with deflation by the CPI-U, the shortfall of the real AHE is -1.84 percent per year (i.e., 0.45 minus 2.29).

If we shift the time interval to 1979-2005, we can bring the ECI into the comparison, as shown in the far right column. For this interval the private sector CPH falls short of private sector productivity growth by 0.73 percent per year, while the shortfalls are greater for the ECI (-1.03 percent), the AHE deflated by the GDP deflator (-1.71 percent), and the AHE deflated by the CPI-U (-2.28 percent). What accounts for these discrepancies? Why do the ECI and AHE not reflect the income earned by labor as reflected in the NIPA income distribution data displayed in Figure 2? Abraham et al. (1999) dealt with the discrepancy between AHE and a series very similar to CPH, and found that much of the difference was explained by the fact that AHE only covers production and non-supervisory workers. Given that this is the case, workers not covered by AHE must be seeing much faster wage growth than those covered. A working hypothesis of this paper is that the CPH data are skewed upwards by compensation earned by

the top percentiles of the income distribution, whereas the ECI and AHE indexes provide a more accurate depiction of income gains for the median worker. Our examination of the IRS micro data files in subsequent sections of this paper will validate that hypothesis.

#### **IV. The Effect of Changes in the Productivity Trend in a Model of Inflation Dynamics**

This paper began with the definitional statement that an increase in trend productivity growth could result in lower inflation, faster nominal wage growth, and/or in faster growth of non-labor income, particularly profit income. This section of the paper provides a new analysis of the effects of productivity growth on the inflation rate, using and extending the longstanding “mainstream” model of inflation dynamics that was developed in the late 1970s and was last reported upon at BPEA seven years ago (Gordon, 1998). Did the increase in trend productivity growth in 1995-2005 reduce inflation, thus easing the job of the Fed in managing the economy? Did the decrease in trend productivity growth in 1965-1979 raise the inflation rate and thus complicate the job of the Fed in managing the economy of that era that was already buffeted by oil and import price shocks, and by the destabilizing effects of the Nixon price controls?

This section begins by presenting the background and specification of the dynamic inflation model, including the role of changes in the productivity growth trend, and then discusses several closely related issues in the literature on inflation dynamics that have arisen recently. Issues of particular interest are the frequent use of much more spartan specifications of the inflation equation, and the impression among some analysts that the slope of the Phillips

curve has become smaller.<sup>12</sup>

### The “Mainstream” Model of Inflation and the Role of Demand and Supply Shocks

The inflation equation used in this paper is similar in most details to the specification developed 25 years ago (Gordon, 1982; Gordon-King, 1982). It builds on earlier work (Gordon, 1975, 1977) that combined the Friedman-Phelps natural rate hypothesis with the role of supply shocks as a source of direct shifts in the inflation rate. These supply shocks can create macroeconomic externalities in a world of nominal wage rigidity. Since the mid-1990s, this research has built on the work of Staiger, Stock, and Watson (1997, 2001) by incorporating time variation in the natural rate of unemployment or NAIRU, using the abbreviation TV-NAIRU.

The term "mainstream" model refers to a Phillips Curve that has three distinguishing characteristics — (1) the role of inertia is broadly interpreted to go beyond any specific formulation of expectations formation to include other sources of inertia, e.g., wage and price contracts; (2) the driving force from the demand side is an unemployment or output gap; and (3) supply shock variables appear explicitly in the inflation equation.<sup>13</sup> The specification can be written in this general form:

$$p_t = a(L)p_{t-1} + b(L)D_t + c(L)z_t + e_t. \tag{11}$$

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12. See Gali and Gertler (1999), Gali et al. (2001) and Stock and Watson (2002, 2003) for simplified simplified new Keynesian Phillips curves. For discussion of changing parameters see Atkeson and Ohanian (2001) and Tetlow and Ironside (2005).

13. The work of Staiger, Stock, and Watson (1997, 2001) is included within the label "mainstream approach." While Gordon's work (1998) adopted their modeling of the TV-NAIRU, their work adopted Gordon's specification of the inflation equation itself, including the specification of demand and supply shocks and lags thereof.



Lower-case letters designate first differences of logarithms, upper-case letters designate logarithms of levels, and  $L$  is a polynomial in the lag operator.

The dependent variable  $p_t$  is the inflation rate.<sup>14</sup> Inertia is conveyed by a series of lags on the inflation rate ( $p_{t-1}$ ).  $D_t$  is an index of excess demand (normalized so that  $D_t=0$  indicates the absence of excess demand),  $z_t$  is a vector of supply shock variables (normalized so that  $z_t=0$  indicates an absence of supply shocks), and  $e_t$  is a serially uncorrelated error term.

Distinguishing features in the implementation of this model include unusually long lags on the dependent variable, and a set of supply shock variables that are uniformly defined so that a zero value indicates no upward or downward pressure on inflation.

If the sum of the coefficients on the lagged inflation values equals unity, then there is a "natural rate" of the demand variable ( $D^{N_t}$ ) consistent with a constant rate of inflation.<sup>15</sup> The estimation of the time-varying NAIRU combines the above inflation equation, with the unemployment gap serving as the proxy for excess demand, with a second equation that explicitly allows the NAIRU to vary with time:

$$p_t = a(L)p_{t-1} + b(L)(U_t - U^{N_t}) + c(L)z_t + e_t, \quad (12)$$

$$U^{N_t} = U^{N_{t-1}} + v_t, E(v_t) = 0, var(v_t) = \sigma^2 \quad (13)$$

In this formulation, the disturbance term  $v_t$  in the second equation is serially uncorrelated and is

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14. Note in particular that lower-case  $p$  in this paper represents the first difference of the log of the price level, not the log of the price level itself.

15. While the estimated sum of the coefficients on lagged inflation is usually roughly equal to unity, that sum must be constrained to be *exactly* unity for a meaningful "natural rate" of the demand variable to be calculated.

uncorrelated with  $e_t$ . When this standard deviation  $\sigma = 0$ , then the natural rate is constant, and when  $\sigma$  is positive, the model allows the NAIRU to vary by a limited amount each quarter. If no limit were placed on the ability of the NAIRU to vary each time period, then the time-varying NAIRU would jump up and down and soak up all the residual variation in the inflation equation (12).

The reduced-form inflation equation (12) includes the gap between the actual unemployment rate and the NAIRU, as well as the lagged dependent (inflation) variable. In addition, five variables are included that are interpreted as supply shocks (the  $z_t$  variables in (11) and (12) above), namely the change in the relative price of non-food non-oil imports, the changes in the relative price of food and energy, changes in the relative price of medical care, the change in the trend rate of productivity growth, and dummy variables for the effect of the 1971-74 Nixon-era price controls.<sup>16</sup> Lag lengths were originally specified in Gordon (1982) and have not been changed since then, and in the discussion of results below we will reassess the statistical significance of the lags, particularly on the lagged inflation variable and the current and lagged unemployment rate.

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16. The relative import price variable is defined as the rate of change of the non-food non-oil import deflator minus the rate of change of the dependent variable, e.g., GDP deflator or PCE deflator. The relative food-energy variable is defined as the difference between the rates of change of the overall PCE deflator and the "core" PCE deflator. The Nixon control variables remain the same as originally specified in Gordon (1982). Lag lengths remain as in 1982 and are shown explicitly in Table 3. The medical care variable is defined in the same way as the food-energy variable, that is, as the difference between the inflation rate of the GDP deflator and the inflation rate for that deflator when medical care spending is deducted from total GDP. The productivity variable is the two year change in the Hodrick-Prescott filtered trend of productivity using 6400 as the smoothness parameter. The only changes from the previous published paper on this approach (Gordon, 1998) are the introduction of the medical care

Figure 4 displays four-quarter moving averages of the relative import price variable in the top frame and of the food-energy effect in the bottom frame. The central role of the import price variable in explaining the spike of inflation in 1974-75 is clearly visible, as is its role in helping to push the inflation rate down in 1982-85.<sup>17</sup>

The food-energy effect, plotted in the bottom frame of Figure 4, has somewhat different timing. Note also the different orders of magnitude of the import and food-energy effects, reflecting the fact that the first is defined as a change in a relative price, and the second is defined as the difference between one aggregate and a second “stripped” aggregate.<sup>18</sup>

In this paper we go beyond previous work by entering into the equation an additional “z” variable, specified exactly as in the case of food-energy prices, namely as the growth rate of the GDP deflator minus the growth rate of that deflator excluding expenditures on medical care services. The top frame of Figure 5 plots the four-quarter moving average of the medical care effect, and this exhibits a succession of cyclically volatile positive values, i.e., medical care inflation was faster than the inflation rate in non-medical care goods and services. The excess rate of medical care inflation peaked in 1988-93 and dipped in 1996-2000, another factor helping to explain why inflation in the late 1990s was so low.

Besides the addition of the medical care variable, the other major change in the current

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variable and the treatment of the productivity trend variable.

17. Gordon-King, 1982 concluded in the middle of this process that the endogeneity of the exchange rate and import prices substantially reduced the sacrifice ratio of achieving lower inflation.

18. Namely, the import variable is the change in the relative price of imports, which reaches a peak of about 12 percent in 1974-75. The food-energy variable is *not* the relative price of food and energy, but rather the difference between the growth rates of the PCE deflator including and excluding food and

inflation equation from the (Gordon, 1998) Goldilocks specification involves productivity growth, the point of departure for the current paper. In previous papers the difference in the growth rates of actual and trend productivity has been included in the inflation equation and described as the "productivity deviation" variable. But the difference between actual and trend growth misses the main impact of the post-1995 productivity growth revival, which is the acceleration in the growth rate of the trend itself. Here we use the Hodrick-Prescott (H-P) filter as in Figure 1 to define the productivity trend and then define the acceleration or deceleration in the productivity trend as the two-year (eight-quarter) change in the growth rate of the trend. This productivity trend acceleration is plotted in the bottom frame of Figure 5. Its deceleration into negative territory from 1965 to 1980 might be as important a cause of accelerating inflation in that period as its post-1995 acceleration was a cause of low inflation in the late 1990s.

### **Coefficients in Alternative Inflation Equations**

Table 3 displays coefficients or sums of coefficients, significance levels, and simulation results for our basic inflation equation and several other variants. The sample period is 1962:Q1 to 2005:Q2, and the rows designate different variables and, in some cases different choices of lag lengths.

What we call the "naive" Phillips curve is displayed in column (1). This contains only the current level of the unemployment rate and four lags on the dependent variable. This equation fits the data poorly; the sum of squared residuals (SSR) is 177. Column (2) provides

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energy, and this variable peaks at 3.2 percent in 1974-75.

the 1998 “Goldilocks” (Gordon, 1998) version of the full specification in equation (2) above. Included are 24 lags on the dependent variable, the unemployment gap relative to the TV-NAIRU that is estimated simultaneously, and the listed supply shock variables. The 1998 version was lacking the current explicit treatment of the medical care variable and also the trend productivity growth acceleration.<sup>19</sup> Comparing the first two columns, the full version in column (2) cuts the SSR by a factor of three. The new variables in this paper are added in steps in columns (3), (4), and (5).

With an R-squared that is already above 94 percent in column (2), there is little residual variance left to explain, but these two “new” variables are still both significant and improve all the summary statistics. Columns (3) and (4) show that the medical care effect and productivity acceleration are both significant and both improve the equation. Moreover, they do not significantly affect any of the other coefficients, showing that they are adding new information. In column (3), the productivity acceleration enters with its first and fifth lags, and these coefficients sum to minus 1.39, indicating that an acceleration in the productivity trend reduces inflation by more than one-for-one. As opposed to the Goldilocks specification using the deviation of actual productivity growth from trend, this variable is highly significant, and shows that changes in the productivity trend have a major impact on inflation.<sup>20</sup>

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19. The 1998 paper explicitly maintained the specification to be identical to that in Gordon (1982), in order to highly the stability of the research approach over time. The only change between 1982 and 1998 was the replacement of a fixed NAIRU by the TV-NAIRU.

20. While the first lag on the productivity acceleration variable is not significant, the fifth lag is highly significant, and the sum of the two coefficients (-1.39) has a T ratio above 4.

The bottom frame of figure 5 gives an idea of the scale of this impact. The acceleration in the trend hit its peak of 0.46 in 1999, and the effect of the variable near the peak of the last business cycle, between 1998 and 2000, would have been to lower inflation by about a half percentage point. One can see how the Fed might have been forced to raise interest rates much earlier if not for this beneficial shock hitting its historical peak at the same time as demand pressure, measured by the negative unemployment gap, was also at its most intense.

In column (4), the medical care variable is added. It improves the summary statistics slightly more than the productivity acceleration in column (3), and it enters with a coefficient of 1.31. Again, it does not seem to affect the other coefficients. The simulation errors in columns (3) and (4) are very similar and show a distinct improvement over those in column (2).

Column (5) finally shows our preferred specification, incorporating both the productivity acceleration and medical care effect, and this column is clearly superior to the other four. It has better summary statistics, all of the coefficients are significant, and the simulation errors show that the equation has little drift over time and has very small mean squared error.<sup>21</sup> As section two suggested might happen, the reaction of inflation to an acceleration or deceleration in trend productivity growth is partly delayed.

### **The Inflation Equation: Simulation Performance**

While most papers presenting time-series regression results display coefficients,

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21. As in column (2), the sum of the coefficients on the two productivity acceleration terms is highly significant, with a T-ratio of -4.07. The two individual coefficients are not significant, indicating that they

significance levels, and summary statistics, few go beyond that and display results of dynamic simulations. Yet the performance of the inflation equation is driven in large part by the role of the lagged dependent variable terms, making dynamic simulations the preferable method for testing. To run such simulations, the sample period is truncated ten years before the end of the data interval, and the estimated coefficients through 1995:Q2 are used to simulate the performance of the equation for 1995:Q3 to 2005:Q2, generating the lagged dependent variables endogenously.

Since the simulation has no information on the actual value of the inflation rate and no error correction mechanism, there is nothing to keep the simulated inflation rate from drifting far away from the actual rate. The bottom rows of Table 3 summarize the simulation results in two statistics, the mean error (ME) over the 40-quarter simulation period and the root mean-squared error (RMSE). The ME reflects the drift of the simulated value away from the actual value, so that in column (1) the naive Phillips curve on average over 1995-2005 has a predicted value of inflation that on average is fully 4.0 percentage points higher than the actual outcome. The 1998 Goldilocks specification in column (2) has a ME of much less, -0.64 points, but still a substantial overprediction of inflation.<sup>22</sup> The simulation errors decline as we move to the right in Table 3 and have a miniscule ME of -0.11 for our preferred simulation in column (5). The

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convey the same information. Nevertheless, we include both rather than one or the other, for expositional convenience in Part V below.

22. The simulation errors shown in column (2) are calculated with the 1998 specification run on today's data through 2005. The simulation ME reported in the 1998 paper (Table 3, p. 315) was -0.46, but that was for a simulation period of only 22 quarters contrasted to the more demanding 40-quarter simulation period in this paper.

RMSE of the preferred specification is actually substantially lower than the within-sample standard error of estimate (SEE), 0.56 versus 0.65.

Figure 6 provides a vivid display of the differences among these specifications. The solid black line plots the four-quarter change in the actual PCE inflation rate. To the left of the vertical bar are within-sample predicted values of the Naive specification in column (1), the Goldilocks specification in column (2), and the preferred specification in column (5). The naive specification has no clue as to why inflation was so low in the late 1990s, so its simulated inflation rate soars up close to 9 percent by 2005. The Goldilocks specification drifts above the actual outcome but by 2005 is still only half a percentage point too high. The preferred specification hugs the actual values with amazing tightness. The RMSE of the preferred specification is actually substantially lower than the within-sample standard error of estimate (SEE), 0.56 versus 0.65.

The excellent simulation performance has two important implications. First, the equation is more than simply a random walk. The supply shock variables and unemployment gap add a substantial amount of information beyond that from the lagged dependent variable. Second, this absence of drift shows that the equation is stable after 1995. If the coefficients had changed, then presumably we would see drift in the form of larger mean errors.

The price equation is not only stable after 1995, but it is also stable across the full sample.



A Chow test for a break at 1983:Q4 cannot reject the null of no break.<sup>23</sup> Furthermore, when interaction terms are added allowing any of the coefficients to change, none of the sums of interaction terms is significantly different from zero, except for the food-energy effect in the PCE equation. When allowed to change, the food-energy coefficient drops from a value of 1.01 during 1962-83 to 0.33 during 1984-2005, both of which are significantly different from zero.

Atkeson and Ohanian (2001) claimed that the relationship between inflation and unemployment no longer holds.<sup>24</sup> We refrain from examining the broad range of fundamental flaws in their research, such as ignoring the effects of supply shocks, and simply note that the estimated change in the slope is not even remotely significant, only from -0.67 to -0.63. This result solidly rejects the notion that inflation is no longer dependent on the unemployment gap, an idea that can only be supported in naive Phillips curves like that of column (1) in Table 3 that introduce only short lags and omit most or all of the supply shock variables.

### **Estimating the TV-NAIRU**

The time-varying NAIRU or “TVN” is estimated in equation (3) simultaneously with the inflation equation (2) above. In the process of estimating the NAIRU, the coefficients are forced to sum to unity. For each set of dependent variables and explanatory variables, there is a different TVN. For instance, when supply-shock variables are omitted, the TVN soars to 7 percent and above in the mid-1970s, since this is the only way the inflation equation can

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23. The value of the  $F(27,114)$  ratio based on estimating separate equations for 1962:Q1-1983:Q4 and 1984:Q1-2005:Q2 is 1.25, compared to a 5 percent critical F value of 1.55.

“explain” why inflation was so high in that decade. However, when the full set of supply shocks is included in the inflation equation, the TVN is quite stable.

As explained above, the NAIRU can either be so smooth as to be a constant, or so jumpy as to explain all the residual variation in the inflation equation. Rather than estimate the gain ratio for the Kalman smoother, either through a maximum likelihood estimate or by using the Stock-Watson median unbiased estimator, we impose a gain ratio of 0.0125.<sup>25</sup> This was chosen as a level that would allow the NAIRU to vary over time, yet also removed all negative serial correlation.<sup>26</sup> Had we used the Stock-Watson estimate of 0.048, the TVN would have been allowed to take up four times as much of the residual variance. The maximum likelihood estimate on the other hand, at 0.0059 implies a nearly invariant NAIRU.<sup>27</sup> The extremely small value of this estimate indicates that the maximization algorithm may have picked up the large density around zero that motivates the Stock-Watson estimator. The chosen parameter of 0.0125 is therefore a convenient compromise between the two estimates.

The TVN series associated with our basic inflation equation for the PCE deflator is displayed in figure 7. It does not fall below 5.6 percent or rise above 6.1 percent over the period

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24. See also Tetlow and Ironside (2005) for an analysis of changes in the slope used in the Federal Reserve’s FRB/US model.

25. See Stock and Watson (1996). Specifically, we used a Quandt likelihood ratio statistic and drew our estimate of the gain ratio from their table 3.

26. We reject negative serial correlation in the TVN, because the basic idea of the NAIRU is to reflect the gradual evolution of frictions in labor and product markets. For a further discussion of the “smoothness issue,” see Gordon (1998, pp. 311-12).

27. Since we use the smoother, zero variance in the random walk implies a constant NAIRU. If we used the Kalman filter (the one-sided estimate), zero variance would produce an estimate that converges to a constant over time.

between 1962 and 1988. However, beginning in the late 1980s, the TVN drifts downwards until it reaches 5 percent in 1995, and then it gradually rises to a final value of 5.33 percent in 2005:Q2. Thus we concur with the general consensus that the TVN is currently roughly in the vicinity of 5.0 percent.<sup>28</sup> For historical continuity, Figure 7 also displays the TVN that was estimated for the PCE deflator in Gordon (1998, Figure 1, p. 312). Our current specification yields a TVN that is about half a percentage point below the 1998 “Goldilocks” specification for most of the sample period, but the 1998 version of the TVN declines more rapidly in the mid-1990s and is exactly equal to our current version in 1997:Q1 and virtually the same in 1997-98.

### **Price and Wage Equations without Mutual Feedback**

Table 4 displays two equations with inflation as the dependent variable and two equations for wages, with the form of the dependent variable discussed below. The first column repeats our preferred specification of the PCE deflator equation, copying the final column of Table 3 into the first column of Table 4. To assess the sensitivity of the results to the choice of dependent variable, column (4) of Table 4 provides an identical specification for the deflator for non-farm private business (NFPB) sector output, the deflator that is relevant in comparing NFPB sector productivity and labor compensation. The sum of coefficients on the lagged inflation terms is always very close to unity, and the long 24-quarter lag process continues to be strongly supported in exclusion tests.<sup>29</sup> The sum of the unemployment gap

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28. The standard error for the estimate of the NAIRU is 0.92.

29. The inclusion of lags 13-24 (years four through six) is strongly significant in an exclusion test at the 0.0001 confidence level. As stated in the notes to Table 3, we conserve on degrees of freedom by

variables is -0.66 for the PCE deflator, and -0.54 for the NFPB deflator, neither significantly different from -0.5. This is consistent with a stylized fact, first noticed in the 1960s, that the slope of the short-run Phillips curve is about minus one-half (as first noticed by Samuelson and Solow, 1960). For both equations, the coefficients on lags one to four of the unemployment gap pass an exclusion test. For the NFPB deflator at the 10 percent level, and for the PCE deflator at the .001 percent level.

Of the supply shocks, the change in the relative import price and relative food-energy effect are consistently significant in both equations with plausibly sized positive coefficients. The coefficient on the relative price of non-food non-oil imports is 0.13 in the NFPB deflator equation and 0.07 in the PCE deflator equation. The PCE coefficient of 0.07 is about half of the 14 percent share of imports in nominal GDP. We would have expected the import-price coefficient to be smaller for the NFPB deflator than for the PCE deflator, rather than the reverse, since imports are excluded from NFPB output but included in consumption. As expected, the coefficients on the food-energy variable are higher in the equation for the PCE deflator than for the NFPB deflator because imported energy is a part of consumption but not part of NFPB output. The coefficients for the Nixon control variables are highly significant and have the expected signs and magnitudes similar to those in past research.

The TVN for the NFPB deflator is in the same general range as that for the PCE deflator.

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including six successive four-quarter moving averages of the lagged dependent variable at lags 1, 5, 9, 13, 17, and 21, rather than including all 24 lags separately. In the full PCE specification, if the lagged dependent variable is not constrained to unity, its coefficients would sum to 1.03, indicating that the

Any difference in the means of the two TVN's can be explained by the fact that the supply shock variables are not mean zero, so differences in their coefficients force the TVN to absorb the changes in the mean that the constant normally would absorb.

## V. Adding a Wage Equation and Closing the Model

It has long been recognized that any factors that affect prices could also affect wages. This can be supported from a wage aspiration framework, from the basic supply shock perspective set out above, or from a purely statistical argument.<sup>30</sup> Our baseline wage equation is therefore estimated with identical explanatory variables as the equation for prices. We will later add a feedback term in the form of the lagged change in trend labor share that will allow wages and prices dynamically to interact with each other. This will complete the conceptual framework set out in equations 8 to 10.

The explanatory variable in the wage equations, rather than being simply compensation per hour, is the change in trend unit labor cost, which is defined as the growth in compensation per hour minus trend productivity:

$$(w-\theta^*)_t = d(L) (w-\theta^*)_t + e(L)(U_t-U^N_t) + f(L)z_t + e_t \quad (14)$$

There are a number of issues that arise when estimating wages that do not occur in estimating reduced-form inflation equations like those in Table 3. First, measured growth in compensation per hour (CPH) is much more volatile than inflation. One of the reasons for using the change in

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constraint has little real effect.

trend unit labor cost, rather than actual unit labor costs is that it removes the added variance associated with measured productivity growth. Throughout this paper, we choose to deal with trend productivity; it is used as the explanatory variable in Tables 4 and 5 and in the wage equations as part of the dependent variable. Eventually it will be a part of our closed form estimates modeling the change in labor's share. But even if our wage variable has gotten rid of the quarterly variance in actual productivity growth, the enormous variance of quarterly changes in the raw CPH data still presents us with a daunting research task.

### **Estimated Coefficients and Simulation Performance**

Table 4 displays results from the preferred specification of the inflation equation in Part IV applied in columns (2) and (5) to trend unit labor costs. There are two versions of the wage equation, one that uses a NAIRU estimated with the PCE deflator as the dependent variable, and one with the NFPB deflator.

The biggest differences between the wage equation and the inflation equation are in the summary statistics. Rather than R-squareds of 0.85 or higher, here they are only 0.57. The standard errors of the estimates and sums of squared residuals are also much higher.

Coefficients are somewhat different in the wage equation from those in the price equations. The reaction of trend unit labor costs to the unemployment gap is marginally smaller than that of prices, and the reactions to the medical care effect and the relative price of imports are negative rather than positive. Because the standard errors are generally larger than unity for the relative

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30. Sims (1987) argued that equations with wages and prices as alternative dependent variables are

price of medical care, we place little weight on these coefficients. Few of the coefficients in the wage equations are significant, which we take to be due to the volatility of measured compensation per hour.

### Closing the Model

Part II showed that if the lagged change in labor's share does not affect prices and wages, it is possible that a shock in productivity growth could imply that labor's share will fall to zero or rise to unity. The only way this can be avoided is a particular condition on the coefficients in those stylized price and wage equations of Part II. It is easy to fit the econometric equations estimated so far into the context of Part II, because the estimated change in trend labor's share ( $tls$ ) is simply the estimated change in TULC in Table 4 minus the inflation rate. Since our productivity variable refers only to the NFPB sector, we also have to use the inflation measure associated with that sector in order to get the correct estimates for the coefficients in the labor's share equation. By aggregating all of the supply shocks except productivity temporarily into  $z'_t$ , algebra gives us this result for labor's share:

$$tls_t = (w - \theta^*)_t - p_t \tag{15}$$

$$tls_t = d(L)(w - \theta^*)_{t-1} - a(L)p_{t-1} + [e(L) - b(L)](U - U^*)_t + g(L)(\theta^*_{t-1} - \theta^*_{t-4}) + h(L)z'_t \tag{16}$$

Since this equation is just the difference between TULC growth and the inflation rate, the  $g$  coefficients in (16) equal the productivity acceleration coefficients from the wage equation minus those from the price equation. In columns (3) and (6) of Table 4, it is clear that the effect

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simply alternative "rotations" of each other.

of a productivity shock in the form of any change in the trend growth rate of productivity, will cause trend labor share to have a permanent negative growth rate, implying that eventually its level would fall to zero. Columns (1) through (3) do not strictly produce estimates for labor's share because the deflator does not match productivity, but it is still illustrative of the interaction of the coefficients in the equation. Therefore, in order to complete the conceptual framework of section 2, we add the lag of the change in trend labor share to the price and wage equations.

This can be viewed in two ways. The informal explanation is the equilibrium framework that motivates the addition as a necessary condition to keep labor's share from becoming unstable. If labor's share has been rising, that may cause wages to grow slower or prices to grow faster, depressing future labor share growth. The formal reasoning follows from a rearrangement of a wage-wage-price and price-price-wage setup:

$$(w-\theta^*)_t = d(L) (w-\theta^*)_t + i(L)p_{t-1} + e(L)(U_t-U^N_t) + f(L)z_t + e_t \quad (17)$$

$$(w-\theta^*)_t = [d(L)+i(L)] (w-\theta^*)_t - i(L)(w-\theta^*_{t-1}) + e(L)(U_t-U^N_t) + e(L)z_t + e_t \quad (18)$$

Equation (17) generalizes the basic wage (TULC) equation (14), which allows the lagged response of TULC to include only TULC, with no influence at all from lagged prices. This is far from the spirit of the original Phillips curve, which had lagged feedback from prices (or "expected inflation") to wages but not wages to wages. Thus equation (17) is completely general in allowing *any mix* of lagged TULC change and lagged inflation to drive the evolution of TULC changes.



Equation (18) is a simple algebraic rearrangement of equation (17) that adds and subtracts the “*i*” coefficients multiplied by the change in TULC  $(w-\theta^*)_t$ . By constraining the sum of the *d* and *i* coefficients, the natural rate hypothesis can be retained. An identical transformation can be applied to a price equation that adds the lagged effect of trend unit labor costs as a supply shock term. As we saw in Part II, this mechanism may allow our empirical model to match the stylized fact that labor’s share does not show persistent positive or negative growth rates.<sup>31</sup>

### **TLS coefficients and results**

Table 5 reports regression results for the same four equations as Table 4, except the first through eighth lags of the growth of trend labor share have been added. In all of the equations, the sum of coefficients on lagged *tls* is significant. As would be expected, all the summary statistics are also improved. The simulation errors for inflation are similar to those in the model without wage feedback, but those for trend unit labor costs are noticeably improved. These simulations are somewhat more difficult for the equations to withstand because now two equations are being estimated simultaneously, but on the other hand, there is a first-difference variety of error correction mechanism in the form of the lagged change in trend labor share.

When the coefficients are subtracted in columns (3) and (6) in order to derive an equation for the change in trend labor’s share, we get almost exactly the results sketched out in

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31. Equation (18) is identical to equation (8) in Gordon (1998, p. 306). That paper worked out the role of changes in trend labor’s share in transmitting wage impulses and price impulses back and forth between

Part II. An interesting result in row 2 of columns (3) and (6) is that as aggregate demand improves, as represented by a smaller positive unemployment gap or a bigger negative unemployment gap,  $tls$  is predicted to be negative as the extra demand boosts prices more than wages. This is nothing more than the famous result of the countercyclical real wage (or negatively sloped labor demand curve) debated in the late 1930s by Keynes and his critics.

Another important implication of Table 5 is that the sum of coefficients on the lagged  $tls$  terms in line 7, column (6), subtract to a value of -0.86, implying that all other things being equal, the growth rate of  $tls$  will tend towards zero through an error-correction mechanism, eventually finding an equilibrium as in Part II. Second, the early (lag 1) effect of a productivity acceleration (line 8) implies a fall in labor's share, and the late (lag 5) corrects some of this. The long run effect of changes in productivity is extinguished by the negative coefficient on lagged  $tls$ , but in the short run the growth rate of trend labor's share is negative, and so a positive shock to trend productivity growth implies a reduction in the level of labor's share.

### Counterfactual Simulations

While the coefficients on the productivity acceleration variable in Tables 5 and 6 indicate that such an acceleration should cause a shift in the level of labor's share, a better way of illustrating exactly how productivity has influenced labor's share is to calculate a dynamic simulation of the price and wage equations. We will assume first that the productivity growth slowdown of the late 1960s and 1970s never occurred. Then we will assume that the post-1995

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the inflation and wage change equations, but it did not develop an adequate empirical implementation of

productivity acceleration never occurred. These counterfactual simulations are calculated by using the coefficients from the regressions over the full sample to simulate prices and wages, first with all the variables taking on their actual values, and then alternatively with the productivity acceleration terms set to zero. The simulation that “turns off” the productivity slowdown runs from 1965:Q1 to 1980:Q1. The simulation that “turns off” the productivity revival runs from 1995:Q2 to 2005:Q2. Recall that the 1995-2005 simulation results differ from those summarized at the bottom of Tables 5 and 6, because those simulations terminated the sample period at 1995:Q2, whereas these simulations use coefficients based on the entire 1962-2005 sample period and thus would be expected to have lower mean errors.

Table 6 summarizes the results of the two simulations. The top section shows five lines of results for the NFPB deflator, the actual change, the simulated change assuming the actual behavior of the productivity growth trend acceleration variable, the counterfactual simulation that suppresses to zero the same productivity variable, the simulation error (line 1 minus 2), and the counterfactual effect of the change in trend productivity growth (line 2 minus 3). The middle section shows the same for the change in trend unit labor cost, and the bottom section shows the same for the change in trend labor share.

Looking horizontally, Table 6 is divided into four columns, two for each of the two simulations. The left two columns summarize results for the productivity slowdown simulation of 1965-80, and the right two columns summarize results for the productivity revival after 1995.

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the model.

For each simulation, there are two columns. The first displays the mean annual percentage rate of change over the the full simulation period, whereas the second identifies drift in the simulations by displaying the four-quarter change in the final year of each simulation.

Lines A4, B4, and C4 summarize our findings for the simulation errors in each time period. As in previous simulation results displayed earlier in the paper, the simulation results for the inflation rate are very small, with no drift at all in the final four quarters of the simulation period. For the change in TULC (the middle section), the mean errors are modest but the final year errors are higher, indicating an overprediction of TULC changes at the end of the 1965-80 simulation and a substantial underprediction at the end of the 1995-2005 simulation. The TLS change errors match those for the change in TULC, since the inflation errors are so low.

Lines A5, B5, and C5 provide the main results of this section. The mean effect over the simulation period of the 1965-80 productivity growth slowdown was to add 1.28 percentage points to the inflation rate, 1.46 to TULC growth, and 0.18 to the change in TLS. Symmetrically, the mean effect over the simulation period of the 1995-2005 productivity growth revival was to subtract 1.19 percentage points from the inflation rate, 1.38 points from TULC growth, and 0.19 points from the change in TLS. These results are consistent with our simple model in Part II. A sustained productivity growth acceleration shifts labor's share down and a sustained productivity growth slowdown shifts labor's share up, explaining part of the sharp jump in labor's share observed in the NIPA data for 1966-71. The second and fourth columns show that these productivity effects continue to grow, so that after 15 years the post-1965 productivity

growth slowdown had caused the inflation rate to be 2.68 higher than otherwise, and after 10 years the post-1995 productivity growth revival had held down the annual inflation rate by 1.7 percentage points, with even greater effects on the change in TULC.

## **VI. Changes in the income distribution.**

While macro models that deal with aggregate income shares are informative and important for understanding trends in compensation, they say very little about the welfare of the majority of the population. Part II showed how labor's share of income is altered in identical ways by changes in either wages or prices. For the income distribution though, price changes and wage changes mean very different things. Inflation is by its nature egalitarian. In principle, everyone is affected equally, and the distribution of income is entirely independent of price changes.

On the other hand, an increase in the growth of compensation per hour can have a multitude of effects on the income distribution. If the distribution of hours worked stays fixed, workers may still have divergent experiences in their hourly pay. While changes in the mean of the distribution of income are interesting, so also are changes in the median and skewness of the distribution. Part III hinted at this issue by looking at the gap between overall NIPA-based compensation per hour and average hourly earnings for production and non-supervisory workers. The basic framework through which we will view changes in real income in each income bracket is that they are determined by changes in hours worked, nominal compensation

per hour, and the price level.

The distribution of capital income may also change. Corporate profits and other forms of after-tax capital income eventually end up in the personal income accounts as dividends, rents, and interest accruing to owners of capital. The distribution of these payments affects the aggregate income distribution just as do wages and salaries. In order completely to describe the changes in the income distribution then, we examine changes in the distribution of labor and non-labor income separately, and then put them together to come to a conclusion about who has reaped the benefits of the post-1995 acceleration in productivity growth.

### **Data Issues**

For every year between 1966 and 2001 that IRS has released data on income tax returns from over 100,000 filers. These returns oversample those at the very top of the distribution so that one can study the distribution at the level of the top 0.1 percent (one-tenth of one percent) or even the top 0.01 of one percent. There are two main problems with counting returns. The first is that each return is unlikely to represent a single person. In every year for which we have data, it has been advantageous for married couples to file jointly. Many couples obviously have children too. Every piece of information we provide in this part of the paper refers to these tax units, not to individuals. Luckily, according to Piketty and Saez (2004), the number of people in each tax unit is not dependent on income, so conclusions about tax units should also hold generally for individuals or households.

The second issue is that not everybody is required to file tax returns, since some people have such modest incomes that they are not required to file. We therefore follow Piketty and Saez's method of counting the total number of tax units in the economy by adding the total number of married couples and non-married men and women over the age of eighteen. Total tax units and total returns filed are reported in Table 7. Tax returns have consistently accounted for over 90 percent of tax units. Given that those who do not file necessarily have very little income, and only account for five to 10 percent of the population, the data provided by the IRS micro files allow us to obtain a very accurate snapshot of who earns how much income in each year over the 1966-2001 interval. Table 7 also shows how many tax units reported wage income each year, and how many hours were worked per tax unit. There is obviously a large amount of variance in this measure, but we use it to illustrate general trends in hours worked, and it will become important when comparing IRS compensation growth to growth in output per hour.<sup>32</sup>

Disappointingly, income is not always faithfully reported to the IRS. Every year, the BEA publishes data comparing its estimates of the amount of income that should be reported to the IRS, and what is actually reported on tax returns. And in each year, the gap between the IRS and BEA measures of adjusted gross income (AGI) ranges between 9 and 13.5 percent. For wages, because nearly all wage earners file tax returns, and because their wages are reported by

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<sup>32</sup> Juhn, Murphy, and Topel (2002) find that many former income earners have dropped out of the labor force and thus appear neither in wage data nor in our IRS tax data. They do, however, continue to consume, providing one of many reasons for the greater equality of consumption than of income, as we discuss in Part VII below.

their employers, this gap is smaller, and is never greater than 6 percent.<sup>33</sup> We make no adjustments to wages for misreporting, and simply assume that misreporting is equally distributed across income levels.<sup>34</sup>

### The Distribution of Labor Income

Figure 8 shows that the distribution of the wage and salary income reported to the IRS has changed drastically over the past 40 years. It displays the percentage of wage income that accrues to selected quantiles of wage earners. The broadest measures of income are the 20-50 and 50-80 quantiles. Their shares have declined significantly over the data interval. The 20-50 quantile started with 17 percent of wage income, and by 2001 had fallen by nearly a fifth to a 13 percent share. The 50-80 quantile also fell about one fifth, from 36 to 30 percent.

Since income share changes are zero-sum, Figure 8 also identifies the quantiles that have gained. The 80-90 quantile stayed approximately constant, rising from 12.3 to 13 percent. But the 95-99, 99-99.9, and 99.9-100 quantile shares rose by 29 percent, 73 percent, and 291 percent, respectively. Of the 11 percentage points of the income share lost by the bottom 90 percent between 1966 and 2001, one point accrued to the 90-95 quantile, and approximately three points accrued to the remaining three quantiles above the 95<sup>th</sup> percentile.

The top section of Table 8 summarizes the changes in the shares of the quantiles. While income shares are useful for comparing relative incomes, knowing the total amount of income

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33. Park (2002), Table 3.



accruing to each quantile is more helpful for analyzing changes in welfare, and particularly our central topic in this paper, the response of individual real incomes to the post-1995 revival in productivity growth.

The bottom section of Table 8 displays the total real amount of wage income (in billions of 2000 dollars) going to each of our selected quantiles, and its raw change between 1966 and 2001.<sup>35</sup> Of the total increase in real labor income of over 2.8 billion dollars, less than 12 percent went to the bottom half of the income distribution.<sup>36</sup> More income accrued to the top one percent than the entire lower 50 percent. It is difficult to compare these data to the macro data on compensation and output per hour summarized in Part III, because it is likely that those in the bottom of the income distribution work fewer hours than those towards the top. Nevertheless, the aggregate increase in compensation since 1966 seems to have gone to a very small subset of the population.

Figure 9 shows how much of the increase in real compensation between 1997 and 2001 went to each quantile. There is a lot of symmetry here. The 90-95 and 20-50 slices are approximately the same size. The slices representing the bottom 80 percent and the top 5 percent are approximately the same size (36.1 percent and 38.2 percent, respectively). The

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34. One is tempted to assume that misreporting is more prevalent among the rich, who have the means with which to do it legally, and the incentive to do it illegally. If this is so, then our estimates of top income shares can be viewed as a lower bound.

35. Every inflation-adjusted number in this section of the paper is calculated by using the PCE deflator, not any version of the CPI.

36. The \$2805 billion estimate for the total increase in real wage income matches nicely with the BEA reported change of \$3080 billion given the decline in the percentage of BEA wages reported to the IRS

shares of wage growth in recent years are distributed approximately the same way over the past 35 years.

A careful reader might note here that tax units are not the same as households, and since there are an average of 1.3 tax units per household, it is possible that the average household might have one tax unit that is earning very little, say an eighteen year old high school senior, and one tax unit, his or her parents, that is in the upper half of the distribution and has reaped greater gains. While this is possible, it cannot apply to most households, since the average number of units is only 1.3, and the minimum is obviously one.

The top section of Table 9 shows the actual levels of wages and salaries at each percentile, their changes between 1966 and 2001, and the skewness of the wage distribution. Since skewness is unaffected by the magnitude of the values in the distribution, it can be used as a consistent measure of changes in inequality over time. The most notable result here is that the median real wage has risen by only 11 percent in 35 years. That is an average real gain of 0.3 percent per year. Compare this to average productivity growth of 1.57 percent for the entire economy, somewhat slower than the 1.74 percent growth rate for 1966-2001 for the NFPB sector. As would be expected from the discussion of shares so far, real incomes in the higher quantiles have risen much more, with the 99.9<sup>th</sup> percentile growing at an average rate of over 3.4 percent. Skewness tells the same story, rising from 11 in 1966 to 319 in 2001. Measured skewness is fairly volatile since it is heavily influenced by the top few observations which are many orders

of magnitude above the mean, but it has unambiguously risen an enormous amount over our sample.

Since 1966, NIPA wages and salaries have comprised a steadily smaller portion of NIPA total compensation, as the share of fringe benefits has steadily increased. In order to correct for this, we multiply the data in the top section of Table 9 by the factors necessary to correct the percentiles after 1966 for the decline in wages' share of total compensation reported in the NIPA. This adjustment does not assume that every percentile has the same amount of its compensation come in the form of wages, but simply that the relative decline of wage and salaries has affected every percentile in the same proportion. The last column in the bottom of Table 9 displays the wage share of compensation.<sup>37</sup> The reason we make this adjustment is that the average growth rates of the raw percentiles cannot be compared to productivity growth, when we know that wages and salaries have grow slower than total compensation.

The bottom section of Table 9 displays two measures of income change. The first is just the cumulative percent growth over the data period. The second line converts this change into an annual percentage growth rate. The third line displays "hours adjusted" growth, which adds 0.22 percentage points to the growth rate of each percentile to account for the decline in hours per tax return noted in Table 7. We make no assumptions about the distribution of the change in hours, we simply show what compensation growth would have been had there been no general decline in hours per tax unit. With these adjusted growth rates, we can compare the

changes in each percentile to changes in overall productivity. In the full economy, productivity growth has averaged 1.57 percent (as opposed to 1.74 percent in the NFPB sector). Since labor's share has been approximately constant over this time, our benchmark for compensation growth is therefore 1.57 percent. In the bottom of Table 9, which percentiles grew at the average rate of productivity growth of 1.57 percent or at a higher rate? Which part of the wage distribution received the average increase in compensation that would be expected? Our answer is that *nobody below the 90<sup>th</sup> percentile received the average rate of productivity growth*. Even the 80<sup>th</sup> percentile, even after adjusting their wages upwards for fringe benefits and hours, has had less income growth than productivity data would imply.<sup>38</sup>

Even the 90<sup>th</sup> percentile has only outpaced average productivity growth by only 0.20 percentage points. The 99<sup>th</sup> and 99.9<sup>th</sup> percentiles, in contrast, have done fantastically well, a true "Golden Age" for the top earners worthy of the Robber Barons of the 1890s or the Gilded Age of the 1920s.<sup>39</sup> Their hours-adjusted compensation has grown by 1.15 and 2.35 percentage points faster than productivity, respectively. It makes sense to wonder if there are any factors in the data that could explain away some of this extreme concentration. One issue is how nominal values are deflated. Productivity is deflated using the GDP deflator, while income data use the PCE deflator. The gap between the two averages 0.06 percentage points over 1966

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35. We also experimented with adjusting between the gap in ECI wages and total compensation for various subsets of employees, but the adjustments are very similar, and no major results are changed.

38. We didn't initially believe this result, but similar analysis of data reported in Piketty and Saez (2004), Table B3, gives similar results. The difference between their results and ours are due to differences in counting total returns.

to 2001. In a mechanical sense, this explains a small amount of the gap between measured compensation and productivity. On the other hand, we argue that compensation is correctly deflated by the PCE deflator, and therefore we quote adjusted compensation growth according to it and compare it to real productivity growth.

Part of the discrepancy is also explained by the fact that IRS wages and salaries account for a smaller amount of NIPA wages and salaries than in the past. If the undeclared income were spread uniformly over all returns, then average growth would rise by 0.07 percent, an insignificant amount compared to the gap between compensation and productivity for lower percentiles. On the other hand, all unreported income could be going to people who do not file returns. In this case the growth of the median would likely be unchanged, or even decrease. Interestingly, the .13 percent that could be added to compensation to account for missing income and different deflators is offset by the .13 percent per year that compensation growth would be expected to outpace productivity growth to account for the rise in labor's share between 1966 and 2001.

The number of workers per household might also have some effect on the distribution. If over the 1966-2001 period previously stay-at-home moms were entering the labor force, as doubtless happened, then hourly compensation growth would be overstated if translated directly from total compensation, because there would be more workers per tax unit. But the

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37. Piketty and Saez (2004) examine in more detail the recovery of top wage shares after the Great Depression and World War II.

hourly adjusted numbers should account for any effects along these lines by making sure the data account for all the hours in the economy.

Part of the problem here is that workers are probably moving upwards across the income distribution as they get older. So the percentiles could stay fixed, but individuals could still be gaining each year and moving across the percentiles.<sup>40</sup> But this does not seem to be an adequate explanation. Workers expect to move across the distribution over their working lives. Productivity growth would be expected to move that distribution, not accelerate people's shifts across it.

Even if we look at the growth in the income of individual tax units, examining a separate set of IRS panel data from 1979 to 1990, the median growth rate, after accounting for changes in hours per tax unit and wages as a share of compensation, only rises by 0.34 percent per year. This is compared to a change in median income of -0.38 percent per year, and economywide productivity growth of 1.41 percent for the 1979-90 interval. The panel data cover only a small sample of tax returns and years, but they show that even after taking an overly generous measure of income growth, the median does not keep up with productivity.

This all confirms what was noted in a more general form in Part III: the broad middle of working America has reaped little of the gains in productivity over the past 35 years. Labor income, not just capital income, has become increasingly concentrated at the top of the income

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distribution. Those who live at the median have not seen their incomes rise nearly as fast as productivity growth would superficially imply.

### Capital Income

We deal with five general types of capital income: interest, dividends, rent, business, and pension income. Unlike wages and salaries, these income sources cannot be directly mapped to NIPA personal income tables in any productive way, for two main reasons.<sup>41</sup> One is that much income covered by the IRS, such as small business income, is not in the NIPA's. The second is that there is a larger discrepancy between IRS reported income and its BEA equivalent for non-labor income than for wages and salaries (see the discussion on p. 54 above).

The data on non-labor income includes many tax filers who declare losses. Since nobody would stay in business if they were losing money every year, we assume that losses are a one time event, and therefore only serve to distort our measures of the concentration of income. On the other hand, farm income tends to amount only to losses, that is, the average declared farm income is less than zero, so we completely ignore farm income. By ignoring losses, we make the assumption that year-after-year losses are not economically meaningful but rather reflect opportunities provided by the tax system for middle-income and upper-income people to shelter income from taxes. These losses are not what we mean by "poverty" and are

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41. The BEA does provide comparisons of BEA and IRS equivalent measures of income, but the detailed breakdowns are not available for every year, and much of the reconciliation, especially for non-labor income, is simply defined as "income not included in personal income," which is not helpful for the present analysis.

economically different from the situation of those who earn only wage income and are in the bottom 20 percent of the distribution.

Table 10 provides data on real income for quantiles ranked by total income, including both labor and nonlabor income, as contrasted to the ranking based only on labor income in Table 8. As we would expect, this ranking makes income gains look much more concentrated than wages are. Nearly as much of the 1966-2001 real income change went to the top 0.1 percent as went to the bottom 50 percent. The next two panels decompose income into labor and non-labor income. Comparing shares of changes, the data for all three measures of income are roughly similar for the bottom 80 percent, but then diverge sharply for the top 20 percent. The top 1 and 0.1 percent have a far higher share of new non-labor income than wage income. Every other quantile takes a smaller share of non-labor income than total income.

Looking at the bottom section of Table 10, we can see that common sense holds, and as one moves up the income distribution, a larger share of total income tends to be accounted for by non-labor income. Interestingly though, over time, non-wage income has worked its way down the income distribution. The top quantiles have taken most of new non-labor income, but the lower quantiles, especially 50-80 and 80-90, have seen a much larger percentage of their incomes accounted for by non-labor income, while for the top 5 percent, this proportion has declined. In 1966, 72 percent of the income of the top 0.1 percent came from non-labor sources. By 2001 it was only 60 percent. For the 50-80 quantile, the share rose from 10 percent to 18 percent, nearly doubling. So there are two conflicting trends. One, the majority of new non-



labor income, 59 percent, goes to the top 10 percent of the distribution. But on the other hand, non-labor income is taking a smaller share of income at the top, and a larger share in lower quantiles. It is clear that a similar story is told by the full income distribution as the wage distribution. Most income gains have gone to the top of the distribution, and for non-labor income, the gains are even more concentrated than for wages.

Figure 10 shows how the distribution of gains looks for the top 10 percent in the top frame and the top 0.1 percent in the bottom frame. The top decile tends to take about the same share of added labor and non-labor income, but the top centile takes a much larger share of non-wage gains. It is notable how different the bars for 1979 to 1997 and 1997 to 2001 look from those for 1966 to 1979. Income growth was much more unequal after 1979 than before. Regardless, just as in Figure 9, we see that about 50 percent of income gains go to the top ten percent of the income distribution.

There are two general pieces of information to be taken from this analysis of IRS data. First, the top of the income distribution takes most capital income, but the amount of top earners' income that comes from non-wage sources has declined over the years. Second, growth in labor income has been highly concentrated. As much of the increase in wage income since 1966 has gone to the top 10 percent as to the bottom 80 percent. Moreover, only the top 10

percent has kept up with productivity growth. The IRS micro data give lie to the common impression that productivity growth is a boon to all workers.<sup>42</sup>

## VII. Extensions and Implications

Our main findings in Part VI were that a disproportionate fraction of labor, nonlabor, and total income growth during 1966-2001 and during the 1979-1997 and 1997-2001 subperiods went to the top tiers of the income distribution, and that growth in real median income stagnated. These results raise at least three classes of questions. This part of the paper raises these questions and relates them to selected research in the large literature on income mobility, consumption inequality, and the sources of income inequality.

First, the stagnation of median income in our IRS data refers to the median of a series of annual cross sections of taxpayers. It does not imply stagnation for any single taxpayer if there is sufficient income mobility across taxpayers. For instance, taxpayers may find themselves with below-median incomes when they are young and then advance into higher quantiles as they climb the age-earnings profile. Also, independent of age, income gains may have a strong transitory component so that different people find themselves at the top and bottom of the income distribution in successive years. Thus our first task in this section is to examine previous evidence about the nature of income mobility.

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<sup>42</sup> Our results are complementary to those of Kopczuk and Saez (2004), who in their Figure 9 show that the increase in the share of total income for the top 0.01 percent over the period 1976-2000 consists almost entirely of salary and professional income rather than income from capital and capital gains. Comparing 2000 with 1929, the share of the

A second issue raised by Part VI is the apparent conflict between the stagnation of real median earnings during 1966-2001 and the evident increase in consumer well-being over the same period along virtually every dimension including size and quality of housing, number and quality of motor vehicles, household possession of appliances and electronic goods, educational attainment, and longevity. A partial answer might be that the inequality of consumption expenditures across households might not have increased along with rising income inequality. Recently a literature has developed on consumption inequality, and in this section we summarize its main findings and also raise questions.

A third issue is to determine the sources of increased income inequality that has resulted in our apparent finding that the rewards of the recent productivity revival have gone mainly to the top of the income distribution. The economics literature has analyzed the sources of increased income inequality within a traditional supply-demand framework, emphasizing “skill-biased technical change” that has increased the relative demand for high-skilled workers. A complementary strand of the literature has pointed to increased supply of low-skilled workers through at least three channels, increased low-skilled immigration, increased competition from foreign workers embodied in imports, and a steady weakening in the power of labor unions. While accepting parts of this traditional analysis, we go beyond it in our examination of the causes of increased incomes at the top of the distribution.

### **Income Mobility**

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top 0.01 percent was similar at 3.5 percent, but a much larger share in 1929 took the form of capital income and a

Doubts can be raised about the significance of any findings regarding income inequality that are based on a cross-section of individuals who occupy different places in the income distribution from year to year. First, there is an obvious dependence of income on age, with low incomes for youth, higher incomes in the prime earning ages, followed by zero labor income following retirement. A typical MBA student might report wage and salary income from a summer internship of \$5,000 in one tax year but report income of \$120,000 two years later and \$500,000 ten years later. Further, wage and salary incomes of taxpaying units fluctuate from year to year for many other reasons besides age and life cycle reasons, including unemployment, movement in and out of the labor force in response to childbirth or illness, and fluctuations in sales commissions and bonuses in response to changes in national, local, or individual economic circumstances. Going beyond wage and salary income to total income, a host of additional reasons create transitory fluctuations of income, including good or bad harvests for farmers, vacancies that cut the rental income of landlords, financial market fluctuations that change incomes of those dependent on income from interest and dividends, and even fluctuating sales for textbooks written by economics professors.

How much do such factors cause our previous analysis to overstate the increase in inequality? Mishel *et. al.* (2005, p. 73) cite a useful analogy from Joseph Schumpeter of a hotel where the quality of rooms improves the higher the floor. How many people over their lifetimes occupy both basement and penthouse rooms, as contrasted to a totally immobile

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much smaller share the form of salaries and professional income.

society in which some remain stuck in the basement all their lives while others luxuriate permanently in the penthouse?

Evidence provided by Bradbury and Katz (2002) shows clearly that there is substantial income mobility across income quintiles over decade-long periods in the 1970s, 1980s, and 1990s. It would be surprising if this were not true, given the simple life-cycle factors evident in the example of the MBA student and the complementary retirement of his or her business executive father. Examples like the MBA student account for those who started in the basement (the bottom 20 percent) in one year and wound up in the penthouse (the top 20 percent) ten years later, but this basement-to-penthouse decadal transition occurred for only 3.3 percent of basement-dwellers in 1969, 3.2 percent in 1979, and 4.3 percent in 1989. Stories like Daddy's retirement, or his Enron-like or Worldcom-like transition from the penthouse to jail, account for 5.0, 4.2, and 3.0 penthouse dwellers in 1969, 1979, and 1989, respectively. Overall, the Bradbury-Katz evidence shows no increase in income mobility alongside the increase in income inequality, and indeed there were small increases in the penthouse dwellers who remained in the penthouse a decade later – 49.1 percent in 1969, 50.9 percent in 1979, and 53.2 percent in 1989.

In short, income mobility due to life-cycle and other reasons is a constant feature of any economy. No one person is the median taxpayer or wage-earner forever. The important fact about income mobility is that it takes place *independently* of the quite new phenomenon of increased skewness of the distribution of labor in the 1980s and 1990s. Not only are half of the

penthouse dwellers still there a decade later, but the differential of opulence in the penthouse relative to the basement as measured by the skewness statistics in the top section of Table 9 keep increasing.

### **Consumption Inequality**

If income for the median taxpayer has increased so slowly, only 0.76 percent hours-adjusted in the bottom part of Table 9, how has the average American household succeeded in so substantially increasing its standard of living over the past four decades? Only a cursory look through the pages of the *Statistical Abstract of the United States* and the literature on quality change will reveal significant increases in the size and quality of housing, the number and quality of automobiles per household, the number and quality of household appliances, including the spread first of room air conditioners and more recently central air conditioning, the enormous improvement of television sets and the invention of electronic devices not dreamed of in 1966, and less tangible dimensions of advance, including the transition of women from the home to the workplace, the advance of women in the professions, the overall increase in educational attainment, and the increase in longevity. A skeptic might say "Why worry?" The average American household is doing just fine, thank you.

These observations raise three questions. The first is whether real consumption could increase faster than measured real income. The second is why consumption inequality is so much lower than income inequality. The third and more difficult question, with which

economists have recently wrestled, is whether consumption inequality has increased at all, much less at the same pace as income inequality.

The evidence on rising household possession of more and better housing and consumer durables can be at least partly explained by price index bias. While the 1995-96 Boskin Commission suggested that the CPI was upward biased by 1.1 percent per year at that time, its estimates suggested an even higher 1.5 percent rate of bias prior to 1992. The bottom line of Table 3 above shows that the PCE used to deflate our IRS income measures increased during 1966-2001 at roughly 0.4 percent per year less than the CPI, implying a rate of PCE bias of between 0.7 and 1.1 percent per year. Much of this bias relates to quality improvements in durable goods and invention of new products whose attributes are not captured by price indexes, providing a simple explanation of the impression that real household welfare has increased substantially even if income deflated by conventional price indexes has increased much less.

Perhaps the easiest of these questions is why consumption inequality is so much less than income inequality. By one measure based on the Consumer Expenditure (CE) survey from Krueger-Perri (2002, Table 1, p. 8), the ratio between the 90<sup>th</sup> percentile and the 10<sup>th</sup> percentile, the so-called 90-10 ratio, consumption inequality was roughly one-third of income inequality in 1997-98.<sup>43</sup> Even a novice with no economics training could think up a long list of reasons why consumption inequality is so much lower than income inequality. Transfers across age groups

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<sup>43</sup> Krueger-Perri (1992) compute a 90-10 ratio of 9.13 for income and 3.35 for consumption.

head the list, including consumption out of social security, saving, and pensions for retirees with no wage income, bequests, cash and in-kind gifts from parents to children, grandparents to grandchildren, and parents to grandparents (including the ultimate in-kind gift of allowing one generation to move in and live with another generation, whether adult children living with their parents or aged grandmothers moving in with her children). Saving and debt helps households smooth across Friedman-like fluctuations in transitory income and Modigliani-like changes of income over the life cycle. Bankruptcy allows some low-income households to consume more than their income over the life-cycle. Price index bias and the sources of consumption smoothing interact to create a surprisingly high apparent standard of living for many individuals in the bottom 50 percent of the income distribution.<sup>44</sup>

The most difficult of the three questions is whether the inequality of consumption has increased in tandem with the inequality of income. There is an active debate in the economics literature which has not yet been resolved. Krueger-Perri (2002) claim to have shown that consumption inequality did not increase over the 1972-98 period when income inequality increased substantially, and they explain this apparent contradiction by the endogenous emergence of credit markets which allow an increased degree of consumption smoothing. But Attanasio, Battistin, and Ichimura (ABI, 2004) raise a measurement issue involving the separate interview and diary methods of the CE survey. Their carefully merged hybrid measure shows a substantial increase of consumption inequality between 1986 and 2001. Another paper by

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<sup>44</sup> We never cease to be amazed when a cleaning woman arrives at our house in her own car from a single-family



Krueger and Perry (2003) takes a broader view of welfare inequality which includes both market consumption and leisure, and they also find a substantial increase of inequality, partly due to an increase in hours of work and decrease of leisure for low-income individuals.<sup>45</sup>

We are struck at a basic defect of this literature as it relates to measuring consumption inequality involving the top 10 percent of taxpayers who have accrued most of the income gains in Table 10 and Figure 11. ABI (2004, p. 13) report that their study (as well as that of Krueger-Perri and others) omits many of the consumption categories that differentiate the upper-income households from the rest, including expenditures on all consumer durables, housing (including both rent and imputed rent for owner-occupied dwellings), health, and education. It is as if a median income suburbanite was being compared to an imaginary Barbara Walters purely on the criterion of her expenditures in the grocery store, drug store, and clothing store, without taking any notice of Barbara's Fifth Avenue apartment worth \$10 million, her second house in the Hamptons, her limousine that is available to drive her to work, the private school or elite Ivy-league university to which she sends her daughter, or the exclusive medical clinics that she is able to visit while lower-income Americans wait for care in hospital emergency rooms. Further, in using consumption instead of income as a source of welfare, this approach neglects the welfare benefits of simply having a high income without consuming it at all, including the ability to donate money to put one's name on wings of hospitals or college professorships, and

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house, brandishing a cell phone, in contrast to the 1960s when she would arrive by bus from an apartment in the inner-city ghetto.

<sup>45</sup> An excellent discussion of the role of data inconsistencies in compromising Krueger-Perri's (2002,2003) finding of no increase in consumption inequality is provided in the discussion of their 2003 paper by Steven J. Davis.

the role of large charitable contributions as a social “glue” that brings together like-minded rich people in their Gilded Age society of benefit balls and parties.

### **Causes of Increased Income Inequality**

Whatever their thoughts on consumption inequality, nobody debates that income inequality has increased in the United States over the past three decades. There is a substantial consensus in the economics literature, of which Acemoglu, Aghion, and Violante (AAV, 2001) is a prominent example, that the primary cause of increased inequality is “skill-biased technical change”. Labor economists point to other factors that are consistent with rising inequality, including the diminishing power of unions and the decline in the real minimum wage.

To be convincing, a theory must fit the facts, and the basic facts to be explained about income equality are not one but two, that is, not only why inequality rose after the mid-1970s but why it declined from 1929 to the mid-1970s.<sup>46</sup> Three events fit neatly into this U-shaped pattern, all of which influence the effective labor supply curve and the bargaining power of labor: (1) the rise and fall of unionization, (2) the decline and recovery of immigration, and (3) the decline and recovery in the importance of international trade and the share of imports. Unions rose and declined in part because of the encouragement by government legislation in the 1930s and increasing discouragement in the postwar years. In addition, the invention of air conditioning facilitated the dispersion of employment into the Old Confederacy with their

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<sup>46</sup> The most vivid representation of the U-shaped historical pattern of income inequality is Kopczuk-Saez (2004, Figure 9), which shows the income share of the top 0.01 percent and its composition across labor and capital income. This share fell from 3.7 percent in 1929 to 0.6 percent in 1976 and then rose to 3.6 percent in 2000.

“right to work” laws, and the steady decline in the share of employment in manufacturing and mining in light of the failure of unions to organize employees in the service sector. Partly as a result of restrictive legislation in the 1920s, and also the Great Depression and World War II, the share of immigration per year in the total population declined from 1.3 percent in 1914 to 0.02 percent in 1933, remained very low until a gradual recovery began in the late 1960s, reaching 0.48 percent (legal and illegal) in 2002. Competition for unskilled labor not only arrives in the form of immigration but also in the form of imports, and the decline of the import share from the 1920s to the 1950s and its subsequent recovery is a basic fact of the national accounts.

Going beyond the decline of unionization, the rise of immigration, and the movement toward free trade, economists are naturally attracted to the idea of skill-biased technical change (SBTC), because it allows them to use their tools of supply and demand to explain rising income inequality. However, the SBTC hypothesis fails the plausibility test, because it fails to explain the absence of an increase of income in equality in Europe despite the free flow of technology across borders.<sup>47</sup> Another problem for the proponents of the SBTC hypothesis is that inequality increased fastest during the 1977-92 period when productivity growth and presumably technical change was slowest.

Our analysis of the IRS data in Part VI suggests that most of the shift in the income distribution has been from the bottom 90 percent to the top 5 percent. This is much too narrow a group to be consistent with a widespread benefit from SBTC. The rise of inequality at the top

ratifies the genius of the late Sherwin Rosen, whose 1981 article “The Economics of Superstars” explains most if not all of the increase in inequality in the top narrow slice of the income distribution, as long as the definition of a “superstar” is broadened to include not just the usual entertainment and sports figures to include CEOs of corporations.

If SBTC had been a major source of the rise in inequality, then we should have observed an increase in the relative wages of those most directly skilled in the development and use of computers. Yet in the 1989-97 period [to be updated] total real compensation of CEOs increased by 100 percent, while those in occupations related to math and computer science increased only 4.8 percent and engineers decreased by 1.4 percent.<sup>48</sup> Again, Europe provides perspective, because the increase in the ratio of CEO pay to average worker pay so evident in the United States has not occurred in Europe.

CEOs together with sports and entertainment stars explain what is going on in the top 1 percent of the income distribution, as documented in Part VI above. The top 100 entertainment stars have incomes of \$10 million or more, according to *Forbes*. Major sports figures who would have earned six-figure salaries 30 years ago now earn eight-figure salaries. Why have these multiples expanded? Ironically, the underlying cause may have been technology, but not the kind of computer-based technology imagined by the proponents of SBTC. The impetus to higher superstar incomes include the invention of television, cable television, CDs, VCRs,

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<sup>47</sup> For the latest data on the change in inequality in the U. S. vs. European countries, see Mishel *et. al.* (2005, Chapter 7). For an attempt to develop theories of how European institutions distort the evolution of technical change, see Acemoglu (2002).

DVDs, and the other equipment that has made American superstars household names not just within the U. S. but in most of the rest of the world. In this discussion, we treat CEOs as superstars, enjoying a halo of reputation that leads a board of directors to shower him or her with tens of millions of compensation, often without regard to performance, when an equally capable but less famous alternative might have been willing to do the job at one-tenth the compensation. This approach to understanding inequality of labor income as in Tables 8 and 9 is then compounded by high capital income of the top quantiles as they invest the fruits of their superstar labor in financial and real assets.

## VIII. Conclusion and Further Research Agenda

This paper started as a detective story titled “Where Did the Productivity Growth Go?” We have conducted a detailed search, worthy of Sherlock Holmes or Columbo, to locate the effects of the post-1995 productivity revival, with a partial parallel search for the effects of the post-1965 productivity growth slowdown.

### The Stunning Micro Conclusion

A basic tenet of economic science is that productivity growth is the source of growth in real income per capita. Productivity is the seed that creates the flower of a nation’s standard of living. But our results raise doubts, that we find surprising and even shocking, about the validity of that ancient economic paradigm.

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<sup>48</sup> These numbers come from Mishel *et. al.* (1999, Table 3.50, p. 210), to be updated in the next version of this paper.

Doubtless our most surprising result is based on our extensive study of the large IRS micro data set that provides a relatively accurate and complete description of the evolution of income by source over time. We examine labor and nonlabor income separately and combine them into total income, excluding negative declared nonlabor income and also excluding capital gains. The standard link between the standard of living and productivity growth is broken by our finding that over the entire period 1966-2001, which encompasses the period of the 1965-1979 productivity growth slowdown and subsequent 1995-2005 productivity growth revival, *only the top 10 percent of the income distribution enjoyed a growth rate of total real income (excluding capital gains) equal to or above the average rate of economywide productivity growth.* The bottom 90 percent of the income distribution fell behind or even were left out of the productivity gains entirely. Over the more recent 1997-2001 period in which productivity growth accelerated, fully 49 percent of real income gains were earned by the top 10 percent of the income distribution.

Another way to state our main results is that the *top 1 percent* of the income distribution accounted for 21.6 percent of real total income gains during 1966-2001 and 21.3 percent during the productivity revival period 1997-2001, again excluding capital gains. Still another and perhaps even more stunning way to describe our results is that the top one-tenth of one percent of the income distribution earned as much of the real 1997-2001 gain in wage and salary income, excluding nonlabor income, *as the bottom 50 percent.* In developing these results, we have used the raw observations from the IRS data file and made numerous adjustments for incomes

earned by those at the bottom who are not liable to file, and those at the top who report negative income on such returns as Schedule C and Chapter S corporations.

Our results show that the dominant share of real income gains accruing to the top 10 percent and top 1 percent is almost as large for labor income as for total income. This contradicts those economists who believe that growing inequality is entirely a matter of the dominant share of wealth and capital income at the top, as for instance Philip Swagel who recently stated “It looks like the gains from the recovery haven’t really filtered down . . . The gains have gone to owners of capital and not to workers” (quoted in Leonhardt, 2005, p. A14). It is not that all the gains went to capital and none to labor; rather, our finding is that the share of gains that went to labor went to the very top of the distribution of wage and salary incomes.

Previous papers, especially Piketty-Saez (2004) have documented the ups, downs, and ups of income inequality over the twentieth century. However, ours is the first to create a direct link between macro productivity growth and the evolution of individual real incomes at the micro level. The post-1995 productivity growth revival did not automatically signal good news for the majority of American workers and households. Indeed, to the extent that the productivity growth “explosion” of 2001-2004 was achieved by cost-cutting, layoffs, and abnormally slow employment growth (as suggested in Gordon, 2003), then the historical link between productivity growth and higher living standards falls apart. Not only have the bottom 90 percent of American workers failed to keep up with productivity growth, many have been harmed by it.

## The New Macro Analysis

As fascinating as are the micro data conclusions of this paper, the macro analysis provides an important advance along several dimensions in the longstanding literature on inflation and wage dynamics. The most important result directly related to our topic, “where did the productivity growth go?” is that an acceleration or deceleration of the productivity growth trend alters the inflation rate by at least one-for-one in the opposite direction. This is an impact of the *change* in the rate of trend productivity growth and dies out if trend productivity growth stabilizes at a new level, e.g., accelerating from 1.5 to 3.0 percent in the decade after 1995. Symmetrically, the post-1965 acceleration of inflation that is usually attributed to Vietnam-war excess demand was at least in part caused by the first part of the post-1965 deceleration of productivity growth, the infamous “productivity slowdown” that economists have so notably failed to explain to anyone’s satisfaction. Counterfactual simulations of our econometric model suggests that the 1965-80 slowdown in productivity growth boosted inflation on average by 1.3 percentage points on average during the 1965-80 simulation period, while the 1995-2005 revival of productivity growth held down inflation on average by 1.2 percentage points over the 1995-2005 period.

Linking the macro and micro analysis, a deceleration of inflation caused by a productivity growth revival is good news for everyone. But it does not overturn or in any way conflict with the story of this paper’s micro analysis. For a bottom-group wage earner with a real income growth rate after 1995 of 0.5 percent, that real income growth rate would have been



-0.5 percent without the productivity growth revival. For a top-group wage earner with real income growth of 4.0 percent, the absence of the productivity growth revival would have reduced that to 3.0 percent. There were no distributional consequences of the inflation impact of the productivity growth revival (and 1965-80 slowdown), yet that inflation impact made a strong contribution to macroeconomic stability and the conduct of monetary policy.

The paper includes important results about price and wage dynamics that provide an antidote to much research published over the past decade asserting that the Phillips curve is dead, or (as in the so-called New-Keynesian literature) that the inflation process can be modeled by simplistic equations with short lags and no supply shocks. The basic “mainstream” inflation equation is extremely stable and easily passes Chow tests for instability more than two decades after it was originally specified. We provide strong evidence that the slope of the Phillips curve has *not* shifted, and that any such conclusion is based on fitting naive equations with missing lags and missing supply shock variables that are highly significant by every conventional statistical criterion, including not just goodness of fit but also performance in post-sample dynamic simulations.

Much of the literature on inflation dynamics over the past two decades has focused on reduced-form inflation equations with no explicit mention of wages. This paper revives research on wage adjustment in a form that has not appeared in previous research. Wage equations should involve the same variables as price equations. Prices should influence wages, and wages should influence prices. The channel of transmission between the wage and price

equations should explicitly involve productivity growth, as in the “trend labor share growth” variable that is introduced in this research.

The paper achieves a unified treatment of the effect of a hypothetical productivity trend growth revival, as in 1995-2005, on the key macro variables – inflation, nominal and real wage growth, and labor’s income share. We show in Part II that lagged responses may cause substantial changes in labor’s income share after a permanent productivity growth revival or slowdown, but that the empirically observed data feature of a long-term stable labor’s share can be preserved by adding a modest amount of error correction in the form of a response of both inflation and wage change to sustained changes in labor’s income share. The counterfactual implications at the end of Part V show that the post-1965 productivity growth slowdown caused an increase in labor’s income share and the post-1995 productivity growth revival caused an increase in labor’s income share.

### **Policy Implications of Increased Skewness**

The new evidence in this paper on the large share of productivity gains accruing to the top narrow slice of the American income distribution brings us to policy. The enormous increase in skewness suggests a simple policy recommendation as a solution to many of America’s problems. As Henry George (1879) taught us, the optimal tax base is pure rents. The top 1percent of the American income distribution has earned most of the gains of the post-1995 productivity growth revival. These superstars earn pure rents, in the sense that they are earning many multiples of what they could earn in the best alternative occupation. They will

not reduce their economic contribution if we raise their taxes. If the top rate tax bracket were raised from 33percent to 50percent, would Tom Cruise stop making movies or Oprah cancel her program? Of course not.

As Bob Hall once taught one of us in graduate school in 1966, the best way to think about economic puzzles is to look, in the context of an Edgeworth box diagram, into where the “daylight is showing.” For the United States, now more than ever, the daylight is showing in the skewness of the income distribution, and the no-brainer solution is to raise taxes on the top 1percent by a major amount, say from 33 to 50 percent, in order to finance central social objectives, including reducing the budget deficit and fostering reforms in Social Security and health care.

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**Figure 1. Actual and Trend Changes in Output per Hour,  
NFPB Sector and Total Economy, 1950-2005**

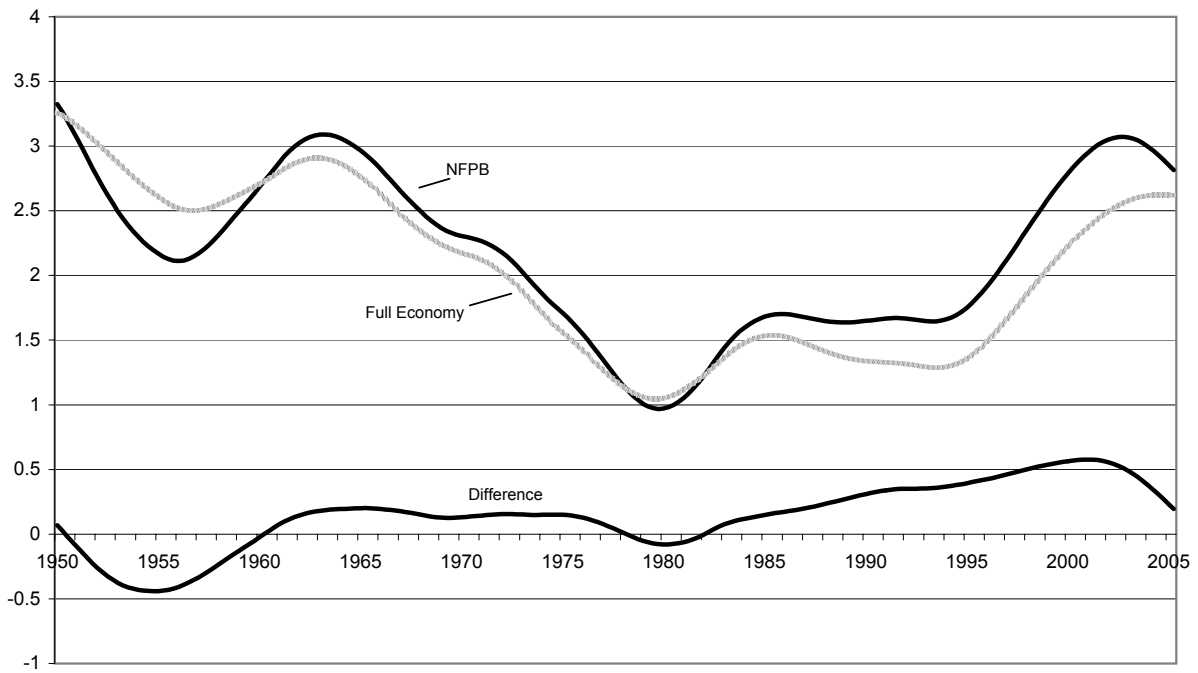
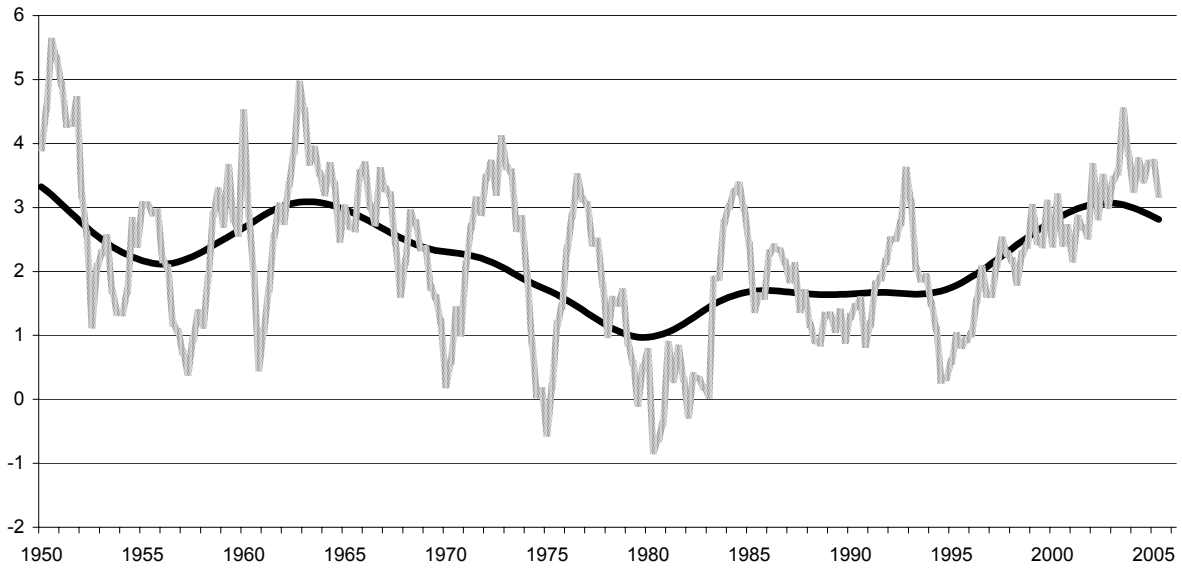


Figure 2. NIPA Labor Income Share With and Without Proprietor's Income, 1950-2005

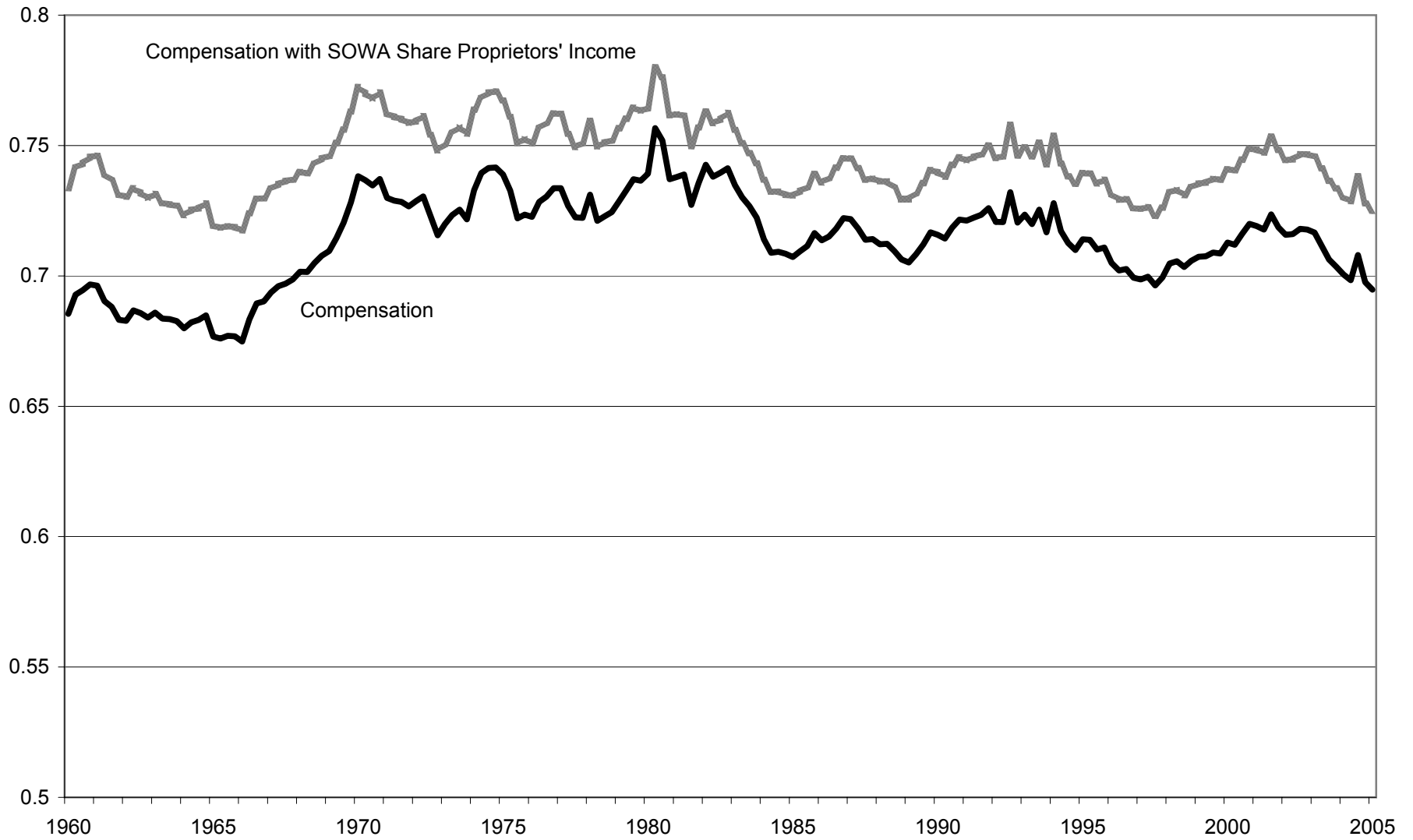
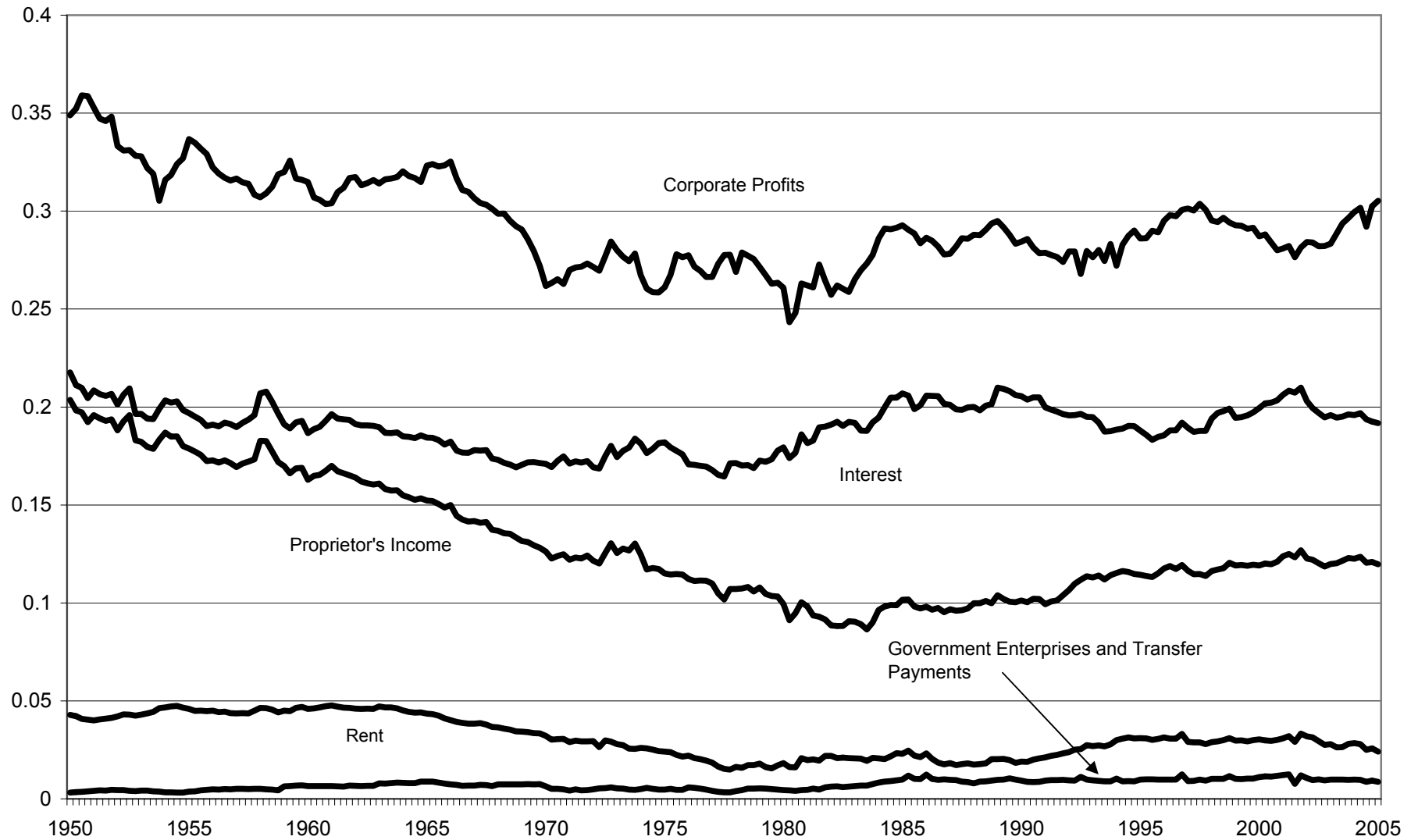
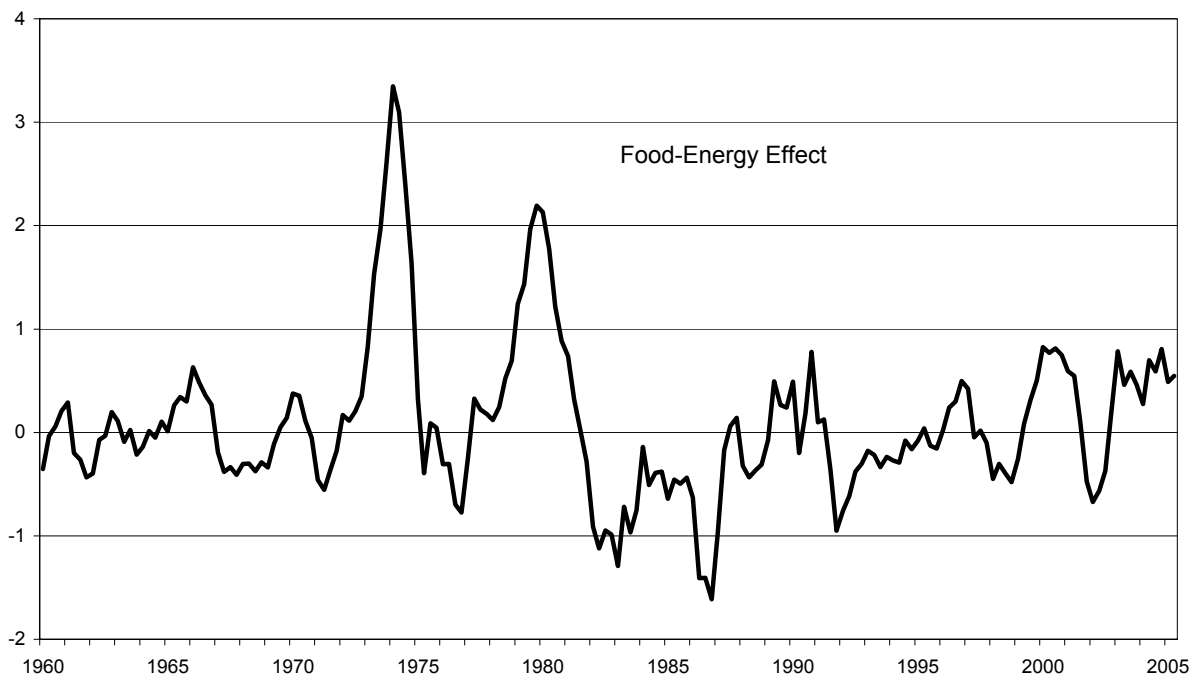
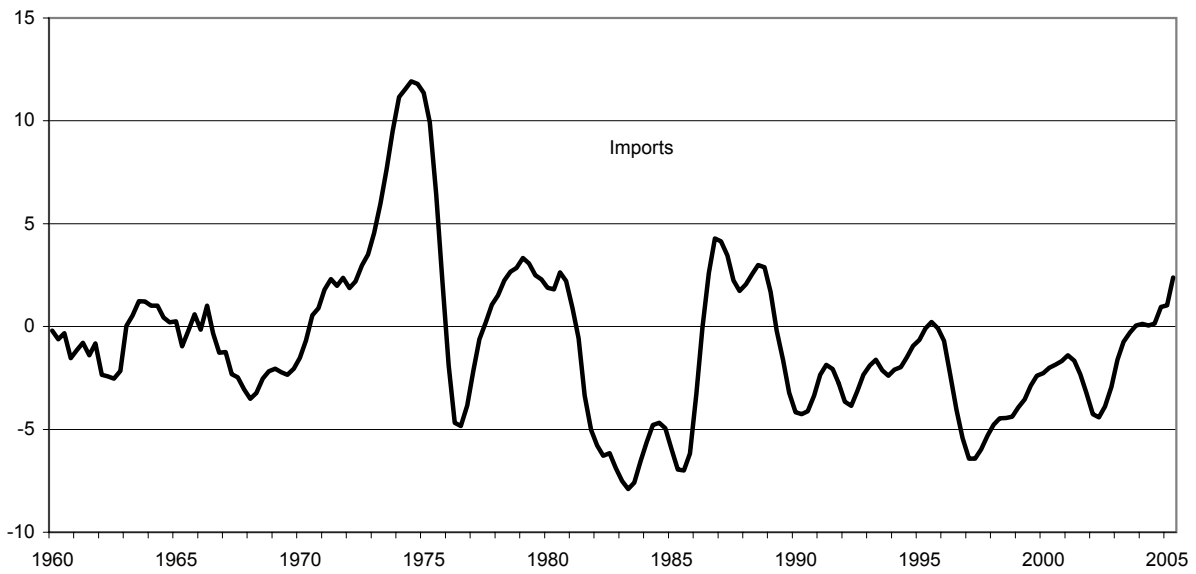




Figure 3. NIPA Nonlabor Income Share by Component, 1950-2005



**Figure 4. Four-quarter Changes in Relative Import Price and Food-Energy Effect, 1960-2005**



**Figure 5. Four-quarter Changes in Medical Care Effect and Actual Value of Productivity Acceleration Effect**

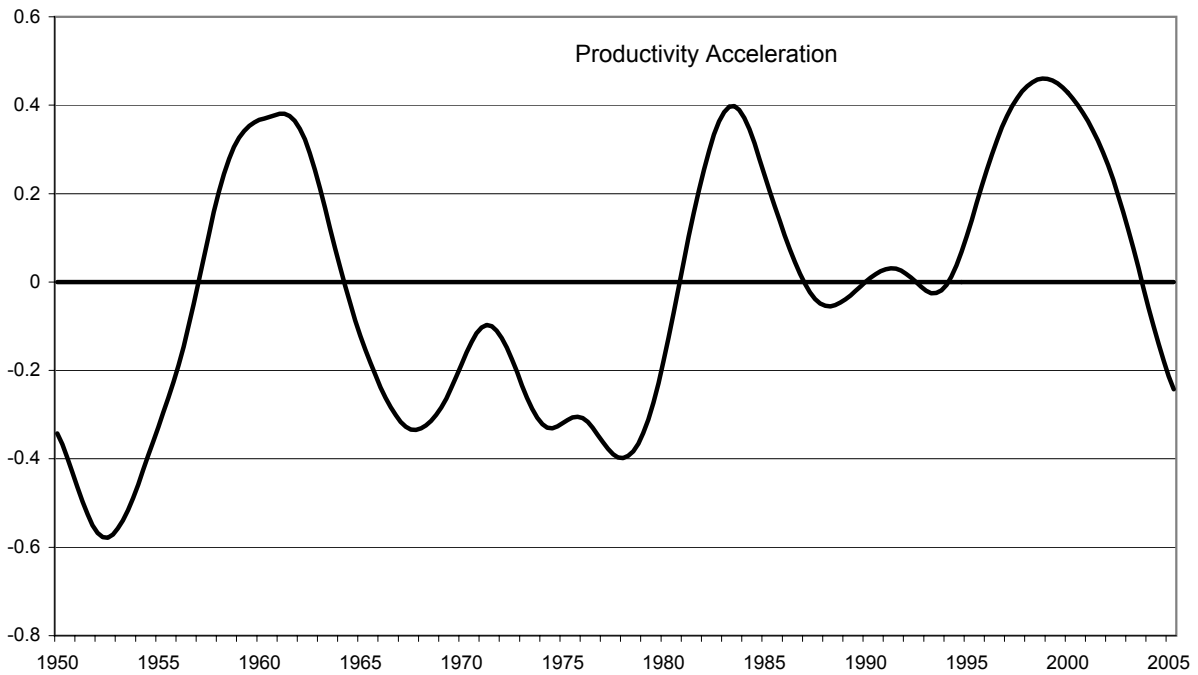
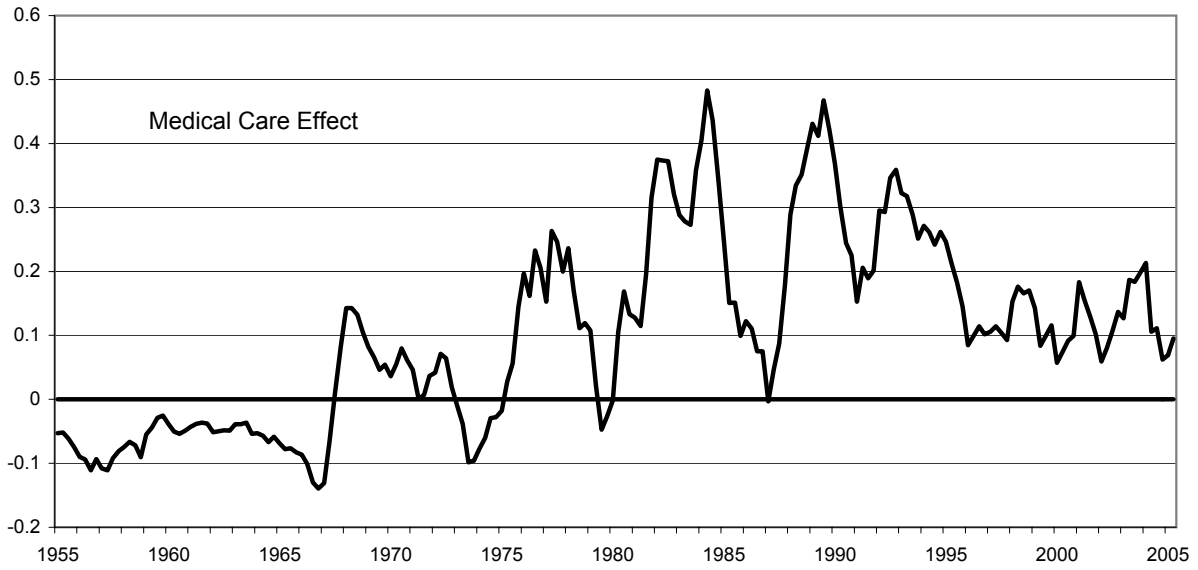


Figure 6. Four-quarter Changes in Actual and Simulated Values of PCE Deflator, 1984-2005

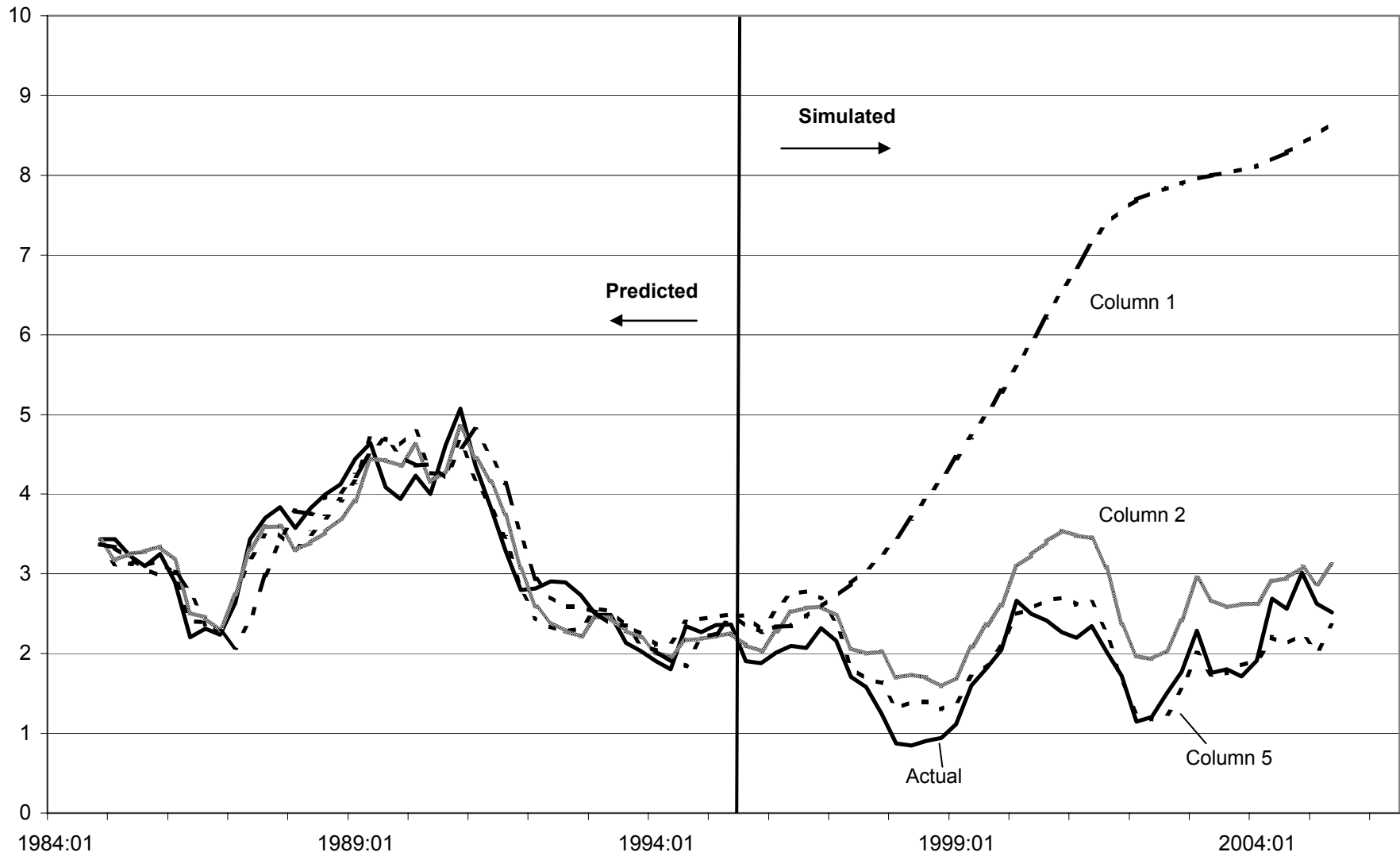


Figure 7. Time-Varying NAIU, 1998 and Current Version, 1962-2005

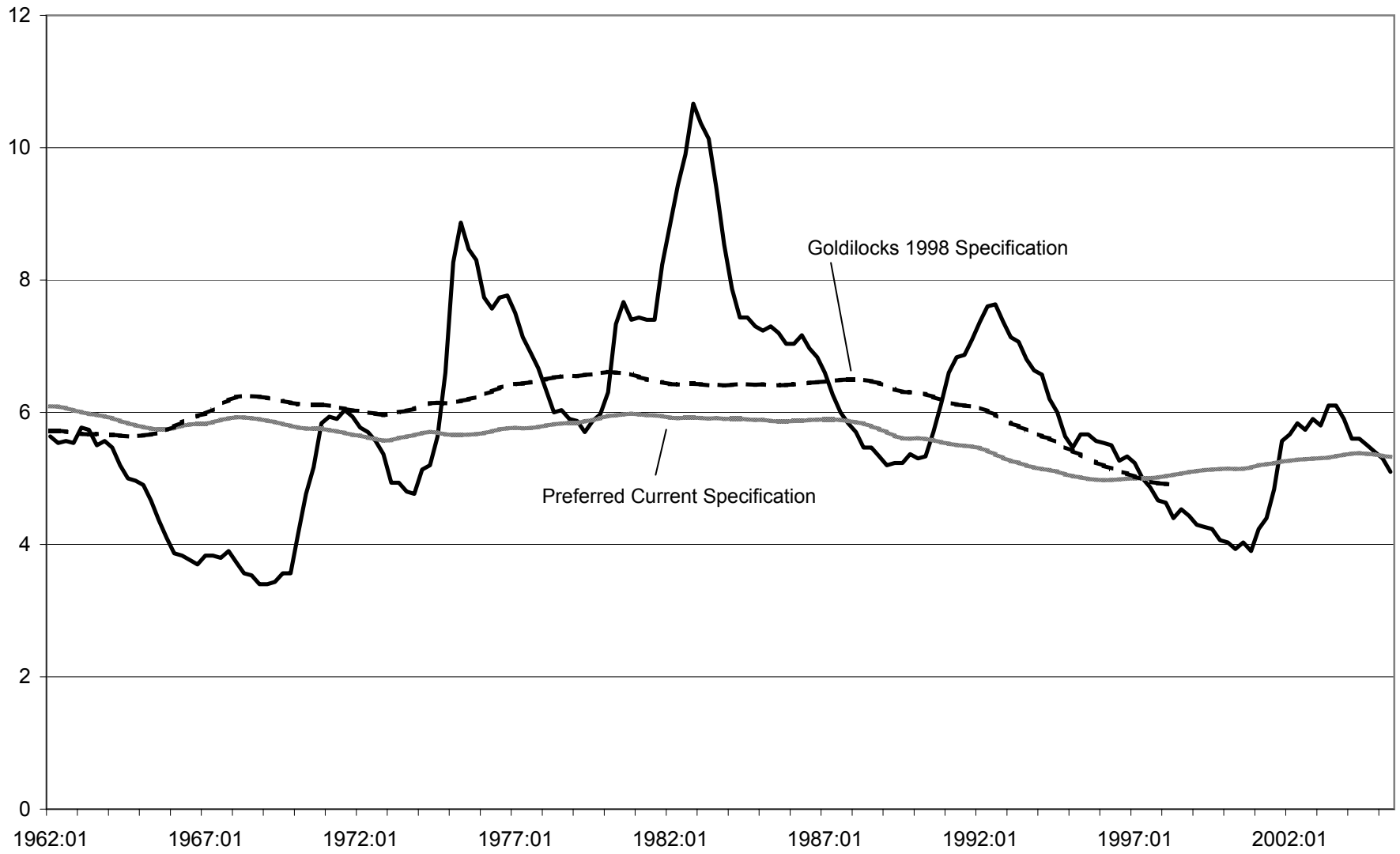
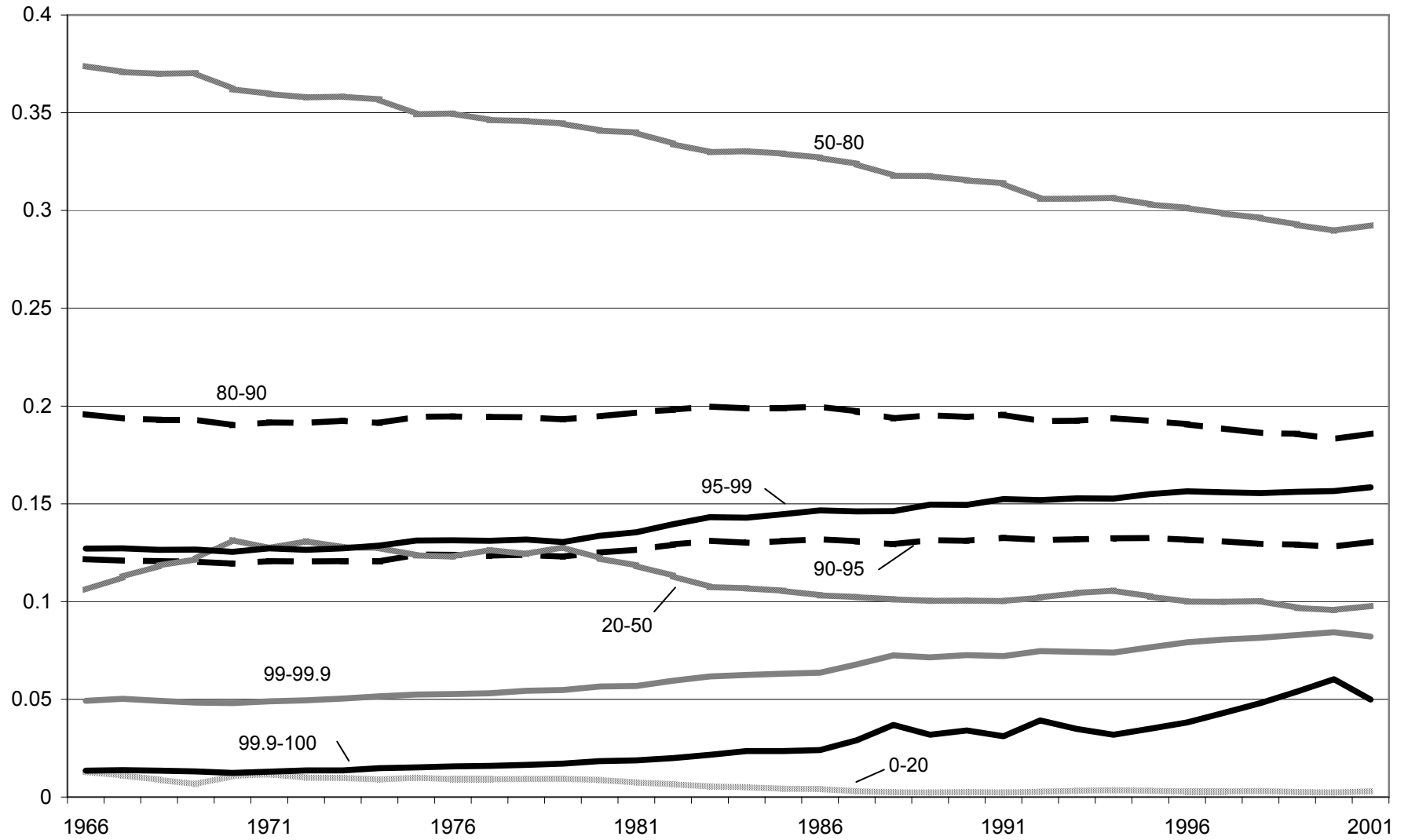
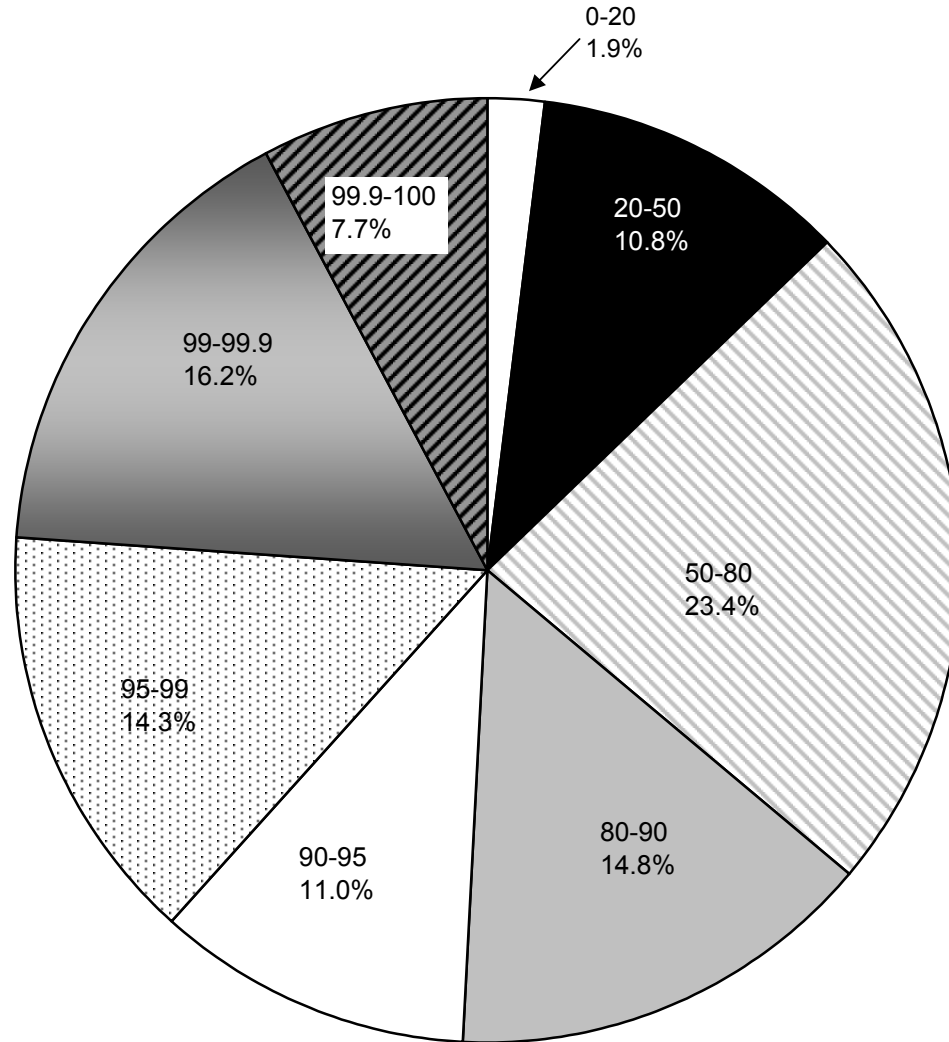


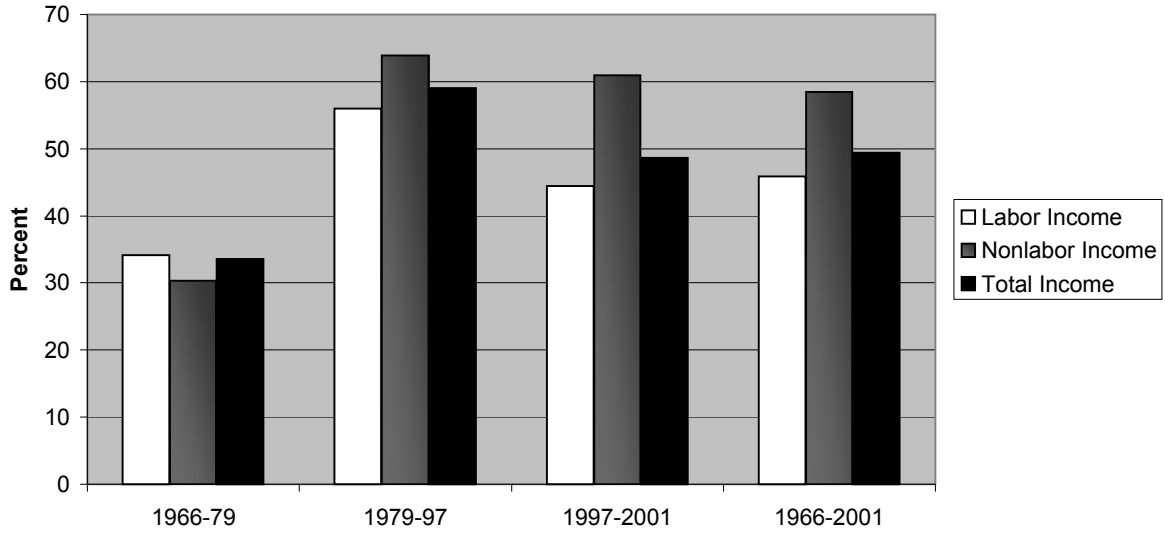
Figure 8. Shares of Wage Income



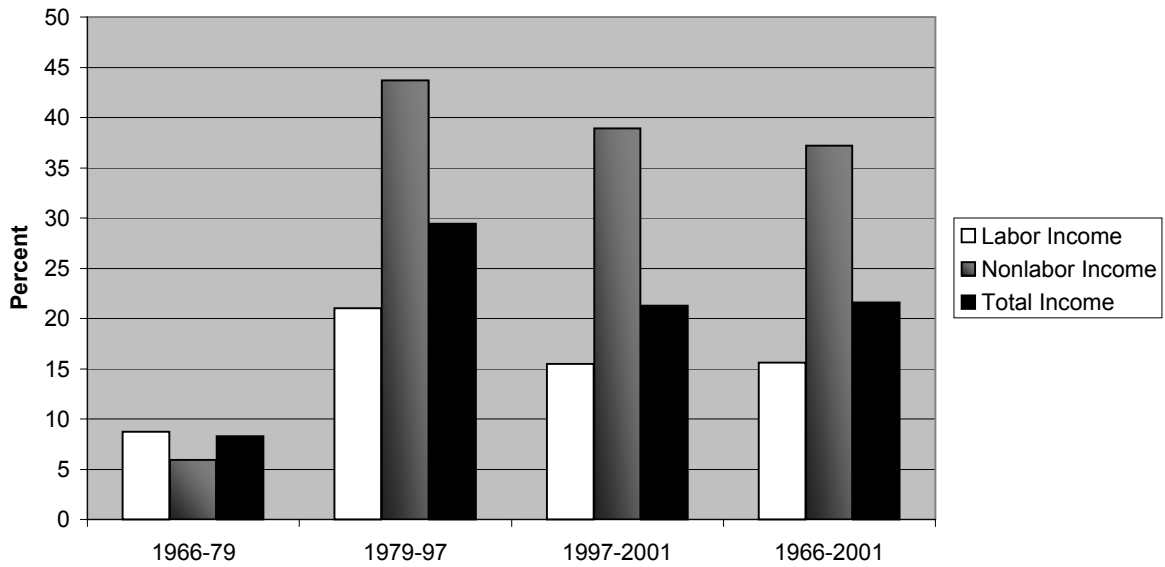
**Figure 9. Share of Wage Growth, 1997-2001**



**Figure 10.**  
**Share of Top 10 Percent in Increase of Real Income, \$2000, Selected Intervals**  
**1966-2001**



**Share of top 1 Percent in Increase of Real Income, \$2000, Selected Intervals**  
**1966-2001**





**Table 1**  
**Annual Growth Rates of Output per Hour, Compensation per Hour and Labor's Share of Income**  
**by Sector, Selected Intervals, 1954:Q4 - 2005:Q1**

	1954:Q4- 1963:Q2	1963:Q2- 1972:Q1	1972:Q1- 1979:Q1	1979:Q1- 1987:Q4	1987:Q4- 1997:Q4	1997:Q4- 2005:Q1	<i>Entire</i>	<i>Addendum</i>	
							<i>Period</i>	1954:Q4- 2005:Q1	1997:Q4- 2001:Q1
<b>Output per Hour</b>									
Total Economy	2.56	2.12	1.57	1.36	1.32	2.48	1.92	2.10	2.78
Private Business	2.83	2.54	1.88	1.61	1.65	3.12	2.29	2.54	3.58
Residual ("GHI")	1.39	0.84	0.87	0.64	0.24	0.38	0.73	0.59	0.21
Government	0.66	-0.10	-0.23	0.47	-0.21	0.62	0.19	0.22	0.93
Households	5.57	5.31	3.95	3.53	4.57	3.07	4.49	8.92	-1.68
Institutions	0.29	1.61	0.80	0.34	0.01	0.14	0.56	0.18	0.11
<b>Real Compensation per Hour</b>									
Total Economy	2.87	2.63	1.51	1.24	1.07	2.72	2.03	3.60	2.02
Private Business	2.80	2.45	1.74	1.06	1.12	2.98	2.03	4.18	2.00
Residual ("GHI")	3.07	3.14	0.81	1.80	0.88	1.95	2.01	1.68	2.17
Government	3.02	3.01	0.48	1.75	0.75	2.03	1.91	1.41	2.53
Households	1.92	0.57	-1.09	-2.28	4.65	0.71	0.92	4.57	-2.43
Institutions	2.57	4.07	1.10	2.32	0.88	2.18	2.27	2.48	1.94
<b>Labor's Share of Income</b>									
Total Economy	0.31	0.51	-0.06	-0.12	-0.25	0.25	0.11	1.49	-0.77
Private Business	-0.03	-0.08	-0.13	-0.55	-0.53	-0.14	-0.26	1.64	-1.58
Residual ("GHI")	1.68	2.30	-0.06	1.16	0.64	1.57	1.28	1.09	1.97
Government	2.37	3.11	0.71	1.27	0.96	1.41	1.72	1.18	1.59
Households	-3.65	-4.74	-5.03	-5.81	0.07	-2.36	-3.58	-4.35	-0.74
Institutions	2.28	2.46	0.30	1.98	0.87	2.04	1.72	2.30	1.83

Source : NIPA Tables and unpublished data provided by Phyllis Otto of the BLS

**Table 2**  
**Annual Growth Rates of Private Business Output per Hour and of Alternative Real Wage Series, Selected Intervals, 1954:Q4 - 2005:Q1**

							<i>Entire</i>	<i>Addendum</i>		
	<i>1954:Q4- 1963:Q2</i>	<i>1963:Q2- 1972:Q1</i>	<i>1972:Q1- 1979:Q1</i>	<i>1979:Q1- 1987:Q4</i>	<i>1987:Q4- 1997:Q4</i>	<i>1997:Q4- 2005:Q1</i>	<i>1954:Q4- 2005:Q1</i>	<i>1997:Q4- 2001:Q1</i>	<i>2001:Q1- 2005:Q1</i>	<i>1979:Q1- 2005:Q1</i>
<b>Output per Hour</b>	2.83	2.54	1.88	1.61	1.65	3.12	2.29	2.54	3.58	2.05
<i>Deflated by GDP Deflator</i>										
<b>Compensation per Hour</b>	2.80	2.45	1.74	1.06	1.12	2.98	2.03	4.18	2.00	1.32
<b>Employment Cost Index</b>	--	--	--	1.02	1.12	1.73	--	1.99	1.51	1.02
<b>Average Hourly Earnings</b>	1.52	1.67	0.07	-0.34	0.57	1.11	0.80	2.00	0.39	0.34
<i>Deflated by PCE Deflator</i>										
<b>Compensation per Hour</b>	3.02	2.85	1.77	0.87	0.76	3.05	2.05	4.07	2.23	1.17
<b>Employment Cost Index</b>	--	--	--	0.83	0.75	1.80	--	1.88	1.74	0.87
<b>Average Hourly Earnings</b>	1.74	2.07	0.09	-0.53	0.21	1.19	0.83	1.90	0.62	0.19
<i>Difference in Growth Rates Among Price Indexes</i>										
<b>PCE Deflaotr minus GDP Deflator</b>	-0.22	-0.40	-0.02	0.19	0.36	-0.08	-0.02	0.11	-0.23	0.15
<b>CPI-U minus PCE Deflator</b>	-0.14	0.28	0.60	0.68	0.42	0.45	0.38	0.73	0.22	0.42

Source : NIPA Tables

**TABLE 3**  
**Estimated Equations for Quarterly Changes in**  
**the PCE Deflator, 1962:Q1 to 2005:Q2**

Variable	Lags	Naïve Equation: Only Lagged Inflation and Actual Unemployment (1)	Deviation of Productivity Growth from Trend (2)	Productivity Acceleration (3)	Medical Care Effect (4)	Productivity Acceleration and Medical Care Effect (5)
1. Constant	0	1.45 **	-----	-----	-----	-----
2. Lagged Dependent Variable	1-4	0.95 **	-----	-----	-----	-----
3. Lagged Dependent Variable <sup>a</sup>	1-24	-----	1.00 **	1.00 **	1.01 **	1.00 **
4. Unemployment Rate	0	-0.20 *	-----	-----	-----	-----
5. Unemployment Gap	0-4	-----	-0.66 **	-0.63 **	-0.65 **	-0.66 **
6. Relative Price of Imports	1-4	-----	0.08 **	0.06 *	0.10 **	0.07 **
7. Food-Energy Effect	0-4	-----	1.02 **	1.06 **	1.08 **	1.10 **
8. Medical Care Effect	0-4	-----	-----	-----	1.31 *	1.57 **
9. Deviation of Productivity Growth from Trend	0-1	-----	-0.04	-----	-----	-----
10. Productivity Acceleration	1	-----	-----	-0.16	-----	-0.41
11. Productivity Acceleration	5	-----	-----	-1.23 **	-----	-0.93
12. Nixon Controls "on"	0	-----	-1.70 **	-1.55 **	-1.83 **	-1.52 **
13. Nixon Controls "off"	0	-----	1.78 **	2.01 **	1.86 **	1.97 **
<b>R<sup>2</sup></b>		0.791	0.932	0.930	0.944	0.934
<b>S.E.E</b>		1.176	0.659	0.650	0.651	0.648
<b>S.S.R.</b>		176.9	63.4	62.1	60.5	59.2
<b>Dynamic Simulation<sup>b</sup></b>						
<b>1995:Q3-2005:Q2</b>						
<b>Mean Error</b>		-4.00	-0.64	-0.29	-0.21	-0.11
<b>Root Mean-Squared Error</b>		4.57	0.83	0.64	0.50	0.56

Notes: (\*) indicates that coefficient or sum of coefficients is significant at 5 percent level; (\*\*) at 1 percent level.

a) Lagged dependent variable is entered as the four-quarter moving average for lags 1, 5, 9, 13, 17, and 21, respectively.

b) Dynamic simulations are based on regressions for the sample period 1962:Q1-1995:Q2 in which the coefficients on the lagged dependent variable are constrained to sum to unity.

**Table 4**  
**Estimated Equations for Quarterly Changes in the PCE and NFPB Deflators, and for Trend Unit Labor Cost,**  
**without Wage-Price Feedback, 1962:Q1 to 2005:Q2**

Variable	Lags	PCE Price Equation			NFPB Price Equation		
		Inflation (1)	Trend Unit Labor Costs (2)	Difference (3)	Inflation (4)	Trend Unit Labor Costs (5)	Difference (6)
1. Lagged Dependent Variable <sup>a</sup>	1-24	1.00 **	1.00 **		0.99 **	1.01 **	
2. Unemployment Gap	0-4	-0.66 **	-0.52 *	0.14	-0.56 **	-0.48 *	0.08
3. Relative Price of Imports	1-4	0.07 *	-0.07	-0.14	0.13 **	-0.07	-0.20
4. Food-Energy Effect	0-4	1.10 **	0.91 **	-0.19	0.94 **	0.90 **	-0.04
5. Medical Care Effect	0-4	1.57 **	0.00	-1.57	1.32	-0.71	-2.03
6. Productivity Acceleration	1	-0.41 **	-0.57	-0.16	-0.13	-0.49	-0.36
7. Productivity Acceleration	5	-0.93 **	-1.54	-0.61	-0.80	-1.79	-0.99
8. Nixon Controls "on"	0	-1.52 **	-0.01	1.51	-1.45 *	0.08	1.53
9. Nixon Controls "off"	0	1.97 **	0.87	-1.10	2.19 **	0.84	-1.35
R <sup>2</sup>		0.934	0.570		0.850	0.569	
S.E.E		0.648	2.070		1.080	2.068	
S.S.R.		59.2	601.7		165.7	602.7	
<b>Dynamic Simulation<sup>b</sup></b>							
<b>1995:Q3-2005:Q2</b>							
Mean Error		-0.11	2.94		-0.55	2.87	
Root Mean-Squared Error		0.56	4.20		1.01	4.18	

Notes: (\*) indicates that coefficient or sum of coefficients is significant at 5 percent level; (\*\*) at 1 percent level.

- a) Lagged dependent variable is entered as the four-quarter moving average for lags 1, 5, 9, 13, 17, and 21, respectively.  
b) Dynamic simulations are based on regressions for the sample period 1962:Q1-1995:Q2 in which the coefficients on the lagged dependent variable are constrained to sum to unity.

**Table 5**  
**Estimated Equations for Quarterly Changes in the PCE and NFPB Deflators, and for Trend Unit Labor Cost,**  
**with Wage-Price Feedback, 1962:Q1 to 2005:Q2**

Variable	Lags	PCE Price Equation			NFPB Price Equation		
		Inflation (1)	Trend Unit Labor Costs (2)	Difference (3)	Inflation (4)	Trend Unit Labor Costs (5)	Difference (6)
1. Lagged Dependent Variable <sup>a</sup>	1-24	0.99 **	1.02 **		0.99 **	1.05 **	
2. Unemployment Gap	0-4	-0.56 **	-0.32	0.24	-0.43 **	-0.30	0.13
3. Relative Price of Imports	1-4	0.07 *	-0.09	-0.16	0.11 *	-0.07	-0.18
4. Food-Energy Effect	0-4	1.14 **	0.76	-0.38	0.92 **	0.82 *	-0.10
5. Medical Care Effect	0-4	1.95 **	-2.60	-4.55	1.80 *	-1.63	-3.43
6. PCE Trend Labor Share	1-8	0.20 **	-0.73 *	-0.93			
7. NFPB Trend Labor Share	1-8				0.24 *	-0.63 *	-0.87
8. Productivity Acceleration	1	-0.45 **	-0.25	0.20	-0.19	-0.17	0.02
9. Productivity Acceleration	5	-0.90 **	-1.17	-0.27	-0.94	-1.00	-0.06
10. Nixon Controls "on"	0	-1.50 **	-0.30	1.20	-1.20	-0.17	1.03
11. Nixon Controls "off"	0	1.95 **	0.54	-1.41	2.29 **	0.60	-1.69
R <sup>2</sup>		0.936	0.587		0.850	0.580	
S.E.E		0.636	2.020		1.070	2.030	
S.S.R.		53.8	544.7		152.4	549.6	
<b>Dynamic Simulation<sup>b</sup></b>							
<b>1995:Q3-2005:Q2</b>							
Mean Error		0.35	1.77		0.46	2.1	
Root Mean-Squared Error		0.86	3.43		1.26	3.67	

Notes: (\*) indicates that coefficient or sum of coefficients is significant at 5 percent level; (\*\*) at 1 percent level.

a) Lagged dependent variable is entered as the four-quarter moving average for lags 1, 5, 9, 13, 17, and 21, respectively.

b) Dynamic simulations are based on regressions for the sample period 1962:Q1-1995:Q2 in which the coefficients on the lagged dependent variable are constrained to sum to unity.

**Table 6**

**Effects of Counterfactual Simulations that Impose Zero Values on Trend Productivity Change, Simulation Mean values and Four-Quarter Terminal Values, 1965:Q1-1980:Q1 and 1995:Q3-2005:Q2**

Variable and Concept	Simulation 1965:Q1 - 1980:Q1		Simulation 1995:Q3 - 2005:Q2	
	Mean Change in Percent	Final Quarter 4-Quarter Change	Mean Change in Percent	Final Quarter 4-Quarter Change
<b>A. NFPB Deflator</b>				
1. Actual	5.34	9.39	1.55	2.31
2. Factual Simulation	5.52	9.41	1.57	2.32
3. Counterfactual Simulation	4.24	6.73	2.76	4.03
4. Factual Simulation Error (1-2)	-0.18	-0.02	-0.02	-0.01
5. Effect of Productivity Change (2-3)	1.28	2.68	-1.19	-1.71
<b>B. Trend Unit Labor Cost</b>				
1. Actual	5.47	8.65	1.82	3.57
2. Factual Simulation	5.49	9.07	1.61	2.66
3. Counterfactual Simulation	4.03	6.06	2.99	4.57
4. Factual Simulation Error (1-2)	-0.02	-0.42	0.21	0.91
5. Effect of Productivity Change (2-3)	1.46	3.01	-1.38	-1.91
<b>C. Change in Trend Labor Share</b>				
1. Actual	0.13	-0.74	0.27	1.26
2. Factual Simulation	-0.03	-0.34	0.04	0.34
3. Counterfactual Simulation	-0.21	-0.67	0.23	0.54
4. Factual Simulation Error (1-2)	0.16	-0.40	0.23	0.92
5. Effect of Productivity Change (2-3)	0.18	0.33	-0.19	-0.20

**Table 7**  
**Number of Tax Units, Tax Returns, Percentage of Tax Units Filing in IRS**  
**Micro Data File, and Hours per Tax Unit, Selected Years, 1966 to 2001**

<b>Year</b>	<b>Number of Tax Units (thousands)</b>	<b>Number of Tax Returns (thousands)</b>	<b>Percentage of Tax Units Filing</b>	<b>Percentage of Returns With Wages</b>	<b>Annual Hours (Billions)</b>	<b>Hours Per Wage Return</b>
1966	75831	70160	92.5	88.5	154	2472.43
1972	83670	77573	92.7	90.2	161	2301.43
1979	97457	92694	95.1	89.8	185	2229.09
1987	112640	106996	95.0	85.0	207	2276.11
1997	129532	122422	94.5	85.3	244	2339.35
2001	137088	130255	95.0	85.4	254	2287.30

Notes: This table is taken directly from Piketty and Saez (2004) except for hours data

Population and tax units estimates based on census and current population surveys (*Historical Statistics of the United States, and Statistical Abstract of the United States*)

Tax units estimated as sum of married men, divorced and widowed men and women, and singles men and women aged 20 and over.

Hours data from Phyllis Otto, BLS

**Table 8**  
**Shares and Real Amount Earned, Wage and Salary Income by Quantile,**  
**Selected Years, 1966-2001**

Percent Shares of Total Wage and Salary Income by Quantile								
	1966	1972	1979	1987	1997	2001	Percent Change	
<b>0-20</b>	2.6	2.5	2.6	2.2	2.1	2.1	-0.5	
<b>20-50</b>	16.9	16.5	15.2	13.8	12.9	12.7	-4.2	
<b>50-80</b>	36	35.4	34.5	32.7	30.4	29.7	-6.3	
<b>80-90</b>	17.3	17.6	17.9	17.9	17.4	17.2	-0.1	
<b>90-95</b>	10.6	10.9	11.2	11.6	11.8	11.8	1.2	
<b>95-99</b>	11.1	11.4	11.9	12.9	14	14.3	3.2	
<b>99-99.9</b>	4.4	4.5	5.1	6.2	7.4	7.6	3.2	
<b>99.9-100</b>	1.2	1.2	1.6	2.6	4	4.7	3.5	
Real Amount Earned by Each Quantile (Billions of 2000 Dollars)								
	1966	1972	1979	1987	1997	2001	Change	Percent Share of Change
<b>0-20</b>	43.2	54.2	68.1	67.5	78.0	91.9	48.7	1.7
<b>20-50</b>	283.0	360.1	398.3	422.3	488.6	569.1	286.1	10.2
<b>0-50</b>	326.2	414.3	466.4	489.8	566.6	661.0	334.8	11.9
<b>50-80</b>	603.3	770.3	900.1	996.2	1156.4	1330.2	726.9	25.9
<b>80-90</b>	290.5	382.9	468.2	546.7	661.5	771.3	480.8	17.1
<b>90-95</b>	178.1	237.2	293.3	353.7	448.6	530.0	351.9	12.5
<b>95-99</b>	186.0	248.0	311.2	394.0	533.5	640.0	454.0	16.2
<b>99-99.9</b>	73.3	98.4	132.3	188.8	218.6	339.4	266.1	9.5
<b>99.9-100</b>	19.5	27.0	41.1	80.3	152.5	210.1	190.6	6.8
<b>Total</b>	1676.9	2178.1	2612.6	3049.5	3737.7	4482.0	2805.1	



**Table 9**  
**Real and Adjusted Wage and Salary Percentiles in Year 2000 Dollars, Selected Years, 1966 - 2001**

<b>Year</b>	<b>20</b>	<b>50</b>	<b>80</b>	<b>90</b>	<b>95</b>	<b>99</b>	<b>99.9</b>	<b>Skewness</b>
<b>1966</b>	7,242	23,667	42,127	52,683	63,367	99,872	220,653	11.33
<b>1972</b>	8,331	26,353	48,657	62,153	75,084	117,710	263,271	20.75
<b>1979</b>	8,244	24,412	49,668	64,291	78,400	127,524	316,234	44.25
<b>1987</b>	7,621	24,232	52,058	69,749	88,117	155,061	472,230	113.95
<b>1997</b>	7,805	24,285	53,785	75,589	99,222	197,540	636,564	368.32
<b>2001</b>	8,581	26,251	58,566	83,162	110,883	220,590	741,013	318.67
<b>Percent Change</b>	18.5	10.9	39.0	57.9	75.0	120.9	235.8	
<b>Average Annual Growth Rate</b>	0.48	0.30	0.94	1.30	1.60	2.26	3.46	
<b>Adjusted Percentiles</b>								
<b>Year</b>	<b>20</b>	<b>50</b>	<b>80</b>	<b>90</b>	<b>95</b>	<b>99</b>	<b>99.9</b>	<b>Implied Percent Wage Share of Compensation</b>
<b>1966</b>	7,242	23,667	42,127	52,683	63,367	99,872	220,653	90.5
<b>1972</b>	8,554	27,059	49,960	63,817	77,094	120,862	270,320	88.1
<b>1979</b>	8,916	26,402	53,717	69,531	84,790	137,918	342,009	83.7
<b>1987</b>	8,353	26,562	57,064	76,457	96,591	169,973	517,644	82.6
<b>1997</b>	8,496	26,436	58,549	82,285	108,012	215,039	692,955	83.1
<b>2001</b>	9,335	28,559	63,715	90,473	120,630	239,982	806,157	83.2
<b>Percent Change</b>	28.9	20.7	51.2	71.7	90.4	140.3	265.4	
<b>Average Annual Growth Rate</b>	0.73	0.54	1.18	1.55	1.84	2.50	3.70	
<b>Hours Adjusted Growth</b>	0.9	0.8	1.4	1.8	2.1	2.7	3.9	

**Table 10**  
**Real Amount Earned, Sum of Labor and Positive Non-Labor Income,**  
**Selected Years, 1966-2001**

<b>Total income</b>								
	<b>1966</b>	<b>1972</b>	<b>1979</b>	<b>1987</b>	<b>1997</b>	<b>2001</b>	<b>Change</b>	<b>Percent Share of Change</b>
<b>0-20</b>	54.3	69.1	86.7	83.2	101.6	118.2	63.9	1.6
<b>20-50</b>	329.2	418.3	472.3	513.3	602.6	696.5	367.3	9.5
<b>0-50</b>	383.5	487.4	559.0	596.4	704.2	814.8	431.3	11.1
<b>50-80</b>	699.5	881.8	1044.0	1197.9	1404.5	1620.1	920.7	23.7
<b>80-90</b>	344.7	445.7	549.0	667.6	816.9	957.7	613.0	15.8
<b>90-95</b>	218.0	282.6	350.5	439.8	566.9	672.4	454.4	11.7
<b>95-99</b>	253.3	320.8	396.6	515.8	737.3	879.6	626.3	16.1
<b>99-99.9</b>	124.9	150.4	188.3	281.4	467.8	571.9	447.1	11.5
<b>99.9-100</b>	44.1	50.8	71.2	171.1	345.6	434.6	390.5	10.1
<b>Total</b>	2068.0	2619.6	3158.6	3870.0	5043.1	5951.2	3883.3	
<b>Wage Income</b>								
wage	<b>1966</b>	<b>1972</b>	<b>1979</b>	<b>1987</b>	<b>1997</b>	<b>2001</b>	<b>Change</b>	<b>Percent Share of Change</b>
<b>0-20</b>	44.1	57.5	74.6	67.1	81.4	93.4	49.3	1.8
<b>20-50</b>	265.7	344.7	385.3	384.7	456.6	531.7	266.0	9.5
<b>0-50</b>	309.8	402.2	459.9	451.8	538.0	625.1	315.3	11.2
<b>50-80</b>	627.5	791.7	914.6	995.6	1155.4	1326.3	698.7	24.9
<b>80-90</b>	309.4	401.5	488.4	579.2	692.0	812.3	503.0	17.9
<b>90-95</b>	187.6	247.2	304.1	376.9	474.8	562.1	374.5	13.4
<b>95-99</b>	177.0	238.8	298.6	400.6	543.9	653.9	477.0	17.0
<b>99-99.9</b>	53.4	77.8	114.6	176.5	270.5	327.0	273.6	9.8
<b>99.9-100</b>	12.4	18.2	32.3	68.9	126.4	175.2	162.9	5.8
<b>Total</b>	1677.0	2177.4	2612.5	3049.6	3800.9	4481.9	2805.0	
<b>Non-wage income</b>								
non-wage	<b>1966</b>	<b>1972</b>	<b>1979</b>	<b>1987</b>	<b>1997</b>	<b>2001</b>	<b>Change</b>	<b>Percent Share of Change</b>
<b>0-20</b>	10.2	11.6	11.9	15.9	20.2	24.8	14.6	1.4
<b>20-50</b>	63.5	74.0	87.1	128.6	145.9	164.9	101.3	9.4
<b>0-50</b>	73.7	85.6	99.0	144.5	166.1	189.6	115.9	10.7
<b>50-80</b>	71.9	90.1	129.6	202.4	249.5	294.3	222.3	20.6
<b>80-90</b>	35.3	44.2	60.6	88.4	124.9	145.4	110.1	10.2
<b>90-95</b>	30.0	35.1	46.3	62.9	92.3	110.5	80.5	7.5
<b>95-99</b>	76.3	82.0	98.0	115.3	193.3	225.6	149.2	13.8
<b>99-99.9</b>	71.5	72.9	73.8	104.9	197.3	245.0	173.5	16.1
<b>99.9-100</b>	31.8	32.3	38.7	102.1	219.2	259.4	227.6	21.1
<b>Total</b>	390.6	442.1	546.0	820.4	1242.6	1469.7	1079.1	
<b>Non-wage Income as a Percent Share of Total Income</b>								
non-wage	<b>1966</b>	<b>1972</b>	<b>1979</b>	<b>1987</b>	<b>1997</b>	<b>2001</b>	<b>Change</b>	
<b>0-20</b>	18.70	16.75	13.73	19.15	19.88	20.96	2.26	
<b>20-50</b>	19.30	17.69	18.45	25.05	24.21	23.67	4.36	
<b>0-50</b>	19.22	17.55	17.72	24.23	23.59	23.27	4.06	
<b>50-80</b>	10.28	10.22	12.42	16.90	17.76	18.16	7.88	
<b>80-90</b>	10.24	9.91	11.03	13.24	15.29	15.18	4.94	
<b>90-95</b>	13.77	12.41	13.22	14.29	16.28	16.43	2.67	
<b>95-99</b>	30.14	25.57	24.71	22.36	26.22	25.65	-4.49	
<b>99-99.9</b>	57.24	48.48	39.16	37.27	42.18	42.83	-14.41	
<b>99.9-100</b>	72.00	63.45	54.33	59.64	63.43	59.68	-12.32	