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The Impact of IT Investment on Income and Wealth Inequality in the Postwar US Economy

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Abstract

Inequality in the distribution of family income, which had remained virtually unchanged since the end of World War II until 1968, has increased sharply since then. Inequality in household wealth has increased even more dramatically, with the share of the top one per cent doubling since 1976. Perhaps, the most notable technological change over the past 30 years has been the widespread diffusion of computers in the United States However, when we consider the aggregate time-series regression results, we find that the largest effects on income inequality come from equipment investment and unionization. OCA investment is also found to have a positive and significant effect on income inequality, though not as strong as equipment investment. On the other hand, TFP and labour productivity growth, as well as R&D investment, have no statistical effect on income inequality. Unionization has a decidedly negative effect on income inequality. With regard to wealth inequality, the only two significant effects come from the ratio of the S&P 500 stock index to median house, which has a very strong positive relation, and the minimum wage in constant dollars, which has a negative and less strong relation. None of the other variables is statistically significant. However, investment in OCA per worker has a very strong positive relation to movements in stock prices, which suggests that it is indirectly linked to changes in wealth inequality.

Keywords: Inequality, computerization, unionization

JEL classification: D31, O30, J50

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1 Introduction

The last three decades have witnessed some disturbing changes in inequality in the United States. Inequality in the distribution of family income, which had remained virtually unchanged since the end of World War II until 1968, has increased sharply since then. Inequality in household wealth has increased even more dramatically, with the share of the top one per cent doubling since 1976. The main source of the rising inequality of family income stems from changes in the structure of the labour market. One indication of the dramatic changes taking place in the labour market is the sharp rise in the returns to education, particularly a college degree, that has occurred since 1975, particularly in the 1980s. The ratio in annual earnings between male college graduates and male high school graduates increased from 1.50 in 1975 to 1.56 in 1980 and then climbed to 1.92 in 1998. For females, the ratio dropped slightly between 1975 and 1980, from 1.45 to 1.43, and then surged to 1.76 in 1998. Among men, the increase in the return to a college degree relative to a high school degree was due, in part, to the stagnating earnings of high school graduates. Between 1975 and 1998, there was no net change in their annual earnings (in 1995 dollars), while the earnings of men with a bachelor's degree increased by 17 per cent. The biggest increase in earnings occurred among males with an advanced degree (master's or higher), who saw their annual incomes grow by 25 per cent. Among males who did not graduate college, earnings plummeted by 15 per cent. Perhaps, the most notable change over the past 30 years has been the widespread diffusion of computers in the United States. Particular interest is focused on the post-1980 period, which has seen a tremendous growth in the use of computers in production and which Christopher Freeman (1987) and others have termed a new 'echno-economic paradigm', based on computer-driven information technology. The main focus of the paper is the extent to which the computer revolution is responsible for the upsurge of inequality in the United States.

The paper begins with a review of some of the previous studies on the role of technological factors in accounting for rising earnings inequality in the US (Section 2). Some attention is also paid to previous work on the effects of institutional factors on inequality, because they will prove to be important in subsequent analysis. Section 3 provides descriptive statistics on time trends in overall income and wealth inequality, computerization, and other indicators of technological change over the period 1947 to 1997. In Section 4, regression analysis is conducted on the aggregate level to determine the effects of technological and institutional factors on trends in both income and wealth inequality. Concluding remarks are made in Section 5.

2 Review of previous literature

A considerable literature has now accumulated on factors that might have caused earnings inequality to rise since the early 1970s. At the outset, it is important to distinguish between three separate but related trends. The first is the actual rise in the dispersion of earnings among all workers (or among all male workers) in the economy. The second is the rising returns to schooling, particularly a college education over the same period. The third is the large increase of earnings dispersion within education-experience cells—that is, even after controlling for education and experience—over these years as well (see, for example, Levy and Murnane 1992; or Juhn, Murphy, and

Pierce 1993). A successful model must be able to account for all three phenomena simultaneously.

The most prevalent view on the cause of rising wage inequality is biased technological change, due to the introduction of computers and the general diffusion of Information Technology (IT). The argument is that the last twenty-five years or so have witnessed a major technological revolution led by widespread computerization and the consequent diffusion of information technology. This change has skewed the income distribution by placing a high premium on college-educated and skilled labour while reducing the demand for semi-skilled and unskilled workers. One important piece of evidence is a that the rate of return to a college education (the wage premium paid to a college graduate relative to a high school graduate) almost doubled over the decade of the 1980s.

This argument has been made by Bound and Johnson (1992) and Berman, Bound, and Griliches (1994), who identify the declining ratio of production to non-production workers *within industry* as the major determinant of changes in relative wages between skilled and unskilled workers. The fact that both the employment share and relative wages shifted in favour of non-production workers is evidence of biased technological change.

Work on the subject has been limited in three ways. First, most studies measure skills by the relative shares of production and non-production workers in total employment. This division does not constitute a particularly sharp distinction between skilled and unskilled jobs (see Burtless, 1995). Second, because of available data, the analysis is generally confined to manufacturing, which accounted for only 15.3 per cent of total employment in 1995. It may be precarious to make inferences to other sectors on the basis of results for manufacturing. Third, the measure of skill bias is indirect—that is, it is inferred from the rising share of non-production workers in conjunction with their rising relative earnings. Very few direct tests of skill-biased technological change exist.

Mincer (1991), using aggregate time-series data for the US over the period 1963 to 1987, and Davis and Haltiwanger (1991), using data on production and non-production workers in US manufacturing plants from 1963 to 1986, provided some of the early evidence to support this hypothesis. Mincer found that R&D expenditures per worker explained a significant amount of the year-to-year variation in educational wage differentials, while productivity growth was also a significant factor but had weaker explanatory power. Davis and Haltiwanger found that the employment shift toward non-production workers occurred disproportionately in large plants between 1977 and 1986, and this was accompanied by a sharp upgrading of worker education and occupational skill levels. Katz and Murphy (1992) developed a model that accounted for changes in both the demand and supply of unskilled and skilled labour. Using CPS data over the period 1963 to 1987, they concluded that while the supply of college graduates fluctuated over time, there was a steady increase in the demand for skilled labour in the US over the period.

Berman, Bound, and Griliches (1994), using data from the Annual Survey of Manufactures over the period 1979 to 1987 for 450 manufacturing industries, found that over two-thirds of the increase in the ratio of non-production to production workers within manufacturing was due to the increased use of non-production workers within industry, and less than one third to a reallocation of labour between industries. They inferred from this the existence of skill-biased technological change. Berman, Bound, and Machin (1997) also provided evidence that the increase in the share of skilled (non-production) workers in total employment occurred across a wide range of OECD countries. Yet, they also found that the trend decelerated in almost all OECD countries during the 1980s (with the notable exception of the United States). Allen (1996) also concluded that technology variables accounted for 30 per cent of the increase in the college wage premium over the period from 1979 to 1989.

Juhn, Murphy, and Pierce (1993), using a time-series of CPS data between 1963 and 1987, documented the rising variance of earnings within schooling and experience groups. They concluded that it was due to rising employer demand for and hence premium on unobservable skills.

Several papers have looked at the effects of computer usage or IT on earnings. Reich (1991) argued that American workers are divided into two distinct groups—'symbolic analysts' who produce knowledge and new Information Technology and ordinary clerical and production workers, who are outside the IT revolution. Globalization has rewarded the first group of workers with increased earnings but depressed the earnings of the second group.

Krueger (1993) argued that pronounced declines in the cost of personal computers caused their widespread adoption in the workplace and shifted the production function in ways that favoured more skilled workers. He also estimated the rate of return to computer usage at 15 to 20 per cent. This finding was later challenged by DiNardo and Pischke (1997), who estimated, using German household data, a similar return to the use of pencils. They argued that computer use *per se* was not causing workers to earn a premium but, rather, was associated with unmeasured skills that were being rewarded in the workplace. Handel (1998) also showed that the returns to computers fall by half in cross-sectional estimates when other correlates, such as 'reading news or magazine articles', are included as explanatory variables. However, in later work, Autor, Katz, and Krueger (1998) supplied new evidence that there was a substantial and increasing wage premium associated with computer use, despite a large growth in the number of workers with computer skills.

In a more direct test of the effects of new technology on earnings, Adams (1997), using world patent and CPS earnings data for 24 manufacturing industries over the period 1979-93, found that a rise in patenting activity was associated with a widening of the earnings gap between college and high school graduates. One direct test of skill-biased technological change was provided by Betts (1997) for Canadian manufacturing industries between 1962 and 1986. Using a translog cost share equation and treating production and non-production workers as separate inputs, he found evidence of bias away from production workers in 10 of the 18 industries used in the analysis.

A counter argument was presented by Howell (1997), who pointed out an important anomaly—namely, that while employment in low-skill jobs was declining relative to more skilled jobs, the proportion of low-wage workers has actually been rising. He also found that the entire increase in the ratio of non-production to production workers since 1979 took place between 1980 and 1982; between 1983 and the early 1990s, the ratio remained essentially unchanged. Glynn (1997) found, after dividing American workers in educational quartiles, that the employment position of the low schooled workers sharply deteriorated between 1973 and 1981, when wage inequality grew slowly, but hardly declined at all after 1981, when wage inequality surged. Bresnahan (1997) also argued, after a review of the pertinent literature, that there is no direct evidence that the actual use of IT (particularly personal computers) is associated with job enrichment. He concluded that, 'There is little complementarity between highly skilled workers and PC use, certainly not enough to affect skill demand'.

Murphy and Welch (1993), after examining decennial Census of Population data on employment by occupation over the period 1940 to 1980 and CPS data for 1989-91, found that there was a steady increase in the demand for skilled labour between 1940 and 1990 but no particular acceleration during the 1970s and 1980s. Juhn (1999), including 1990 Census of Population data, reported similar results.

Two institutional trends, in particular, have achieved prominence in the literature on rising inequality. The first of these is declining unionization. The proportion of the work force represented by unions peaked in 1954, at 25.4 per cent, and at 34.7 per cent as a fraction of the non-farm labour force. After 1954, the trend was downward, and by 1997, only 14.1 per cent were union members. Unions have historically negotiated collective bargaining agreements with narrow wage differentials between different types of jobs. This is one reason why the dispersion of earnings in manufacturing has tended to be lower than that of service industries. The argument is that the decline in unions has led to widening differentials in the overall wage structure.

The second factor is the declining minimum wage. The minimum wage has fallen by 30 per cent in real terms between its peak in 1968 and 1997. This has put downward pressure on the wages of unskilled workers and may account, in part, for the growing wage disparities between unskilled and skilled workers and the decline in the average real wage since 1973. Gordon (1996) argued that the change in unionization and the minimum wage was part of a broader range of institutional changes in the 1980s in which American corporate mangers exerted increasing pressure on workers, partly in reaction to rising international competition.

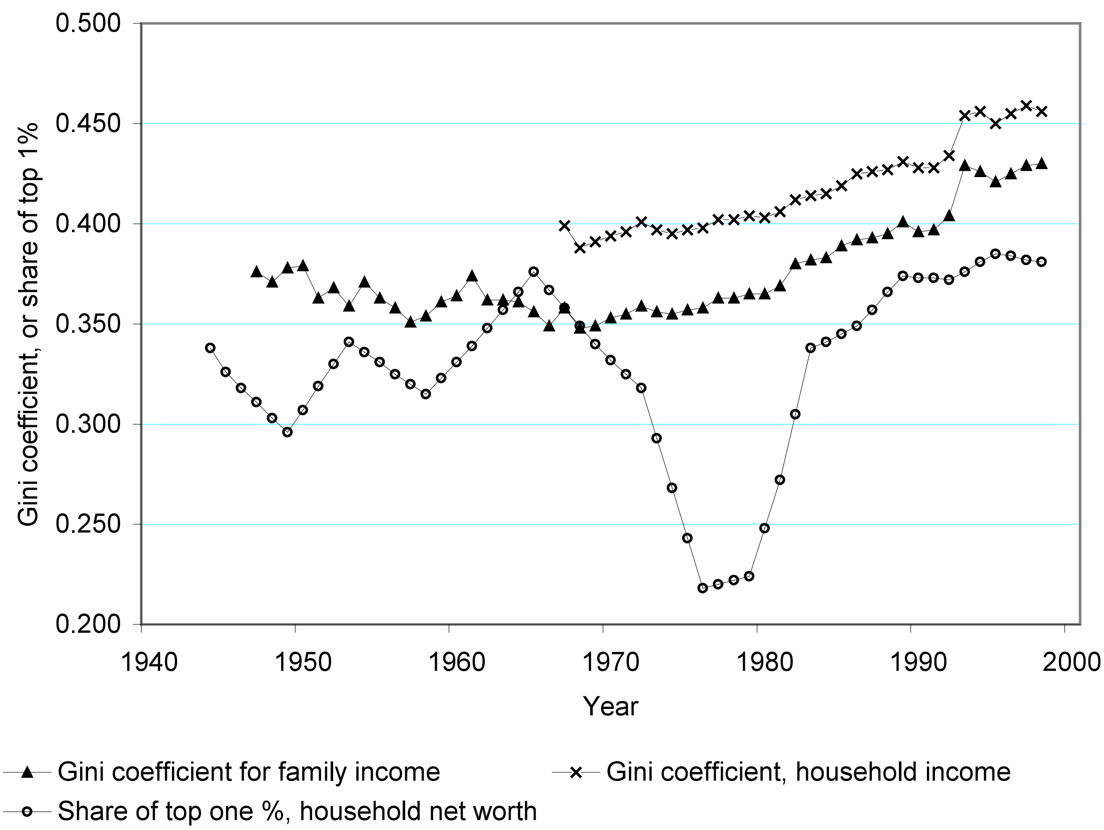
Freeman (1993) argued that the decline of unions in the American economy and/or the decline in the real value of the minimum wage since the late 1960s removed the 'safety net' supporting the wage level of unskilled workers, thereby allowing it to fall. Blackburn, Bloom and Freeman (1990) estimated that as much as 20 per cent of the rising differential of earnings between college graduates and other educational groups between 1980 and 1988 might be due to deunionization. Changes in the minimum wage, on the other hand, had a minimal impact. Freeman (1993) estimated that between 10 and 20 per cent of the increased wage inequality among men was due to the decline in unionization.

Horrigon and Mincy (1993) attributed considerably under a third of the declining share of earnings received by the bottom quintile of wage earnings to the fall in the minimum wage. DiNardo, Fortin, and Lemieux (1996), using a semi-parametric estimation technique on CPS data from 1979 to 1988, concluded that the decline in the real value of the minimum wage over this period accounted for up to 25 per cent of the rise in male wage inequality and up to 30 per cent of the rise in female wage inequality. Lee (1999), using regional data drawn from the CPS together with regional minimum wage levels over the 1980s, concluded that the decline in the real minimum wage over the period accounted for as much as 70 per cent the rise in wage dispersion in the lower tail of the wage distribution among men and from 70 to 100 per cent among women.

3 Inequality on the aggregate level

Figure 1 shows trends in both income and wealth inequality in the US over the postwar period. The first, based on the March Supplement to the Current Population Survey, is for family income and runs from 1947 to 1997. Inequality shows a slight downward trend from 1947 to 1968, with the Gini coefficient falling by 7 per cent. The series bottoms out in 1968 and then rises thereafter, with the rate of increase accelerating after 1976. The 1997 Gini coefficient is 0.429, 0.081 points above its 1968 value. The second series is for household income, beginning in 1967.[1] It is almost perfectly correlated with the first series—a correlation coefficient of 1.00.

Figure 1
Inequality of income and wealth, 1947-97

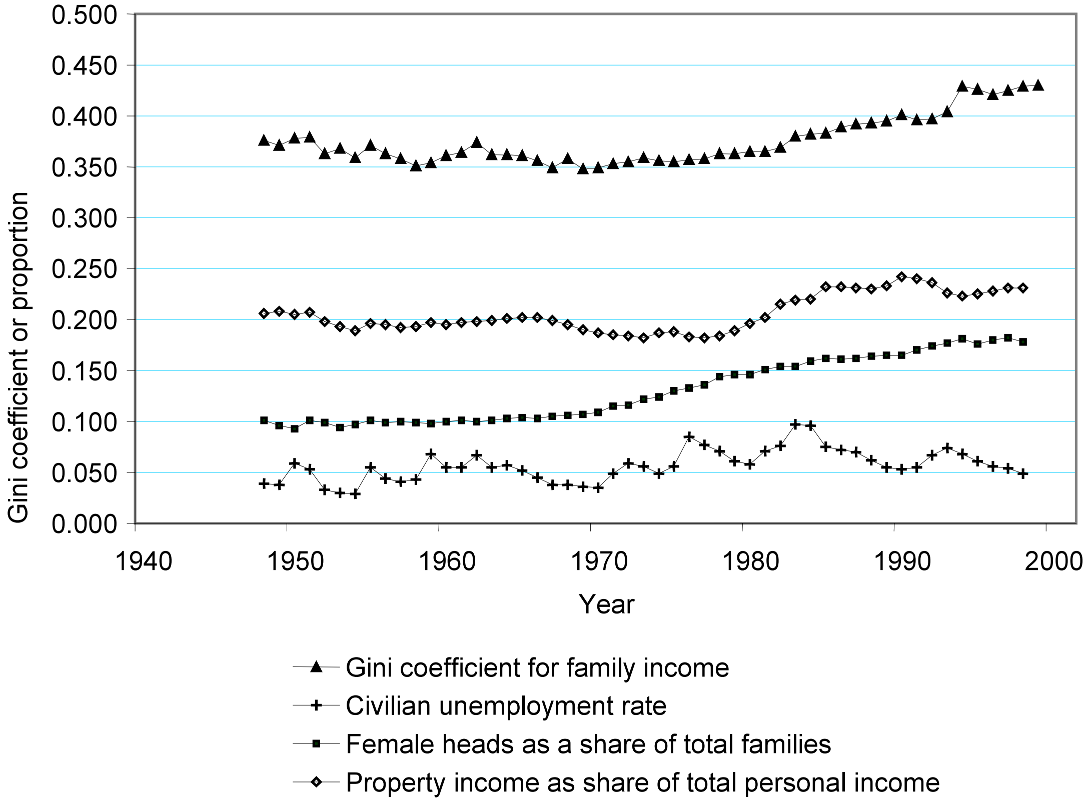


Almost all the theoretical and empirical work on the effects of computerization (as well as many of the other factors discussed in the previous section) on inequality have concentrated on labour earnings, not family (or household) income. The advantage of using family income inequality is that it is the longest consistent time-series available on inequality trends in the US The consistent time-series on labour earnings inequality are rather short, and none of them (as far as I am aware) covers both the slight downward drift in inequality between the late 1940s and the late 1960s and its sharp increase in the 1990s. Moreover, family income inequality is strongly correlated with inequality in labour earnings. For example, the correlation between family income

1 The source for these two series is: US Bureau of the Census, Current Population Survey, March Supplement, the Internet [http://www.census.gov/ftp/pub/hhes/www/incpov.html].

inequality and the log variance of labour earnings of full-time, full-year workers over the period 1972-90 is 0.86.[2]

Figure 2
Income inequality, the unemployment rate, female heads as a share of total families, and property income as a share of total personal income, 1947-97



In the regression analysis below, I shall control for three factors that may account for much of the deviation between income and earnings inequality. The first is the unemployment rate, which controls, in part, for the fact that some families receive zero labour income. Not surprisingly, its movement is cyclical over time, whereas family inequality has trended rather continuously upward since the late 1960s (see Figure 2). As a result, its correlation with family income inequality is rather low, only 0.27. The second control variable is the number of female-headed families as a percentage of total families. It is included since this group has historically had the lowest level of family income of any family type, and a large part of its income has taken the form of government transfers. Its share has trended almost continuously upward since 1959, from 10.1 per cent, to 17.8 per cent in 1997. As result, it is strongly correlated with family income inequality—a correlation coefficient of 0.78.

The third variable in this group is personal property income, defined as the sum of rent, dividends, interest, and one-half of proprietors' income, as a share of total personal income. It is included, since it comprises part of the difference between family income

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2 The source is Gittleman (1992), based on wage and salary income for full-time, full-year workers, 16 years and over, with positive wage and salary income, computed from CPS Annual Demographic Files.

and labour earnings (the other major part is government transfer income). Its time path is somewhat similar to family income inequality. This variable shows a slightly downward trend from 1947 to 1972 (from 21 to 18 per cent) followed by an upward trajectory to a peak of 24 per cent in 1989 and then a slight decline to 23 per cent in 1997. As a result, its correlation coefficient with family income inequality is very high—0.84.

The other variable of interest is wealth inequality. This series is pieced together from several source, including estate tax data, the 1962 Survey of Financial Characteristics of Consumers; the 1969 MESP file; and the 1983, 1986, 1989, 1992, 1995, and 1998 Survey of Consumer Finances (see Wolff 1996 for details on its construction). Moreover, because the series is based, in part, on estate tax data, the inequality measure is the share of total net worth owned by the richest one per cent of households.

This series trends differently over time than income inequality. The wealth share of the top one per cent shows a moderate increase between 1947 and 1965, from 30.3 to 37.6 per cent, a steep decline to 21.8 per cent in 1976, and then an equally sharp ascent to 38.1 per cent in 1998.

One important factor, besides underlying income inequality, that affects movements in wealth inequality is the ratio of stock prices to housing prices. The rationale is that stocks are an asset held primarily by the upper wealth classes, whereas housing is the major asset of the middle classes. If stock prices increase relative to housing prices, the share of wealth held by the top wealth groups will rise, and conversely.

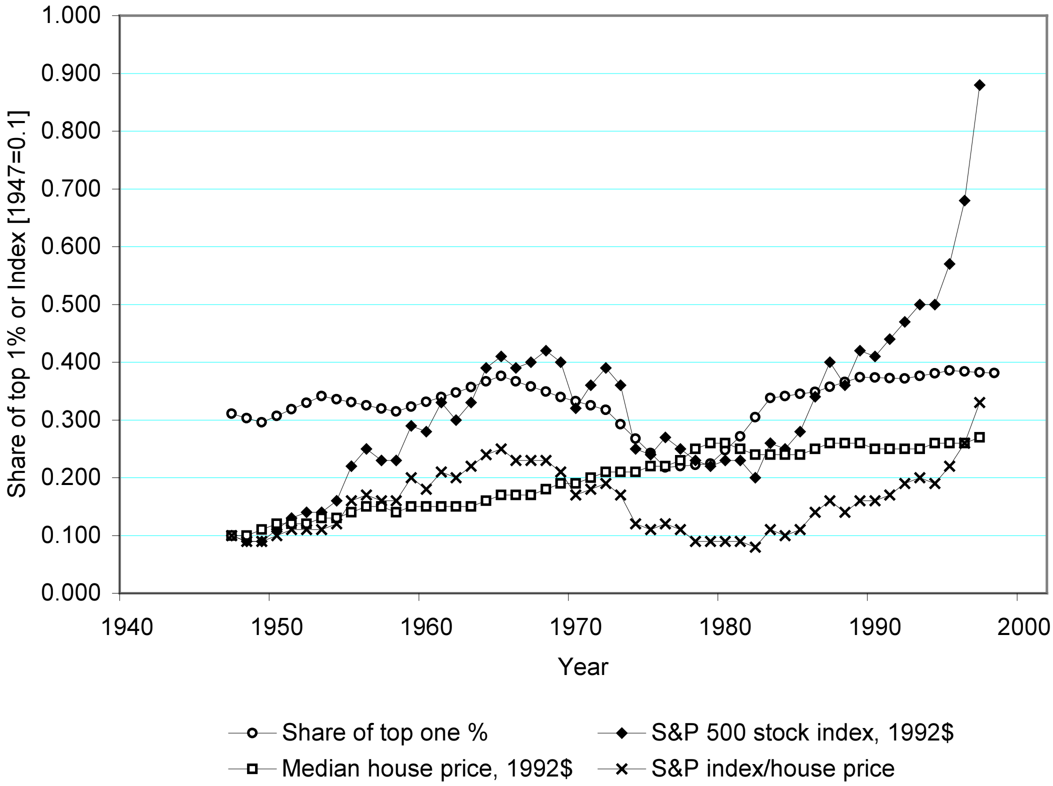
This price ratio (indexed to a value of 0.1 in 1947 in Figure 3) shows a time path very similar to that of wealth inequality. The ratio of stock to housing prices increased by a factor of 2.5 between 1947 and 1965, fuelled mainly by rapidly rising stock values, and this movement corresponded to a rise in wealth inequality. Between 1965 and 1979, this ratio fell by almost two-thirds, with most of the decline occurring after 1972. Before 1972 the main culprit was rising house prices but after 1972 the principal reason was a stagnating stock market. This period was, not surprisingly, characterized by a dramatic decline in wealth inequality. Between 1979 and 1997, the price ratio increased by almost a factor of four, as the stock market flourished, and a sharp increase in wealth inequality was also recorded over this decade.

The next set of factors to be considered are technology variables. As noted in Section 2, the leading argument is that skill-biased technological change is the major cause of rising earnings inequality. The first of these variables is labour productivity growth—GDP in 1992 dollars per persons engaged in production (PEP)—and the second is total factor productivity (TFP) growth, defined as:

(1) $$TFPGRTH_t = dY_t/Y_t - \alpha dL_t/L_t - (1 - \alpha)dK_t/K_t$$

where Y_t is GDP at time t, L_t is the total labour input, K_t is the capital input, and α is the average wage share over the period. The labour input is measured by persons engaged in production (PEP) and the capital input by the fixed non-residential net capital stock (in 1992 dollars). A second index of TFP growth was also used, with Full-Time Equivalent Employees (FTEE) as the measure of labour input. Since the data are for discrete time periods, the Tornqvist-Divisia measure, based on average period shares, is used in the actual estimation.

Figure 3
Wealth inequality, median house price, S&P stock index, and the ratio of stock price to house price, 1947-97

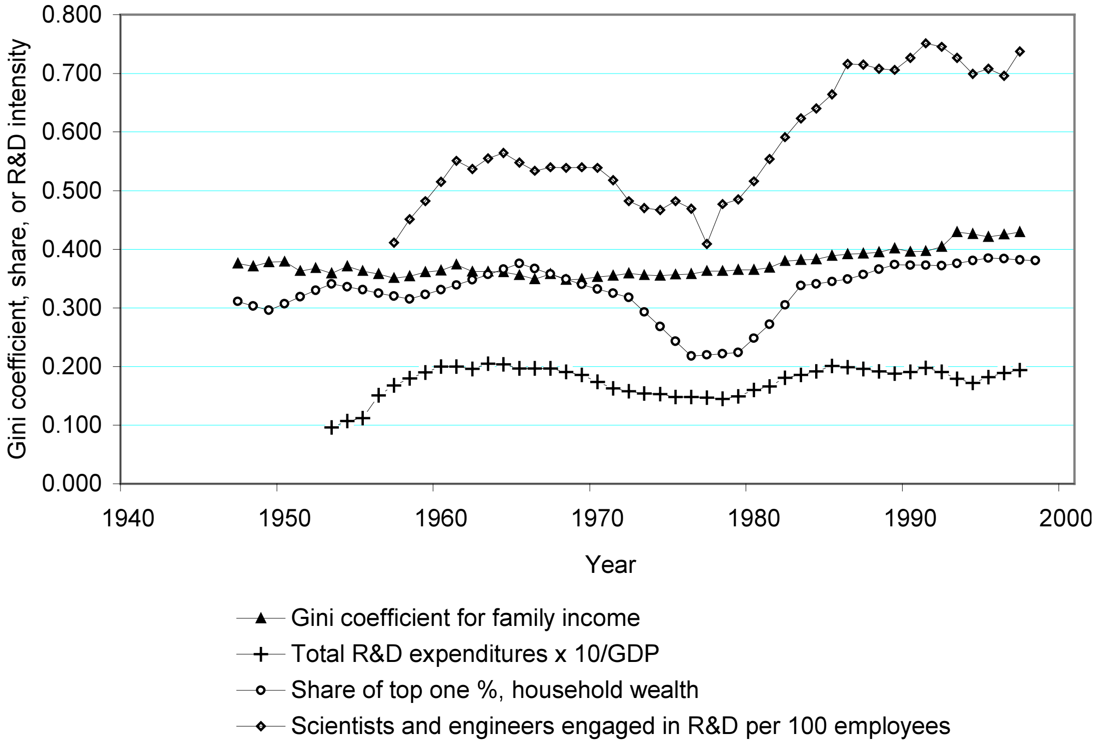


These two indicators trend downward from the high growth period of 1947-67 to the first slowdown of 1967-73 and then fall sharply in the second slowdown of 1973-79 before recovering somewhat in the 1979-97 period (see the table below). Not surprisingly, the productivity growth rates are negatively correlated with income inequality but the correlations are very low (in absolute value): -0.21 and -0.07, respectively. The correlations with wealth inequality are also very low, 0.16 and 0.12, respectively.

Annual growth rates [%]

	GDP/PEP	TFP
1947-67	2.58	1.84
1967-73	1.92	1.26
1973-79	0.49	0.38
1979-97	0.93	0.61
1947-73	2.43	1.70
1973-97	0.82	0.56
1947-97	1.65	1.15

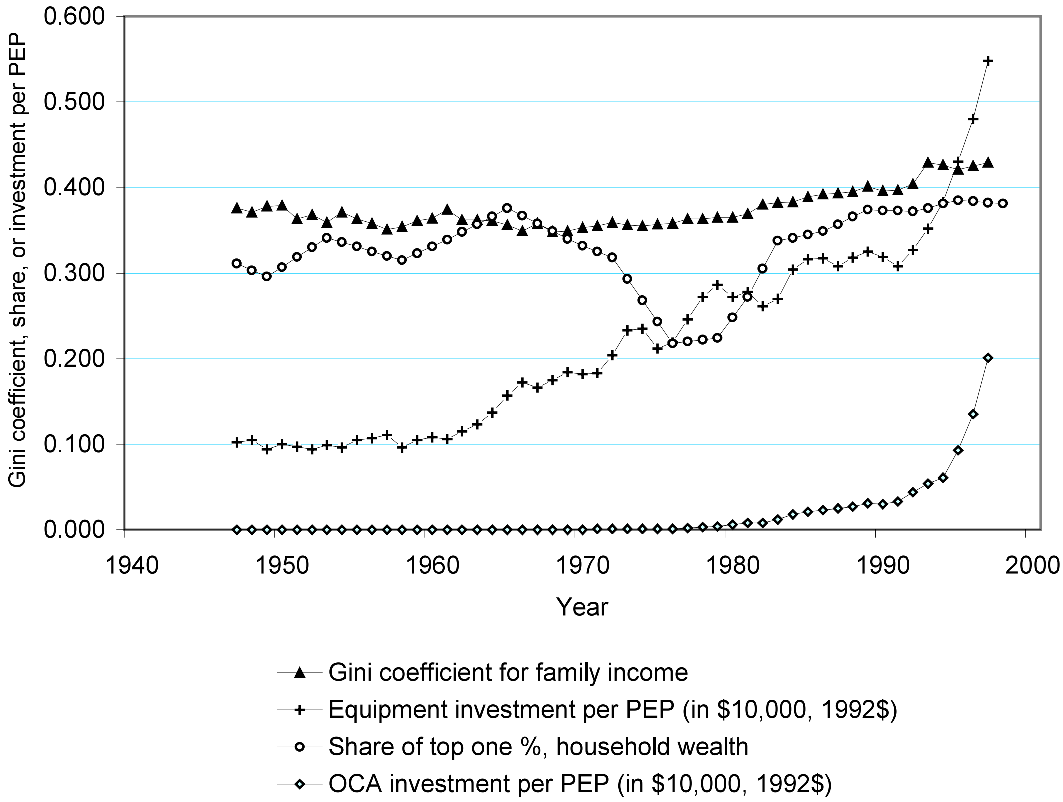
Figure 4
Income and wealth inequality and R&D intensity, 1953-97



The second set of technological indicators are measures of R&D activity—the ratio of total R&D expenditures to GDP and the number of scientists and engineers engaged in R&D per 1,000 employees. As shown in Figure 4, these two variables track much better with movements in income and wealth inequality than does productivity growth. The ratio of total R&D to GDP rose between the early 1950s and the 1960s and then fell in the 1970s before rising again in the 1980s. Its correlation is 0.29 with family income inequality and 0.87 with wealth inequality. In contrast, the number of scientists and engineers engaged in R&D per 1,000 employees increased between the late 1950s and early 1960s, levelled out and then fell in the early 1970s before rising sharply after 1976. It has a much higher correlation with income inequality, 0.87, but a slightly lower correlation with wealth inequality, 0.67.

Another source of bias in technological change might derive from investment in equipment and machinery, particularly computers. Equipment investment per PEP remained relatively flat between 1947 and 1961 and then climbed sharply from $1,056 (in 1992 dollars) in 1961 to $5,480 in 1997 (see Figure 5). It is highly correlated with family income inequality, at 0.78, but only slightly correlated with wealth inequality, at 0.16.

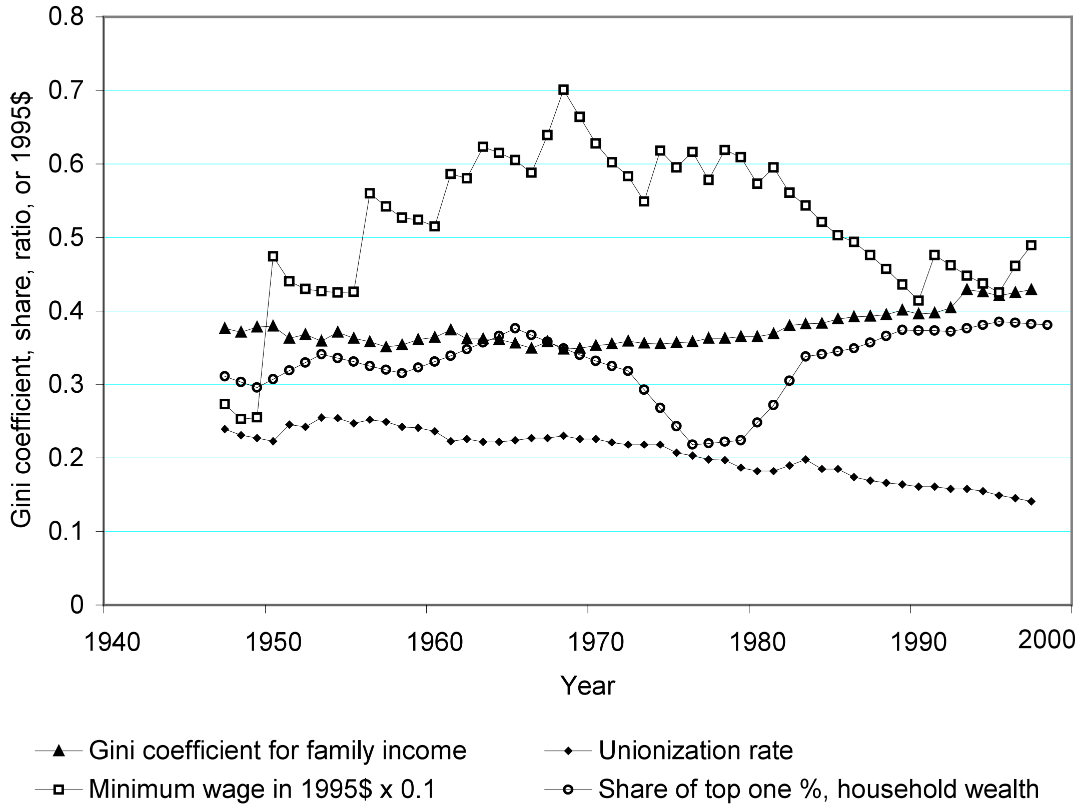
Figure 5
Income and wealth inequality and investment in equipment and OCA per PEP, 1947-97



Investment in office, computing, and accounting (OCA) equipment per PEP grew slowly from 1947 to 1980 and then surged at an incredible pace thereafter. In 1980, investment in OCA per employee was $56 (in 1992 dollars), while in 1997 it was $2,006. It is apparent that the huge growth of OCA investment occurred after the upswing in both income and wealth inequality. Despite this, OCA investment per employee is even more strongly correlated with family income inequality than is total equipment investment per worker—a coefficient of 0.81—and also with wealth inequality, at 0.48. Indeed, OCACM (the sum of communications equipment and OCA) per PEP has an even higher correlation coefficient with family income inequality, 0.84, but a little lower correlation with wealth inequality, 0.39.

The third set of variables, shown in Figure 6, reflects institutional and structural changes. The first of these is the overall unionization rate. The proportion of the work force represented by unions peaked in 1954, at 25.4 per cent, and then diminished almost continuously to 14.1 per cent in 1997. On the surface, the timing is different from the trend in income inequality, which began its upward spiral in the late 1960s. Still, the correlation between the two series is very strong, -0.83. The correlation with wealth inequality, which plummeted from 1965 to 1976, is also negative but much lower, at -0.16.

Figure 6
Income and wealth inequality, the unionization rate and the minimum wage, 1947-97



The second is the minimum wage in constant dollars, which peaked in 1968, the same year as income inequality bottomed out (see Figure 6). The correlation between the two series is -0.50. In contrast, the correlation of the minimum wage with wealth inequality is only -0.29.[3]

4 Regression analysis

I next turn to multivariate regression for the 1947-97 period to separate out the influence of these various variables on both family income inequality and household wealth inequality. Results for the first variable are shown in Table 1. I have selected the regression form with the highest adjusted R^2-statistic (or, correspondingly, the lowest standard error of the regression).

The most consistent variable is the civilian unemployment rate. It is included in the specification to control for the cyclical effects of the economy on inequality—inequality

3 Other variables included in the analysis were various measures of trade intensity, the share of total workers employed in service industries, and white-collar workers as a percentage of total employment. These variables did not prove statistically significant in the subsequent regression analysis and results for them are not reported here.

normally rises during a recession and declines during a recovery. The coefficient has the predicted positive sign and is significant at the one per cent level in four of the five cases and at the five per cent level in the other case. The next most consistent variable is the unionization rate, which has the predicted negative sign and is significant at the five or ten per cent level in most cases (at the one per cent level in one case). The third is investment in equipment per worker (PEP). Its coefficient is positive and significant at the five per cent level in all cases. Investment in OCA per worker also has the predicted positive sign, though its coefficient is significant at only the ten per cent level (Specification 2).[4] The results for these three variables are robust over a wide range of alternative specifications.

Most of the remaining variables do not prove to be statistically significant. These include the minimum wage in 1995 dollars, though it has the predicted negative sign (Specification 3). Both the annual rate of labour productivity growth (Specification 4) and the annual rate of TFP growth (Specification 5) have negative coefficients but are also not significant. Industry R&D as a share of GDP and the number of full-time equivalent scientists and engineers engaged in R&D per employee have positive coefficients but are not significant (results not shown). The coefficients of both the number of female-headed families as a percentage of total families and personal property income as a share of total personal income have the predicted positive sign but neither is significant

As noted above, the coefficient of investment in equipment per PEP is statistically significant at the five per cent level and investment in OCA per PEP is significant at the ten per cent level. Also significant at the ten per cent level are computer investment per PEP and investment in OCACM per PEP, as well as equipment investment as a share of GDP. The best fit is provided by the ratio of equipment investment to PEP.

The goodness of fit is extraordinarily high, R^2 statistics ranging from 0.93 to 0.95 and adjusted-R^2 statistics from 0.93 to 0.94, indicating that these variables explain between 93 and 95 per cent of the variance in inequality over this time period. The Durbin-Watson statistic is in the acceptable range—very close to 2.0.[5] It is also of note that the regression results for the various variables used in the analysis remain very robust among alternative specifications, including the use of both lagged investment in equipment per PEP and lagged investment in OCA per PEP.

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4 When investment in equipment per PEP and investment in OCA per PEP are included as independent variables in the same equation, neither is statistically significant. The reason is that the two are highly correlated—a correlation coefficient of 0.81.

5 Another test that was performed is the Augmented Dickey-Fuller (DF) Unit Root test for non-stationarity in the dependent variable. The regression includes one lagged value of the dependent variable. The results are as follows:

Variables include	DF t-statistic	MacKinnon critical value (1%)	Reject unit root?
No constant; no time trend	-5.003	-2.611	Yes
A constant; no time trend	-5.169	-3.571	Yes
A constant; a time trend	-6.263	-4.158	Yes

Similar results are found using multiple lagged terms of the dependent variable.

Table 1
Family income inequality regressions, 1947-97

Independent variables	Specification (1)	(2)	(3)	(4)	(5)
Constant	0.389**	0.438**	0.389**	0.400**	0.398**
	(9.34)	(15.60)	(8.90)	(9.37)	(9.25)
Unemployment rate	0.292**	0.209*	0.293**	0.297**	0.273**
	(2.96)	(2.36)	(2.92)	(3.01)	(2.69)
Unionization rate	-0.279#	-0.387**	-0.280#	-0.323*	-0.309*
	(1.87)	(3.07)	(1.86)	(2.09)	(2.07)
Equipment investment per PEP	0.010*		0.010*	0.010*	0.010*
	(2.19)		(2.16)	(2.02)	(2.05)
OCA investment per PEP		0.013#			
		(1.91)			
Minimum wage (1995$)			-0.043		
			(0.02)		
Labour productivity growth				-0.054	
(3-year running average)				(1.23)	
TFP growth					-0.034
(3-year running average)					(0.90)
R^2	0.94	0.93	0.94	0.94	0.94
Adjusted R^2	0.93	0.93	0.93	0.93	0.93
Standard error	0.0060	0.0061	0.0061	0.0060	0.0060
Durbin-Watson	2.04	1.91	2.04	1.95	1.96
Sample size	50	50	50	50	50

Note: The dependent variable is the Gini coefficient for family income inequality (GINIFAM). The absolute value of the t-statistic is in parentheses below the coefficient. The estimation technique is AR(1): Autoregressive process, First-order: $u_t = \varepsilon_t + \rho_1 u_{t-1}$, where ut is the error term of the original equation and ε_t is a stochastic term assumed to be identically and independently distributed.

Significant at the 10% level (two-tailed test)
* Significant at the 5% level (two-tailed test)
** Significant at the 1% level (two-tailed test)

Regression results for wealth inequality are shown in Table 2. Due to data limitations on wealth inequality, the sample size is much smaller, only 15 observations. The most significant variable by far is the ratio of the S&P 500 stock index to median house price. Its coefficient is significant at the one per cent level with the predicted positive sign. The second most important variable is the minimum wage in 1995 dollars, whose coefficient is significant at the five per cent level with the predicted negative sign (a lower minimum wage leads to greater wealth inequality).

Neither the unemployment rate nor the unionization rate are statistically significant (Specification 2). The coefficients of both equipment investment per worker and OCA investment per worker have the expected positive sign but neither is statistically

Table 2
Household wealth inequality regressions, 1947-97

	Dependent variable							
	(1) TOP1WLTH	(2) TOP1WLTH	(3) TOP1WLTH	(4) TOP1WLTH	(5) TOP1WLTH	(6) TOP1WLTH	(7) TOP1WLTH	(8) SP500
Constant	0.329**	0.352**	0.316**	0.321**	0.323**	0.330**	0.345**	0.226**
	(7.04)	(3.26)	(6.16)	(6.26)	(6.62)	(6.83)	(4.76)	(8.98)
S&P 500/Median	0.741**	0.757**	0.732**	0.702**	0.732**	0.729**		
House price	(4.49)	(3.60)	(4.32)	(3.67)	(4.30)	(4.24)		
Minimum wage (1995$)	-0.024*	-0.023*	-0.023*	-0.021*	-0.024*	-0.024*	-0.007	
	(2.76)	(2.40)	(2.68)	(2.24)	(2.70)	(2.72)	(0.51)	
Unemployment rate		-0.003						
		(0.00)						
Unionization rate		-0.001						
		(0.35)						
Equipment investment per PEP			0.006					
			(0.67)					
OCA investment per PEP				0.019			0.097#	0.331**
				(0.45)			(2.06)	(3.65)
Labour productivity growth					0.412			
(3-year running average)					(0.60)			
TFP growth						0.367		
(3-year running average)						(0.51)		
R^2	0.66	0.66	0.67	0.67	0.67	0.67	0.25	0.49
Adjusted R^2	0.60	0.53	0.58	0.57	0.58	0.58	0.13	0.45
Standard error	0.033	0.036	0.034	0.034	0.034	0.034	0.049	0.088
Sample size	15	15	15	15	15	15	15	16

Note: The dependent variables are the share of total household wealth owned by the richest one per cent of households (TOP1WLTH) and the S&P 500 stock index (SP500). The absolute value of the t-statistic is shown in parentheses below the coefficient. Data points are 1949, 1953, 1958, 1962, 1965, 1969, 1972, 1976, 1979, 1981, 1983, 1986, 1989, 1992, 1992, and 19958 (for SP500).

Significant at the 10% level (two-tailed test)

* Significant at the 5% level (two-tailed test)

** Significant at the 1% level (two-tailed test) significant (Specifications 3 and 4). None of the other investment variables is significant (results not shown). The coefficient of R&D expenditures as a per cent of GDP is also not significant (results not shown). Likewise, the coefficient estimate of the number of female-headed families as a percentage of total families are not significant (results not shown).

One final set of regressions was run. As shown in Specification 7, wealth inequality was regressed on the minimum wage in 1995 dollars and investment in OCA per worker, with the ratio of the S&P 500 stock index to median house price omitted. In this case, the coefficient of investment in OCA per worker is positive and significant at the ten per cent level. In the final specification, investment in OCA per worker is regressed on the S&P 500 stock index, and its coefficient is positive and significant at the one per cent level.[6]

5 Concluding remarks

When we consider the aggregate time-series regression results, we find that the largest effects on income inequality come from equipment investment and unionization. OCA investment is also found to have a positive and significant effect on income inequality (though not as strong as equipment investment).

These results are generally supportive of skill-biased technological change emanating from equipment investment in general and computerization in particular. They are also loosely consistent with the capital-skills complementarity argument that the adoption of new capital equipment calls forth the need for high skilled (and thus high paid) workers. The introduction of computers into the workplace, in particular, appears to cause a major restructuring of jobs in the workplace and one that favours more skilled over less skilled workers and a consequent increase in overall earnings inequality. These results are consistent with a several previous studies cited in Section 2 above, including Katz and Murphy (1992), Krueger (1993), Berman, Bound, and Griliches (1994), Allen (1996), and Autor, Katz, and Krueger (1998).

On the other hand, TFP growth and labour productivity growth on the aggregate level have no statistical effect on income inequality. Other technological factors such as R&D investment and the number of scientists and engineers engaged in R&D per employee likewise do not appear to affect inequality. These findings are not unexpected, since the rate of productivity growth has been so low in the period 1973-97, compared to the preceding quarter century. My results appear to conflict with those of Mincer (1991) and Adams (1997), who both reported a positive association between R&D expenditures and educational wage differentials.

Unionization has a decidedly negative effect on income inequality. Unions thus appear to retard the restructuring of jobs in the workplace and thereby help mitigate increases in earnings inequality. These results are also consistent with some of the findings in the

6 The same regression was also executed on the entire time-series, from 1947 to 1997, using a first-order autoregressive estimator. The coefficient of OCA investment per worker remains positive and significant at the one per cent level, and the adjusted R^2 statistic increases to 0.93.

earlier literature, including Blackburn, Bloom, and Freeman (1990) and Freeman (1993), and Gordon (1996).

With regard to wealth inequality, the only two significant effects come from the ratio of the S&P 500 stock index to median house, which has a very strong positive relation, and the minimum wage in 1995 dollars, which has a negative and less strong relation. None of the other variables is statistically significant.

However, investment in OCA per worker has a very strong positive relation to movements in stock prices, which suggests that it is indirectly linked to changes in wealth inequality. The finding of the linkage between stock prices and OCA investment is not inconsistent with the fact that both income and wealth inequality started to increase before the huge surge in OCA investment. Indeed, according to some theories of the stock market (see, for example, Greenwood and Jovanovic 1999), stock prices may react to news about a technological revolution as soon as the news becomes available. The rise in stock prices beginning in the mid-1970s may thus have anticipated the huge growth of OCA investment that followed.

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