THE U.S. PRODUCTIVITY SLOWDOWN: A CASE OF STATISTICAL MYOPIA

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ABSTRACT

This paper identifies three major preriods: 1900-1929, 1929-1965, and 1965-1979. In contrast to the middle period, the extreme periods are characterized by rapid growth in private employment and hours worked; because growth in private product increases by less, measured labor productivity growth falls compared to the middle period. However this fall reflects a substantial substitution of quantity for quality in labor force growth: After private employment and hours are adjusted for age, sex, immigration, and education, no difference is observed among the average quality-adjusted labor productivity growth rates. Substantial variation in these growth rates remains within the 1929-1965 and 1965-1979 periods. Slow quality-adjusted labor productivity growth during 1929-1948 is just offset by unusually rapid growth during 1948-1965; these variations are attributed to the near cessation of investment during the Depression and World War II and subsequent recovery of the capital-labor ratio. Thus no substantial variations in total factor productivity growth or technical progress is found. Variations in productivity growth within 1965-1979 are explained by price-control induced biases in reported deflated output. Correction of these biases results in nearly equal quality-adjusted labor productivity growth in 1965-1973 and 1973-1979. A substantial program of future research is proposed. A data appendix is included.

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The decline in American productivity has come to rival inflation as a major economic issue for public policy. Indeed something akin to panic has followed reports that labor productivity growth has declined from an average annual rate of 2.6 percent over 1948-1965 to 1.9 percent over 1965-1973 to 0.5 percent from 1973 to 1979.[1] This paper shows that the productivity panic is based upon statistical myopia and that a careful analysis within the perspective of the entire twentieth century discloses no substantial variation in what is variously described as growth in total factor productivity or technical progress.

The argument is made in two parts. First, three major subperiods are identified: 1900-1929, 1929-1965, and 1965-1979. It is noted first that the early and late periods are very similar to each other and are characterized, in comparison with the middle period, by rapid growth in labor force and a less than equal increase in growth in real output so that measured labor productivity falls. This picture changes dramatically when allowances are made for age, sex, education, and immigration to obtain a quality-adjusted labor force. The differential between the growth rates of output and quality adjusted hours worked is essentially identical across the three periods. Thus simple demographic adjustments eliminate any secular decline in technical progress.

The second part of the argument focuses on variations in productivity growth trends within the middle and later periods. It is shown that very slow growth in the capital-labor ratio from 1929 to 1948 accounts for very slow labor productivity growth during that sub-period as well as very rapid growth during 1948-1965. That is, the very rapid growth of 1948-1965 resulted from our poverty in 1948 and did not reflect desirable economic conditions. The more rapid productivity growth in 1965-1973 as compared to 1973-1979 is explicable by measurement error due to underreporting of price increases and hence overreporting of output increases due to Nixon's price control program. It is of particular interest that the oil price increases of 1973-1974 do not appear to have played a major role in slowing productivity growth.

The analysis was made possible by the development of a historical data base on productivity, labor force, and employment reported elsewhere.[2] Unfortunately, complete census and immigration data required for the demographic adjustments were only available through 1979 when the data base was compiled in 1982. This is not a significant problem for analysis of longer run trends since 1979 is the last year available as of writing (1983) which is characterized by an approximately normal unemployment rate. Where cyclical productivity growth is considered in Section II, it was possible to use data through the first quarter of 1983. Extracts of the relevant data are contained in a data appendix.

I. Analysis of Longer-Period Trends

The broad trends of the twentieth century are summarized in Table 1 for private employment (PE), average and total private hours worked (AHWP and THWP, respectively), gross private product (GPP), and private hourly and employee productivity (GPP/THWP and GPP/PE, respectively).[3] Darby (1984) notes the periods 1900-1929 and 1965-1979 were characterized by rapid employment growth with immigration the relatively dominant factor in the early period and the baby-boom new entrants relatively more important in the recent period. The intermediate period 1929-1965 was marked by both tight limitation on immigration and a low rate of natural increase.[4] The three major periods were thus differentiated both by changes in immigration laws and by the post-war baby-boom's coming of age. Since the rate of decline in average hours worked was nearly constant, the changes in employment growth were the dominant factor determining variation in growth in total hours.

Each of the major periods has been divided roughly in half for later analysis.[5] At least for 1929-1965 and 1965-1979, the growth rates of private employment and total private hours are approximately the same in each subperiod as the mean for the respective major period. Thus each of these periods is roughly homogeneous in terms of labor developments. The unevenness of immigration and estimated average-hours-worked growth in the first 29 years of the century makes the period 1900-1929 appear rather less homogeneous, but demographic adjustments discussed below eliminate most of the differences between the subperiods.

Focusing on the major periods in Table 1, we note that 1965-1979 is rather similar to 1900-1929 not only in employment and hours growth but also in output and productivity growth. Compared to 1929-1965, total hours growth is 1.0 to 1.3 percent higher in the earlier and later periods while GPP growth is only 0.4 to 0.5 percent higher. Thus hourly productivity growth is recorded as 0.5 to 0.8 percent lower in 1900-1929 and 1965-1978 as compared to 1929-1965. Correspondingly, growth in private output per person employed is 0.4 to 0.6 lower in the extreme periods than in the middle period. A possible explanation of the more rapid productivity growth in the middle period is that the hours and employment growth-rate declines in the middle period may be overstated due to failure to adjust for demographic changes, especially immigration and the baby boom.[6]

Measures of private hours do not adjust for differences in human capital although the idea that an hour is an hour is as falacious as the idea that a 1964 dollar equals a 1984 dollar. Although elaborate adjustments such as Chinloy (1980) are precluded by limitations in the historical data, it is possible to make approximate adjustments for observed differences in productivity due to age, sex, education, and immigrant status.

Let us first consider the adjustment for the age-sex composition of the labor force. The private labor force estimates are divided into individual cells by sex and "young" (Y, under 25) or "old" (O, over 24). Standardizing on males over 24 and taking young males, young females, and old females as less productive because of differences in human capital, we compute age-sex adjusted private employment as

$$(1)\quad APE = PE_{MO} + \alpha_1 PE_{MY} + \alpha_2 PE_{FY} + \alpha_3 PE_{FO}$$

where the subscripts M and F indicate sex. The α's are chosen to reflect differences in average hourly earnings. Using data in Denison (1979, p. 33), this suggests α_1 of 0.53 to 0.50, α_2 of 0.43 to 0.41, and α_3 of 0.56 to

0.57.[7] We use 0.515, 0.42, and 0.565 as α_1, α_2, and α_3, respectively.

New immigrants to the United States on average earn substantially less than native-born Americans.[8] In part this reflects permanent differences in human capital endowments, but much of the difference is eliminated over time as the immigrants become acculturated. Since immigration is most important in the earlier period, Francine Blau's (1980) estimates based on 1909 data are used to adjust the foreign-born to native-born equivalents by the following formulas:[9]

$$(2)\quad PE_{Ma} = PE_{MNa} + (1.01076)^{Z_M}(0.753)PE_{MIa}$$

$$(3)\quad PE_{Fa} = PE_{FNa} + (1.01177)^{Z_F}(0.891)PE_{FIa}$$

where PE_{sIa} and PE_{sNa} are the (unadjusted) private employment of foreign born (I) and native-born (N) individuals of sex s and age-group a and where Z_s is the average years since entry of foreign-born workers of sex s.[10] That is, a just-arrived male immigrant is assumed to equal 75.3 percent of a native-born male of the same age group, but this factor grows at a compound rate 1.076 percent per year spent in the country. The average years since entry was estimated according to the recursive formula

$$(4)\quad Z_s = (0.5)\frac{I_s}{P_s} + (Z_{s,-1} + k_s)\left(1 - \frac{I_s}{P_s}\right)$$

where I_s is the inflow of (sex s) immigrants over the preceding year, P_s is the corresponding foreign-born population, and k_s is a number between 0 and 1 to allow for disproportionate frequency of emigration, death, and retirement among the less recent foreign-born. This formula says that the (mid-year) average years since entry is a weighted average — weights I_s/P_s and $1 - (I_s/P_s)$ — of 0.5 year for those arriving in the last twelve months and $Z_{s,-1} + k_s$ for those previously arrived and remaining in the labor force. Benchmarks for 1909 and 1970 were computed from the Immigration Commission data for 1909 and from 1970 Census data.[11] These benchmarks implied $k_M \simeq k_F \simeq 0.603$. The estimated values of Z_s are reported in the data appendix. Since the adjustments for years since migration of the foreign-born were made before the adjustment for age and sex described in equation (1), the variable APE is in fact adjusted for all these factors.

The final demographic factor believed to be important in determining the human capital content of the labor force is education. It is assumed that human capital is increased by 7 percent per year of education,[12] so that quality-adjusted private employment is

$$(5) \quad QAPE = (1.07)^{E} APE$$

The education variable E is measured by the median school years completed by those 25 years and over.[13]

Table 2 indicates the relative importance of the various demographic factors across the period by breaking the difference between unadjusted and quality-adjusted private-employment growth rates into age, sex, immigration, and education components.[14] Table 3 displays the differential effects in the three major periods by subtracting the average 1900-1978 value of each adjustment from the value of the adjustment for the period. For example, failure to adjust for age in the productivity measures in Table 1 resulted in understating 1965-1978 productivity growth by -0.24 - 0.03 = -0.27 percent per annum relative to 1929-1965. Overall, the productivity growth differential from 1929-1965 was overstated by 0.29 - (-0.19) = 0.48 percent per annum for 1900-1929 and by 0.29 - (-0.37) = 0.66 for 1965-1978.

Table 4 illustrates that after private employment is adjusted for these demographic factors, both the hourly and employee productivity measures show no significant variation across the major periods. In particular there is no indication of a secular productivity slowdown in 1965-1978 versus 1929-1965 or indeed the entire twentieth century. Furthermore, as noted above, we have used the hours measure most favorable to finding such a slowdown; if we had used alternative data on average private hours paid, average private nonsupervisory hours paid, or average civilian hours worked, the 1965-1979 growth rates of output per quality-adjusted hour would have equalled or slightly exceeded the corresponding 1929-1965 growth rate.[15]

Francine Blau (1984), among others, has suggested that all or part of the sex differential in wages may reflect discrimination of the type in which women are paid less than their marginal product, presumably to compensate male employers or employees for associating with females. Fortunately that issue is not important for the question of whether there was a productivity slowdown: If women are weighted equally to their male counterparts of the same age (α_2 = 0.515, α_3 = 1) quality-adjusted private employment growth is 0.50 percent per annum higher in 1965-1978 than in 1929-1965 compared to a 0.48 percent per annum differential using our standard weights (α_2 = 0.42, α_3 = 0.565). Only for the 1900-1929 period is the sex adjustment a substantial factor (0.12 percent per annum differential) relative to 1929-1965. If we suppose that half of the sex wage differentials reflect true marginal product differentials, the effect on the analysis of productivity growth is strictly de minimis.

In conclusion, changes in immigration laws and the entry of the baby-boom divide the twentieth century into three major periods: before 1929, 1929-1965, and after 1965. From the point of view of growth in employment and hours, each major period seems reasonably consistent, but the middle period is characterized by considerably lower growth than either of the exterior periods. Since the growth rate of gross private product declines by less than the decline in hours growth in the middle period, measured productivity growth rises. However, the demographic factors of age, sex, immigration, and education explain essentially all of the measured secular variation in hourly or per-employee productivity growth. Thus, it appears that there is no substantial variation in trend private productivity growth over the twentieth century to be explained by variations in regulation growth, oil prices, the failure of American management, labor, or any of the other popular whipping boys. So far as broad trends go, the U.S. productivity slowdown appears to be a case of statistical myopia.

Demographic adjustments also appear to explain observed variations in private employee productivity growth within the period 1900-1929. The hourly productivity growth measure shows some residual variation (1.50% for 1900-1916 versus 2.09% for 1916-1929), but this appears to be related to anomolous growth in our measure of average hours. It is left for economic historians to unravel whether the hourly productivity measure reflects a real phenomenon or simply measurement error.

Much more substantial variations in hourly and employee productivity growth are reported in Table 4 within the periods 1929-1965 and 1965-1978. For example, quality-adjusted hourly productivity growth is reported as 1.2, 2.4, 2.3, and 0.7 percent per annum for 1929-1948, 1948-1965, 1965-1973, and 1973-1978, respectively. It is the task of Section II to explain this residual variaton.

II. Analysis of Intra-Period Variations

Section I argues that the quality-adjusted hourly productivity growth rate has had a constant secular value of 1.75 percent per annum throughout the twentieth century. Then how are we to explain the fact that this growth rate exceeded 2.3 percent per annum from 1948-1973 and was only 0.7 percent from 1973-1978? In this section it is first shown that the rapid 1948-1965 growth is explained by the recovery of the capital-labor ratio from its abnormally low level at the end of World War II and the Great Depression. That is, the rapid (slow) growth in labor productivity during 1948-1965 (1929-1948) is due to abnormal movements in the capital stock relative to labor and output and therfore is not reflected in total factor productivity growth or technical progress. Next it is demonstrated that the reported variations within the 1965-1979 appear to be the result of biases in measured output due to evasion of the 1971-1974 price controls. Correction of these biases nearly eliminates any tendency for quality-adjusted hourly productivity growth to slow in 1973-1979 or to be above 1.75 percent per annum in 1965-1973.

The 1929-1965 Period

The slow growth in 1929-1948 and rapid catch-up growth in 1948-1965 is attributed here to the very low ratio of investment to output during the Great Depression and World War II. The idea is that in 1948 we were quite poor in the sense of a low capital-labor ratio and it took until around 1965 to recover to the steady-state capital-labor and output-labor ratios as illustrated in Figure 1.

An implication of the approximately equal quality-adjusted hourly productivity growth rates for 1900-1929, 1929-1965, and 1965-1979 is that the output-labor ratio is approximately the same in 1900, 1929, 1965, and 1978 after allowing for a constant rate of labor-augmenting technical progress.[16] Therefore, if capital growth explains the observed variation of output growth within the period, it follows that there was no significant intra-period variation in technical progress (total factor productivity growth).

A simple and usually serviceable characterization of the aggregate production function is the Cobb-Douglas form

$$(6) \quad y = e^{\tau t} k^{\beta} \ell^{(1-\beta)}$$

where τ is the rate of total factor productivity growth and ℓ is measured (quality-adjusted) labor input. This can equivalently be written in logarithmic form as

$$(7) \quad \log y = \beta \log k + (1-\beta)\log(\ell e^{\gamma t})$$

where $\gamma \equiv \tau/(1-\beta)$ is the constant rate of labor-augmenting technical progress. Subtracting $\log \ell$ from both sides of equation (7) and using Γ for the continuously compounded growth rate operator, we have

$$(8) \quad \Gamma(y/\ell) = \gamma + \beta[\Gamma k - (\Gamma\ell+\gamma)]$$

That is, the growth rate of labor productivity equals the rate of technical progress plus the product of capital's share and the difference between the capital and the adjusted labor growth rates.

The capital growth rate has been estimated as about 0.6 and 4.0 percent per annum for 1929-1948 and 1948-1965, respectively.[17] Equation (8) is used to predict the observed quality-adjusted labor productivity growth rate for a capital share of 1/4 as well as alternative value of 0.2 and 0.3. Table 5 reports the results which indicate that the actual and predicted growth ratio of quality-adjusted hourly and employee productivity correspond quite closely for 1929-1948. Thus the near cessation of investment during the Depression and World War II nicely explains the observed slowdown in productivity growth. Since the output-labor ratio has already been shown to return to its trend value by 1965, the solution seems to be complete.

Unfortunately, the second line of each part of Table 5 indicates that the predicted productivity growth falls short of actual growth by 0.3 or 0.4 percent per annum. It may be that this unexplained growth reflects a real temporary increase in technological progress that offsets an unusual fall in the capital-output ratio of some 24 percent over 1929-1965,[18] but a simpler and economic explanation is also possible. Quite possibly the fault lies in the capital data themselves: The quantum leap in tax rates during World War II provides an incentive to write off as current expense as much capital formation as possible; thus gross investment and capital growth could be systematically understated in the postwar period.[19] Suppose that a consistent data series would in fact show no decline in the capital-output ratio. This would imply that the true capital growth rate over 1948-1965 is 5.6 percent per annum.[20] In order for this to be the case, firms would have had to alter their accounting practices so that reported net investment was reduced relative to earlier practices by almost 24 percent. Given the large incentives, this magnitude does not appear unreasonable, but further research is clearly indicated.[21] In any case, the lower halves of each part of Table 5 indicates that a 5.6 percent or even smaller capital growth rate would be sufficient to eliminate any apparent 1948-1965 rise in total factor productivity growth.

In summary, measured capital growth variations can explain all of the 1929-1948 slowdown in quality-adjusted labor productivity growth and a large part of the 1948-1965 increase in that growth relative to trend. The remaining 0.3 to 0.4 percent excess growth in 1948-1965 can be attributed either to an unexplained temporary increase in total factor productivity growth or to changes in net investment reporting in response to increased income taxes.

The 1965-1979 Period

It is not widely recognized that the main problem with productivity growth in 1973-1979 is concentrated in the seven quarters 1973 II through 1974 IV:

> The productivity decline in 1973-74 was particularly striking. Labor productivity in the nonfarm business sector fell in every quarter from the second quarter of 1973 to the fourth quarter of 1974, dropping a total of 4.2 percent in a 7-quarter period. On the basis of the usual relationship between fluctuations in productivity and fluctuations in output, no more than 1 percentage point of that decline could be attributed to the sharp recession during the period. The additional drop of 3.2 percentage points accounts for much of the difference between the expected 2 percent annual growth rate between 1973 and 1977 and the 0.9 percent rate that actually occurred.[22]

This section will demonstrate not only that the progressive relaxation and ultimate removal of general price controls during 1973-1974 can fully account for this anomolous excess productivity decline of 3.2 percent but also that the imposition of these controls during 1971 II through 1973 I can account for the peculiarly rapid productivity growth observed during those quarters.[23] This rapid productivity growth permits us to reject the popular oil-price hypothesis in favor of the price control hypothesis.

Before examining the evidence, it is useful to sketch these two competing hypotheses: The oil-price hypothesis as developed by such authors as Rasche and Tatom (1977, 1981) asserts that higher oil prices will significantly lower the equilibrium level of output consistent with a given level of labor and capital and will further induce a fall over time in the level of capital. The price-control hypothesis as developed in Darby (1976a, 1976b) asserts that measured real output was progressively overstated (and price understated) from the imposition of price controls in 1971 III through 1973 I and that this overstatement was progressively eliminated under Phase III and decontrol (1973 II-1974 III). Sung Hee Jwa (1983) has extended Darby's basic model by a formal analysis of firm and industry equilibrium. Darby (1982) examines the oil-price and price-control hypotheses in detail using both U.S. and international data and finds that the preponderance of evidence supports the price-control hypothesis. This evidence will be supplemented below by directly estimating a productivity growth equation and by other empirical evidence. The second oil shock can be included and quarterly data used only at the cost of not making the demographic adjustments of Section I. Instead it will be assumed that from 1966 onwards demographic factors reduce conventionally measured labor productivity growth by a constant amount.

First we wish to test whether oil price, price controls, or both had a significant influence on productivity growth other than via any temporary effects causing unemployment and employment to differ from their steady-state values. Standard productivity equations have deflated values on both sides inducing spurious correlation if the price control hypothesis is true. Fortunately, a simple dynamic Okun's Law extended by other current and leading labor-market indicators provides very respectable explanatory power without potential spurious correlation. The basic equation used corresponds (with one minor exception) in right-hand variables to equation (5) in Darby (1982):[24]

$$\text{(9)} \quad \Delta\log\,(y/\ell)_t = a_1 + a_2TS_t + a_3\Delta u_t + a_4\Delta\log\,E_t + a_5\Delta\log\,E_{t-1} + \varepsilon_t$$

where $(y/\ell)_t$ is the private-hours-paid definition of labor productivity,[25] TS_t is a time shift dummy equal to 0 before 1966 and 1 otherwise,[26] u_t is the total unemployment rate, and E_t is employment in manufacturing, mining, and construction. Note that the cyclical indicators used in this equation are all based on counts of individuals and so not subject to possible reporting biases (as are deflated series) under price controls. The estimated equation for 1950 II-1983 I is:[27]

$$\text{(10)} \quad \Delta\log\,(y/\ell)_t = \underset{(7.65)}{0.0069} - \underset{(-2.21)}{0.0027}\,TS_t - \underset{(-3.47)}{0.010}\,\Delta u_t + \underset{(0.44)}{0.039}\,\Delta\log\,E_t - \underset{(-5.62)}{0.293}\,\Delta\log\,E_{t-1}$$

$$S.E.E. = 0.00690, \qquad \bar{R}^2 = 0.28, \qquad D\text{-}W = 1.95$$

This equation does reasonably well at explaining quarterly fluctuations in productivity growth, although only the current change in unemployment and the lagged growth rate of employment are significant among the cyclical indicators.

To test the price control hypothesis, a simple quantitative variable was formed: CD_t grows linearly from 0 in 1971 II to 1 in 1973 I and then falls linearly back to 0 in 1974 IV. The deflated dollar price of a barrel of Venezuelan oil was used for the oil price P_t. The following general equation was estimated with up to a one year adjustment lag permitted for oil prices to take effect:

$$(11)\quad \Delta\log\,(y/\ell)_t = a_1 + a_2 TS_t + a_3\Delta u_t + a_4\Delta\log\,E_t + a_5\Delta\log\,E_{t-1} + a_6\Delta CD_t + \sum_{i=0}^{3} a_{7+i}\Delta\log\,P_{t-i} + \varepsilon_t$$

Table 6 reports the results of various alternative hypothesis tests that might be conducted. Line 1 pertains to equation (11) as stated while all the other lines involve various zero constraints on $a_6,\ldots,a_{10}$.[28] We see that whenever the price-control variable is included it is significant at the 1 percent level or better. The oil variables, in contrast, are never significant except for lines 5 and 6 in which, with the price-control variable forced out, current oil-price growth is significant at the 10 percent level on a one-tailed test. I conclude that oil-price changes had no significant effect on productivity growth. Note particularly that a major increase in real oil prices occurred between 1979 I and 1980 I, but no direct effect was detectable.

The final form of the regression is

$$(12)\quad \Delta\log(y/\ell)_t = \underset{(8.06)}{0.0070} - \underset{(-2.39)}{0.0027}\,TS_t - \underset{(-3.42)}{0.010}\,\Delta u_t + \underset{(0.31)}{0.027}\,\Delta\log\,E_t - \underset{(-5.61)}{0.280}\,\Delta\log\,E_{t-1} + \underset{(3.77)}{0.04691}\,\Delta CD_t$$

$$S.E.E. = 0.00657, \qquad \bar{R}^2 = 0.35, \qquad D\text{-}W = 2.08$$

Consider the implications of this equation for the level of productivity in the year 1973. The average value of CD_t in 1973 is 0.7857 which, when multiplied by 0.04691, implies that the logarithm of labor productivity in 1973 was overstated by 0.0369.[29] This means that the 1965-1973 growth rates of private labor productivity are overstated by 3.69/8 = 0.46 percent per annum and correspondingly that the 1973-1979 growth rates are understated by 3.69/6 = 0.61 percent per annum. Table 7 shows that applying this correction to the quality-adjusted productivity growth rates of Section I eliminates any evidence of a major 1973-1979 productivity slowdown. Instead the picture is one of remarkably stable productivity growth over the period 1965-1979 after accounting for the 1973 measurement biases. The growth rate of output per quality-adjusted employee remains within 0.20 percent per annum of the century average rate of 1.52 percent per annum. The same nearly holds for output per quality-adjusted hour worked, and would hold on any of the alternative measures of hours.[30] The remaining small fluctuations of the productivity growth rates around secular trends can be reasonably attributed to small sample fluctuations and the effects of small differences in unemployment rates for 1965, 1973, and 1979.

It is of course true that price controls could have had real effects, but these effects should have operated by changing unemployment and employment. The estimated coefficient of ΔCD captures some additional impact which must either measure output overstatement or some shift in the relationship of output to labor inputs for a reason yet to be proposed in the literature.

Additional Discussion and Evidence on the Price-control Hypothesis

There are three popular models of the effects of Nixon's Economic Stabilization Program (ESP): The first, used as the basic economic support for the program, argued that sticky expectations and nominal contracts would delay adjustment to a new lower, noninflationary equilibrium. The ESP, the argument goes, would accelerate the adjustment process and minimize the transitional increase in unemployment. The second view, associated with Barro and Grossman (1974) and Evans (1982), argues that general price controls reduce real output and inflation by inducing increased consumption of leisure. The third view, which I have proposed (1976a, 1976b, 1982) argues that the ESP was largely window-dressing and was easily evaded by minor covert quality depreciation both in physical products and services and in the terms on which they were sold.

Needless to say, these views are not mutually exclusive. For example, the ESP most probably reduced the unemployment associated with the existing macroeconomic conditions so that true output increased while reported output increased even more due to covert quality depreciation not captured in the official price indices. For the analysis of productivity growth, we are interested in the reporting effects and not the real effects.[31]

It may be useful to look more closely at how these reporting effects could occur. Recall that the ESP established price controls relative to the base-period price of each product produced by each firm. New, higher quality products could be introduced at higher prices reflecting their higher costs. During Phases 1 and 2 (August 1971-January 1973) the controlled prices generally fell relative to the prices which otherwise would have prevailed. This provided an increasing incentive to make covert quality depreciations in existing goods and to claim spurious quality appreciatons in new goods. Or to say the same thing, there was an increasing incentive to publicize every quality improvement and to shade the quality of existing products. If firms reacted to these incentives as we normally suppose, then those collecting data for computing price indices would likely miss more quality depreciation and record more quality appreciation than normal. Controls become progressively less binding under the subsequent Phases III and IV ending de jure on April 30, 1974, with the expiration of legislative authority and de facto in the third quarter with the expiration of certain pricing agreements negotiated in exchange for early decontrol.[32] So during this period firms had an incentive to progressively restore their products to their nominal quality. To the extent price data collectors missed the shading of quality during Phases I and II, they should equally have missed its restoration during the relaxation and removal of controls.

Before going any further, we must consider whether this story is empirically plausible. Some economists, especially those responsible for collecting the price data, have doubted that any significant quality shading could have been missed. However, the price-control hypothesis does not require any huge errors. The estimate in equation (12) of the missed quality decrease — or better, of the decrease in the quality improvement which was missed — only amounts to about 0.2 percent per month (2.7 percent per annum). This magnitude is very small not only in absolute terms but also relative to the supposed margin of error in quality adjustments.[33] Missed quality change always imparts some bias to measured real GNP growth, but price controls impart incentives which change the bias in predictable ways.

Another possible objection is that firms shading quality would be caught by the I.R.S.'s monitoring of the profit margin ceiling. But this is not the case in a balanced inflation in which prices, costs, sales, and profits all rise in proportion. Everyone can accurately report the dollar amounts of revenues, costs, and profits since the profit margin ceiling was purely window dressing absent any effective controls on (quality-adjusted) costs. Thus nominal value added and nominal GNP will be correctly computed; only its division between real GNP and the deflator will be biased.

Above and in Darby (1982) I have already shown that misreporting under price controls can explain the anomolous behavior of Okun's Law during the price control period.[34] Okun's Law should underpredict output growth from 1971 III through 1973 I when the growth is overreported and correspondingly overpredict output growth during the decontrol period. For 1971 II to 1974 IV as a whole, Okun's Law predicts total growth in real GNP rather well.[35]

Let us see what other evidence can be offered in support of the reporting hypothesis. A simple check on the hypothesis that the nominal GNP data will be unaffected involves running a simple reduced-form regression explaining nominal GNP (Y) growth by a distributed lag on nominal money (M1) growth and ΔCD:

$$(13) \quad \Delta \log Y = h_0 + \sum_{i=0}^{7} h_{1+i} \Delta \log M1B_{t-i} + h_9 \Delta CD$$

The estimated regression can be summarized as

$$(14) \quad \Delta \log Y = \underset{(3.33)}{0.0100} + \sum_{i=0}^{7} h_{1+i} \Delta \log M1B_{t-i} + \underset{(0.07)}{0.0012}\, \Delta CD$$

$$\sum_{i=0}^{7} h_{1+i} = 0.7650$$

S.E.E. = 0.00897, $\bar{R}^2$ = 0.19, D-W = 1.80, PERIOD = 1961 I-1983 I

Thus controls do not appear to have any significant impact on nominal GNP.[36] An analogous regression confirms the hypothesized negative impact of controls on the inflation rate as measured by the GNP deflator PD:[37]

$$\text{(15)}\quad \Delta\log PD = \underset{(-0.11)}{-0.0003} + \sum_{i=0}^{7} k_{1+i}\Delta\log M1B_{t-i} - \underset{(-2.69)}{0.0300}\ \Delta CD$$

$$\sum_{i=0}^{7} k_{1+i} = 0.9892$$

S.E.E. = 0.00389, $\bar{R}^2$ = 0.29, D-W = 2.12, PERIOD = 1961 I-1983 I

Thus regression analysis of U.S. data on real GNP, nominal GNP, and the GNP deflator indicates that price controls had no effect on reported total nominal spending, but only upon its division into prices and output. The fact that real output and productivity growth appear to rise and fall relative to that predicted by labor-market conditions strongly supports the reporting hypothesis.

Separate evidence in support of the reporting hypothesis is to be found in comparisons of reported deflated GNP not with inputs but with alternative measures of output. Terborgh (1979) has noted the anomolous behavior of reported real GNP relative to the Federal Reserve index of manufacturing production in the period 1971-1974. As noted by Terborgh, the FRB index is based primarily on counts of physical units. Terborgh shows that although normally the FRB index grows faster than real GNP, this is not true in 1971 and 1972. Furthermore measured real GNP falls sharply relative to the FRB index in 1973, 1974, and 1975.[38] A formal check on whether or not price controls move measured real GNP compared to what would be expected from the Index of Manufacturing Production (IMP) involves running the regression:

$$\text{(16)}\quad \Delta\log y = \underset{(9.55)}{0.0053} + \underset{(16.64)}{0.3166}\ \Delta\log IMP + \underset{(2.62)}{0.0312}\ \Delta CD$$

S.E.E. = 0.00630, $\bar{R}^2$ = 0.69, D-W = 2.08, PERIOD = 1948 II-1983 I

Note that the coefficient on ΔCD is some 0.016 smaller than that estimated in above for the productivity growth equation (12). Although the difference is not statistically significant, it is to be expected since IMP includes some deflated as well as physical unit series.[39] It is proposed in future research to follow up these very promising results by using the underlying individual data series on physical units of homogeneous commodities to construct an independent estimate of real GNP for analysis of recent productivity growth.

In summary, there is a considerable body of evidence that the uneven productivity growth reported in 1965-1978 can be explained by reporting biases in 1971-1974 and normal cyclical factors. Darby (1982) showed that similar adjustments may be required in those countries which adopted programs modeled on the ESP during 1971-1974. These results support the basic conclusion of this paper: that there have been no substantial variations in secular U.S. labor productivity growth after adjustment for changing demographic trends.

III. Conclusions and Areas for Future Research

The results of this study can be clearly summarized by the use of two figures. Figure 2 illustrates the logarithm of hourly productivity measured in the standard way by GPP/THWP. It is difficult if not impossible to discern any overall trend although 1900-1929 and 1929-1948 might be identified as periods of slow growth followed by rapid growth during 1948-1965 and then slowing growth over 1965-1973 and 1973-1979. The logarithm of quality-adjusted hourly productivity (GPP/QATHWP) is plotted in Figure 3. Here a constant trend line dominates the data except during the Depression-Korean War era of slow investment and subsequent rapid recovery. With demographic factors accounted for, the anomolous productivity gains in 1972 and 1973 (which we attribute to measurement biases) stick out like the proverbial sore thumb.

The major conclusion to be drawn is that there have been no substantial variations in trend growth rates of private labor productivity since 1900 if reasonable adjustments are made for the effects of demographic trends on the average quality of labor. Even if one were to ignore the effects of demographic shifts, the measured growth rates of productivity, total private hours, and private employment have essentially the same values in 1900-1929 as in 1965-1979 so that panic may be premature.

The slow labor productivity growth in 1929-1948 can be explained by the near cessation of capital formation, but measured increases in capital growth in 1948-1965 are too small to fully account for the catch-up of labor productivity. Further research is required to determine whether this is due to problems in the measurement of capital or to other yet undiscovered factors. The slowdown in productivity growth within the period 1965-1979 can be explained by measurement biases induced by evasion of price controls. Increased oil prices do not play a significant role.

Taken as a whole, the evidence does not support the view that there has been a substantial, inexplicable decline in total factor productivity growth since 1965 and especially since 1973. Instead the evidence presented here indicates that there has been a surprisingly stable growth rate of total factor productivity throughout the twentieth century. Only in 1948-1965 is there any evidence of a substantial (0.2 to 0.4 percent per annum) temporary increase in total factor productivity growth and there are good economic reasons to suspect that this may be an artifact of tax-induced changes in accounting procedures.

One may ask why this study has succeeded in finding a constant underlying trend in appropriately measured labor (or total factor) productivity where others have been unable to do so. That may be like asking why Sally solved Rubik's Cube fastest, but it is a question to which I must respond. In part, the analysis in this article starts from a firmly macroeconomic viewpoint: This excludes worrying about a lot of trees which may obscure the forests. For example, Denison (1974) attempts to measure an effect on productivity from shifting a given worker from one industry to another; here the assumption is that the allocation of resources will assure a normally efficient use of the pool of human and produced capital. Further, as a macroeconomist I was already aware of the price-control biases during 1971-1974 and did not try to fashion an explanation to fit distorted data. In Darby (1976c), I had shown that the change in reporting procedures for hours when the N.R.A. codes and hours laws become effective significantly distorted hourly wage data; so correcting the discontinuity in hours data at 1933 was an obvious improvement over previous work.

Thus, the major difference between this article and the previous literature seems to be in the conceptual approach. Here we start with an aggregate production function and try to measure aggregate labor very carefully since capital will conform to labor (absent a Great Depression and World War!). The major quantifiable factors (besides numbers of workers) which seem important are age, sex, education, and immigration as determinants of quality of the labor force and the average number of hours worked. The fact is that this approach seems to work where previous attempts based on growth accounting have not.

A considerable program for future research which has been noted in previous sections can be briefly summarized here: (1) An interesting issue for economic historians is whether the intra-period inconsistency between hourly and employee productivity growth for 1900-1929 reflects a real phenomenon or indicates a measurement problem in the data on average hours worked. (2) Certainly improvements can be made to the demographic adjustments reported here. Doubtless others will test these results by doing so. (3) The failure of the closed-economy neoclassical growth model suggests an (industrialized) world linked by capital flows which are quite responsive in the long-run. So like analysis of other economies could similarly explain their postwar labor productivity recoveries and slowdowns. It further suggests investment incentives may be more effective than saving incentives as means of increasing domestic capital stock. (4) In light of the discrepancy between full recovery in the output-labor ratio and incomplete recovery in the capital-labor ratio, a reexamination of the consistency of existing estimates of net investment and the capital stock is in order. (5) The potential importance of price-control induced biases in deflated (and deflator) data during the 1971-1974 period is once again demonstrated. Further evidence is called for on this issue, but the time has come to reexamine various claims for effects of oil-price and other variables which may serve as a proxy for these reporting biases.

A warning note is in order: The fact that factors such as regulation, governmental size, oil prices, management practices, educational quality, moral fiber, and the like have not been required to fully explain twentieth century variations in labor productivity does not imply that they have been unimportant. Any or all of them may have been quite important in determining the trend value of total factor productivity growth. Nonetheless in the aggregate their impact has caused quality-adjusted total factor productivity growth to evolve as if following a random walk with constant drift and small variance. For this type of process the average growth rate of total factor productivity growth converges over considerable periods to the constant drift.

Fortunately, the analysis leaves considerable room for optimism. The major factor reducing productivity growth over 1965-1979 was the increasingly youthful labor force. Now as the smaller post-pill generation enters the labor force and the baby-boom generation ages, this effect will be operating in the opposite direction to increase output per (unadjusted) hour. The acculturation of recent immigrants will be another positive, albeit much smaller, factor. The sex factor may cease to slow productivity growth for either of two reasons: (1) Female participation rates are approaching those of men for younger women; so the disproportionate growth of women workers may soon slow.[40] (2) As lifetime market work becomes the norm for women, their investment in human capital should rise toward that of men. The one factor which public policy can directly influence is education. Whether the last two decades of the twentieth century will witness the equivalent of another G.I. Bill and whether the same marginal effects would continue to accure is an open question, but surely three positive factors are enough for the dismal science.

DATA APPENDIX

The primary data base for this paper is reported in Darby (1984). Table 8 extracts the data on private employment (PE), total hours worked in the private sector (THWP), the implicit average hours worked in the private sector (AHWP), and gross private product (GPP) from that source. Table 9 reports the data for the five main calculated series: quality-adjusted private employment (QAPE), quality-adjusted total private hours worked (QATHWP), the average years since migration of foreign-born workers by sex (Z_M and Z_F), and the median years of education E.

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FOOTNOTES

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[1]Productivity trend growth rates are normally computed from high-employment to high-employment year to avoid the large cyclical variations in productivity analyzed by such authors as Oi (1962), Fair (1969), Solow (1973), Sims (1974), Gordon (1979), and Morris (1983). The figures in the text are for the private-nonfarm-output-per-hour-paid-for definition of labor productivity and are computed from data in the U.S. Council of Economic Advisers (1980, pp. 246).

[2]Darby (1984).

[3]As discussed below, the results are not very sensitive to the particular measures chosen. The ratio of GPP to total private hours worked indicates the largest 1965-1979 private hourly productivity slowdown (0.65 percentage

points) and is accordingly used. At the other extreme, total private hours paid would indicate only a 0.53 percentage point deceleration.

[4]Most of the growth in employment over 1900-1929 appears to be concentrated in the years of massive immigration 1900-1916, but the early data (especially for average hours worked) are not of sufficiently high quality for close analysis of movement within the 1900-1929 period. Immigration was sharply limited by the "national origin" quota system which became fully operative in 1929 and was finally abolished by the Act of October 3, 1965. The average ratio of the annual flow of immigrants (16 and over) to civilian labor force was 1.42, 0.20, and 0.34 percent for 1900-1929, 1930-1965, and 1966-1978, respectively.

[5]The break years 1948 and 1973 are the standard ones in the literature. The year 1916 was chosen as a convenient high employment year.

[6]In earlier versions of this paper an alternative capital-deepening hypothesis was considered. Along the lines of the neoclassical growth model [see, e.g., Solow (1970, pp. 17-38) or Darby (1979, pp. 105-115, 139-140, 440-441)] the slower growth in labor should increase steady-state equilibrium capital-labor, capital-output, and output-labor ratios. However, we shall see in Section II that the capital-output ratio apparently was lower or the same in 1965 as compared to 1929. The apparent irrelevance of capital-deepening may reflect the operation of an efficient world capital market, a topic which the author will pursue in future research.

[7]The estimates are computed from relative earnings for 1929-1970 and 1970-1976, respectively, for finer age groups. The finer age groups were weighted for percentage of total hours worked. Note that the relative wages reflect not only pure age and sex differences in human capital but also the relative amounts of education, all taken as approximately constant. Changes

in the average level of education are accounted for in equation (5) below.

[8]See Chiswick (1978, 1979) and Blau (1980). Previously Friedman (1974) had noted that the rapid immigration of the early twentieth century reduced measured growth in real per capita income or, as here, labor productivity.

[9]These parameters were derived as follows. Blau (1980, p. 32) indicates gross log differentials in wages at entry for Ethnic Group 2 (the relevant one for post 1900) of -0.351 for men and -0.183 for women. Now $e^{-0.351} = 0.704$ and $e^{-0.183} = 0.833$. These gross differentials were in part due to education, which is adjusted for separately below. Allowance is made for 1 year of education (see Chiswick, 1978, p. 907) or 7 percent which approximately squares with Blau's results for percent literate. (No allowance was made for differences in mean ages as preliminary calculations suggested any effect was negligible.) Thus the gross wage differential on entry used was (1.07) (0.704) = 0.753 for males and (1.07) (0.833) = 0.891 for females. The estimated effect on the log of real wages of years since migration was 0.0107 for males and 0.0117 for females, and $e^{0.0107} = 1.01076$ and $e^{0.0117} = 0.01177$. Using 1970 data for men, Chiswick (1978) obtained values implying an adjustment factor of about $(1.015)^{Z_M}(0.721)$ for males. A sensitivity check showed that substituting this factor made no significant difference to the results. In the early 1900s, immigration were primarily from Blau's ethnic Group 2 (Irish, French Canadians, Southern and Eastern Europeans) while recent immigrants have been primarily of Latin American or Asian origin. While these groups are not strictly comparable, the foreign-born adjustments are primarily important in the earlier period.

[10]Unfortunately, no data was found to make differential adjustments by age group so the same factor was used for both young and old.

[11]The 1909 data came from U.S. Immigration Commission (1911, Table 56, pp. 1521 and 1528). The cells were assigned their mean values (0.5, 1.5, 2.5, 3.5, 4.5, 7.5, 12.5, and 17.5) except for the open cell (20 years and over) for which Blau's value of 30 years was used. The 1970 data were from U.S. Bureau of the Census (1973, Table 18, p. 466) using cell values of 2.65, 7.8, 12.8, 17.8, 22.8, 30.3, 40.3, and 53.1 years for the open (before 1925) cell. The last value was estimated by taking weighted averages of young immigrants arriving 1904 through 1924 who would be 65 or under in 1970.

[12]This value was taken from Chiswick (1978, p. 908) and appears reasonable in terms of such recent cross-section results as reported by Smith and Welch (1977). Yet lower rates of return to education would lower productivity growth in the early period relative to the two later periods, but would not have much effect on the main conclusion of this section: the absence of a secular decline in productivity growth.

[13]Mean years of education were not available, but if the difference is constant the substitution of the median will not affect the growth rates estimated below. Folger and Nam (1964) retroject the 1940 census data back to obtain median estimates for 1930, 1920, 1910. These values of 8.6, 8.4, 8.2, and 8.1 were extrapolated to 8.0 in 1900. Sources for more recent years are given in the data appendix. Log-linear interpolation was used to fill in missing values.

[14]The growth-rate effect of education is separable from those of age, sex, and immigration, but the latter effects are not separable from each other. The age adjustment is most important for the recent periods so we compute first an age-adjusted private employment which makes no adjustment for sex or nativity. (Equations (2) and (3) are not used and $\alpha_1 = \alpha_2 = 0.515$, $\alpha_3 = 1.0$.) Next an age-sex-adjusted private employment

series is computed to find the marginal contribution of the sex adjustment. Finally, the marginal contribution of the immigration adjustment is calculated by comparing the APE derived using equations (1), (2), and (3) with this age-sex-adjusted private employment.

[15]The differences among the various measures of average hours may reflect differences in concepts — private versus civilian, hours worked per employee versus hours worked per employed person, hours worked versus hours paid — or a yet unidentified change in reporting procedures for the establishment data. Such a change occurred in 1934 with the introduction of the N.I.R.A. codes and minimum wages, but the hours data were adjusted for that as described in Darby (1984).

[16]As is well known, technical progress or total factor productivity growth is a euphemism for the increase in output which we cannot explain by the increase in <u>measured</u> inputs. Presumably, the constancy of its <u>average</u> growth rate over substantial periods reflects the law of large numbers and numerous independent contributing factors.

[17]Christensen and Jorgensen (1978, pp. 35, 53) report series on corporate capital input and private domestic captial input with 1929-1948 growth rates of 0.7% and 0.4% per annum, respectively. The NBER-Kendrick capital input series in U.S. Bureau of Economic Analysis (1973, pp. 192-193, Series A65) has an average growth rate of 0.6% per annum during this period. For 1948-1965, Christensen and Jorgensen estimate that private domestic and corporate capital input grew at average rates of 4.0% and 3.8% per annum respectively. The NBER-Kendrick data indicate only a 3.4% growth rate. The preference for the higher growth rate in the latter period is explained in the text below.

[18]The implied average growth rate of capital is 2.21% per annum while output grew at 2.98%; $\exp[(0.0221-0.0298)(36)] = e^{-0.2772} = 0.758$.

[19]Overdeflation of gross investment due to undercorrection for quality changes would have a similar effect.

[20]That is, [(19)(0.6%) + (17)(5.6%)]/36 = 2.96% $\simeq$ Γy = 2.98%.

[21]Obviously, I subscribe to the view that consistent data-collection procedures do not yield consistent data series when incentives or constraints change so as to alter the behavior of the optimizing agents who provide the data. This differs from the uncertainty principle in that economic analysis can be applied to estimate the nature of the changes.

[22]U.S. Council of Economic Advisers (1979, p. 70).

[23]See Perry (1977, p. 37). In terms of my own short-run productivity growth function — equation (10) below -- the residuals for these seven quarters are 0.0104, -0.0049, 0.0059, 0.0088, 0.0109, 0.0057, and 0.0107, respectively, for a sum of 0.0475. The residuals for the next seven quarters are -0.0074, -0.0071, -0.0040, -0.0087, -0.0121, -0.0075, and 0.0027, respectively, for a sum of -0.0441. The difference (0.003) is statistically insignificant and of the wrong sign for an oil-price effect on productivity.

[24]The minor exception is that the layoff rate was dropped because the Bureau of Labor Statistics stopped collecting the data in 1981. The layoff rate was marginally significant in the Darby (1982) real-income equation but had a t-statistic of only -0.4 over the available observations when added to the present equation (9). Dropping the layoff rate did not cause any signficiant change in the remaining coefficients or their t-statistics.

[25]This was the most convenient measure of private productivity available quarterly. All data for this quarterly analysis were taken from the Citibase data bank.

[26]This variable is supposed to capture the differential effects of the demographic adjustments summarized in Tables 2 and 3 above.

[27]The t-statistics are in parentheses below the estimated coefficients. The estimation is over the entire period for which data were available on Citibase at the time the final draft of this paper was prepared.

[28]Thus line 6 refers to equation (10) as reported above.

[29]This estimate is an estimate of the overstatement in deflated private output and thus applies equally well to the annual quality-adjusted private productivity measures reported in Table 4 above.

[30]Recall that the hours series used showed the fastest relative growth in hours in 1973-1979 among the alternatives. The century average growth in GPP/QATHWP was 1.75 percent per annum.

[31]Thus equation (12) in the main text is a way of estimating the spurious increase in reported output conditional upon whatever real effect on unemployment and employment may have occurred. The reporting hypothesis implies that the official division of nominal amounts into quantities and prices is generally suspect during 1971-1974. Deriving implications from (possibly) incorrectly deflated data is a task not unlike that of George Smiley in LeCarre's Tinker, Tailor, Soldier, Spy. Frequently the data seem to tell one consistent story if they are taken at face value and another consistent story if they are assumed biased by the price-control program. The challenge is to find cases in which only one of the hypotheses fit.

[32]Charles Cox (1980) uses October 1973 (i.e., 1973 IV instead of 1973 II) as the beginning of the decontrol period since that was the beginning of sector-by-sector decontrol. I believe that the Phase III removal of requirements for prior approval of price increases was a major relaxation since -- as explained below -- the remaining profit margin ceiling was consistent with any rate of inflation. Some macroeconomic evidence supporting 1973 II instead of 1973 IV as the start of decontrol is offered below, but the

issue is not crucial. The same evidence is consistent with Cox's view that the controls had no effect on price levels past 1974 II (as compared to my 1974 III) nor on growth rates past 1974 III.

[33]Economists have traditionally argued that missed quality improvements might imply a 2 percent measured inflation even if the "true" price level was constant. See, for example, Ackley (1961, p. 87), Price Statistics Review Committee (1961, pp. 35-39), and Griliches (1961).

[34]In a simple dynamic Okun's Law regression, one obtains:

$$\underset{}{\Delta \log y} = \underset{(14.58)}{0.0086} - \underset{(-13.49)}{0.0185\Delta u} + \underset{(2.94)}{0.0377\Delta CD}$$

S.E.E. = 0.00678, $\bar{R}^2$ = 0.61, D-W = 2.02, PERIOD = 1950 II-1983 I

The coefficient on ΔCD is within one standard error of the estimate of 0.04691 obtained in the productivity-growth equation (12) in the text. Note, that although Okun's Law is sometimes reversed to explain Δu given $\Delta \log y$, that form is not appropriate to the current case in which relatively large measurement error is hypothesized for $\Delta \log y$ as compared to Δu.

[35]See Darby (1976a).

[36]These results are inconsistent with the Barro-Grossman-Evans view discussed above. The same qualitative results for price controls (*i.e.*, no effect) are obtained if the estimation period is 1961 I-1980 IV, but the $\bar{R}^2$ is considerably higher, S.E.E. lower, D-W closer to 2, and Σh_i closer to 1. This may be suggestive evidence that shifts in money demand associated with the 1981 introduction of nationwide NOW accounts and other recent reforms have disturbed the nominal-income equation, but that debate is beyond the scope of this paper.

[37]This equation was estimated with a first order correction for autocorrelation ($\hat{\rho}$ = 0.5391). Without this correction the coefficient of ΔCD was estimated as -0.0373 (standard error 0.0089, t-statistic -4.19) and the S.E.E. was 0.0045 with a D-W of 1.01.

[38]Terborgh's use of annual data spreads the adjustment period into 1975 since the average 1974 real GNP data will be overstated on the price control hypothesis.

[39]A formal F-test was conducted for both this regression and the one reported in footnote 34 above to test the implicit hypothesis that the coefficient was the same during the decontrol and control periods. The hypothesis was not rejected.

[40]See Darby (1984, Chapter 2).

TABLE 1

Average Annual Growth Rates of Private Employment,
Private Hours, Gross Private Product, and Productivity
1900-1979

Period	Private Employment PE	Average Hours Worked AHWP	Private Hours Worked THWP	Gross Private Product GPP	Hourly Productivity GPP/THWP	Employee Productivity GPP/PE
1900-1979	1.40	-0.23	1.18	3.23	2.05	1.82
Major Periods:						
1900-1929	1.77	-0.22	1.54	3.42	1.88	1.65
1929-1965	0.87	-0.27	0.60	2.98	2.38	2.10
1965-1979	2.02	-0.12	1.91	3.48	1.57	1.46
Subperiods:						
1900-1916	2.09	0.05	2.14	3.64	1.50	1.56
1916-1929	1.38	-0.56	0.81	3.15	2.34	1.78
1929-1948	0.88	-0.17	0.71	2.28	1.57	1.40
1948-1965	0.86	-0.40	0.47	3.75	3.28	2.89
1965-1973	1.84	-0.21	1.63	3.90	2.27	2.06
1973-1979	2.27	0.00	2.28	2.92	0.64	0.64

Units: Continuously compounded rates in percent per annum computed from the first to the last year of the period.

Source: See Data Appendix, Table 8.

TABLE 2

Growth Rate Effects of Demographic Adjustments to Private Employment
1900-1979

Period	Unadjusted Private Employment	Adjustment for Age	Additional Adjustment for Sex	Additional Adjustment for Immigration	Adjustment for Education	Quality Adjusted Pvt. Emplmt.
1900-1979	1.40	0.06	-0.15	0.01	0.38	1.71
Major Periods:						
1900-1929	1.77	0.13	-0.07	-0.03	0.09	1.88
1929-1965	0.87	0.09	-0.19	0.06	0.64	1.47
1965-1979	2.02	-0.18	-0.21	-0.02	0.34	1.95
Subperiods:						
1900-1916	2.09	0.14	-0.06	-0.15	0.07	2.09
1916-1929	1.38	0.11	-0.08	0.10	0.12	1.63
1929-1948	0.88	0.15	-0.19	0.10	0.28	1.22
1948-1965	0.86	0.03	-0.20	0.00	1.05	1.75
1965-1973	1.84	-0.30	-0.17	-0.02	0.42	1.77
1973-1979	2.27	-0.01	-0.28	-0.01	0.22	2.19

Units: Continuously compounded rates in percent per annum from the first to the last year of the period.

Note: Adjustments may not add due to rounding.

TABLE 3

Differential Effects of Demographic Adjustments
to Private Employment over Major Periods
1900-1979

Period	Age Adjustment	Sex Adjustment	Immigration Adjustment	Education Adjustment	Total Adjustment
1900-1929	0.07	0.08	-0.04	-0.29	-0.19
1929-1965	0.03	-0.04	0.05	0.26	0.29
1965-1979	-0.24	-0.06	-0.03	-0.04	-0.37

Units: Continuously compounded rates in percent per annum computed from the first to the last year of the period.

TABLE 4

Average Annual Growth Rates of Productivity
Measures Adjusted for Age, Sex, Immigration, and Education
1900-1979

Period	Qual. Adj. Private Employment QAPE	Average Hours Worked AHWP	Qual. Adj. Private Hours Worked QATHWP	Gross Private Product GPP	Qual. Adj. Hourly Productivity GPP/QATHWP	Qual. Adj. Employee Productivity GPP/QAPE
1900-1979	1.71	-0.23	1.48	3.23	1.75	1.52
Major Periods:						
1900-1929	1.88	-0.22	1.66	3.42	1.76	1.54
1929-1965	1.47	-0.27	1.20	2.98	1.78	1.51
1965-1979	1.95	-0.12	1.83	3.48	1.65	1.53
Subperiods:						
1900-1916	2.09	0.05	2.14	3.64	1.50	1.55
1916-1929	1.63	-0.56	1.06	3.15	2.09	1.52
1929-1948	1.22	-0.17	1.06	2.28	1.22	1.06
1948-1965	1.75	-0.39	1.35	3.75	2.40	2.00
1965-1973	1.77	-0.21	1.57	3.90	2.34	2.13
1973-1979	2.19	0.00	2.19	2.91	0.72	0.72

TABLE 5

Implications of Variations in Capital and Quality-Adjusted Labor Growth for Productivity Growth 1929-1965

Part A — Hourly Productivity Concept

Period	γ	$\Gamma\ell$	Γk	Predicted $\Gamma(y/\ell)$ β=0.20	Predicted $\Gamma(y/\ell)$ β=0.25	Predicted $\Gamma(y/\ell)$ β=0.30	Actual $\Gamma(y/\ell)$
1929-1948	1.75	1.06	0.6	1.31	1.20	1.09	1.22
1948-1965	1.75	1.35	4.0	1.93	1.98	2.02	2.40
Alternative Γk Estimates							
1948-1965	1.75	1.35	5.0	2.13	2.23	2.32	2.40
1948-1965	1.75	1.35	5.3	2.19	2.30	2.41	2.40
1948-1965	1.75	1.35	5.6	2.25	2.38	2.50	2.40

Part B — Employee Productivity Concept

Period	γ	$\Gamma\ell$	Γk	Predicted $\Gamma(y/\ell)$ β=0.20	Predicted $\Gamma(y/\ell)$ β=0.25	Predicted $\Gamma(y/\ell)$ β=0.30	Actual $\Gamma(y/\ell)$
1929-1948	1.52	1.22	0.6	1.09	0.99	0.88	1.06
1948-1965	1.52	1.75	4.0	1.67	1.70	1.74	2.00
Alternative Γk Estimates							
1948-1965	1.52	1.75	5.0	1.87	1.95	2.04	2.00
1948-1965	1.52	1.75	5.3	1.93	2.03	2.13	2.00
1948-1965	1.52	1.75	5.6	1.99	2.10	2.22	2.00

Units: Continuously compounded rates in percent per annum computed from the first to the last year of the period.

Note: Predicted $\Gamma(y/\ell)$ values are calculated using equation (8).

TABLE 6

Test Statistics for Alternative Versions of Equation (11)

Line Number	Restrictions	S.E.E.	Value and t-stat for a_6	Value and t-stat for a_7	F-stat for $a_7=a_8=a_9=a_{10}=0$	F-stat for $a_8=a_9=a_{10}=0$
1	none	0.00663	0.04104 (2.69)***	-0.00413 (-0.62)	F(4,122) = 0.42	F(3,122) = 0.49
2	$a_8=a_9=a_{10}=0$	0.00659	0.04515 (3.46)***	-0.00301 (-0.48)	--	--
3	$a_7=a_8=a_9=a_{10}=0$	0.00657	0.04691 (3.77)***	--	--	--
4	$a_6=0$	0.00679	--	-0.00868 (-1.31)*	F(4,123) = 2.00	F(3,123) = 1.94
5	$a_6=a_8=a_9=a_{10}=0$	0.00687	--	-0.00928 (-1.47)*		
6	$a_6=a_7=a_8=a_9=a_{10}=0$	0.00690	--	--	--	--

* Significant at 10 percent level or better.

** Significant at 5 percent level or better.

*** Significant at 1 percent level or better.

TABLE 7

Calculation of Quality-Adjusted Labor Productivity Growth Rates
Adjusted for Price-Control Reporting Biases
1965-1978

	Productivity Measures	
	Hourly Productivity GPP/QATHWP	Employee Productivity GPP/QAPE
Reported Growth, 1965-1973	2.34	2.13
Less, (0.0369/8) x 100	- 0.46	- 0.46
Adjusted Growth, 1965-1973	1.88	1.67
Reported Growth, 1973-1979	0.72	0.72
Plus, (0.0369/6) x 100	+ 0.61	+ 0.61
Adjusted Growth, 1973-1979	1.33	1.33

Units: Continuously compounded rates in percent per annum computed from the first to the last year of the period.

TABLE 8

Private Employment, Hours, and Output
1900-1979

Year	Private Employment PE	Total Hours THWP	Average Hours AHWP	Gross Product GPP
1900	26692.1	57.242	118.371	103.680
1901	27679.7	59.715	119.079	115.835
1902	28503.1	62.371	120.783	116.860
1903	29173.3	64.111	121.301	122.717
1904	29389.2	63.195	118.689	120.960
1905	30535.2	66.309	119.864	130.039
1906	32257.1	68.965	118.010	145.416
1907	32813.6	70.522	118.628	147.612
1908	31618.7	67.408	117.675	134.725
1909	33376.9	71.163	117.686	151.566
1910	33993.3	72.995	118.527	153.031
1911	34364.6	74.369	119.452	158.010
1912	35570.0	76.659	118.958	165.478
1913	36386.6	77.300	117.260	172.068
1914	35589.3	75.834	117.615	158.010
1915	35477.5	75.193	116.988	162.256
1916	37268.7	80.597	119.368	185.687
1917	37350.6	82.337	121.678	178.365
1918	37265.9	81.604	120.870	185.833
1919	37906.7	79.040	115.092	193.448
1920	38044.5	80.047	116.137	195.205
1921	35805.3	72.079	111.116	190.666
1922	38402.7	77.483	111.368	201.942
1923	41176.6	83.619	112.091	229.765
1924	40703.8	81.696	110.785	236.648
1925	42297.3	84.627	110.436	242.066
1926	43355.5	87.557	111.472	258.321
1927	43292.4	87.099	111.050	260.518
1928	43419.6	87.832	111.656	263.447
1929	44565.0	89.572	110.942	279.702
1930	42332.0	83.436	108.793	249.226
1931	39136.0	76.475	107.860	228.274
1932	35715.0	67.775	104.745	191.938
1933	35594.0	67.042	103.964	186.810
1934	37591.0	72.000	105.722	202.634
1935	38779.0	75.900	108.034	223.293
1936	40742.0	81.600	110.551	253.622
1937	42544.0	86.700	112.485	270.032
1938	40337.0	79.200	108.377	252.889
1939	41755.0	83.300	110.116	276.478
1940	43318.0	87.300	111.240	301.240
1941	45690.0	94.700	114.405	346.660
1942	48267.0	102.100	116.759	376.989

TABLE 8 (Continued)

Private Employment, Hours, and Output
1900-1979

Year	Private Employment PE	Total Hours THWP	Average Hours AHWP	Gross Product GPP
1943	48390.0	105.800	120.683	399.700
1944	47917.0	104.400	120.261	420.358
1945	46876.0	98.700	116.220	413.912
1946	49655.0	99.700	110.828	403.069
1947	51564.0	101.800	108.972	412.300
1948	52693.0	102.600	107.476	431.500
1949	51795.0	98.800	105.289	429.825
1950	52892.0	100.500	104.880	470.050
1951	53572.0	104.000	107.155	500.375
1952	53641.0	104.700	107.737	515.275
1953	54534.0	104.900	106.175	538.550
1954	53358.0	100.600	104.067	531.825
1955	55256.0	104.100	103.989	572.925
1956	56521.0	105.600	103.126	584.85
1957	56455.0	104.200	101.878	594.70
1958	55197.0	100.000	100.000	590.60
1959	56547.0	103.300	100.834	629.52
1960	57425.0	104.500	100.446	641.95
1961	57152.0	102.800	99.284	657.75
1962	57812.0	104.800	100.060	697.77
1963	58537.0	105.600	99.575	727.35
1964	59709.0	107.700	99.561	767.55
1965	61014.0	111.100	100.508	816.57
1966	62111.0	113.906	101.226	863.97
1967	62981.0	115.704	101.404	883.70
1968	64081.0	117.416	101.137	925.65
1969	65707.0	120.250	101.015	952.00
1970	66073.0	117.680	98.309	949.50
1971	66239.0	118.227	98.519	985.67
1972	68368.0	121.801	98.336	1048.10
1973	70677.0	126.573	98.850	1115.90
1974	71765.0	127.448	98.025	1105.65
1975	70097.0	122.619	96.555	1088.97
1976	72614.0	126.236	95.957	1154.12
1977	75419.0	132.075	96.662	1223.27
1978	78701.0	140.018	98.202	1285.05
1979	80998.0	145.081	98.867	1329.15

Sources: PE, THWP, and GPP are from Darby (1984), Tables A7, A19, and A20, respectively. AHWP = (THWP/PE) * (PE_{1958}) so that the base year value (1958 = 100) of the THWP index is preserved.

TABLE 9

Quality-Adjusted Private Employment and Hours, Years Since Migration, and Median Education 1900-1979

	Quality-Adjusted		Years since Migration		Median Education
Year	Private Employment QAPE	Private Hours QATHWP	Males ZM	Females ZF	E
1900	36435.7	47.998	22.6674	7.3866	8.0000
1901	37794.0	50.085	21.9248	7.7412	8.0099
1902	38887.9	52.272	20.7291	8.0444	8.0199
1903	39731.8	53.635	19.1892	8.2398	8.0299
1904	39996.8	52.831	18.0640	8.4023	8.0399
1905	41479.7	55.332	16.6296	8.5072	8.0498
1906	43745.6	57.452	15.3560	8.5674	8.0599
1907	44390.2	58.603	13.9928	8.6135	8.0699
1908	42834.6	56.096	13.6240	8.7904	8.0799
1909	45280.6	59.304	13.2629	9.0324	8.0899
1910	46115.5	60.829	12.5829	9.1581	8.1000
1911	46636.8	61.997	12.2705	9.2848	8.1099
1912	48572.3	64.303	12.0623	9.4171	8.1999
1913	49374.1	64.432	11.5134	9.4377	8.1299
1914	48265.0	63.175	11.0806	9.4358	8.1399
1915	48288.5	62.868	11.4446	9.8364	8.1498
1916	50903.2	67.621	11.8014	10.2617	8.1599
1917	51275.4	69.434	12.1555	10.6709	8.1699
1918	51690.0	69.530	12.6642	11.1911	8.1799
1919	52552.2	67.311	13.1303	11.6892	8.1899
1920	52686.1	68.095	13.3064	11.9479	8.2000
1921	49628.9	61.371	13.1465	11.8868	8.2198
1922	53351.6	66.123	13.4958	12.1935	8.2396
1923	57304.8	71.484	13.5692	12.3911	8.2595
1924	56717.5	69.927	13.4568	12.4623	8.2794
1925	59097.5	72.632	13.7836	12.8174	8.2994
1926	60734.1	75.343	14.0887	13.1591	8.3194
1927	60792.2	75.131	14.3434	13.4793	8.3395
1928	61131.2	75.962	14.6407	13.7915	8.3596
1929	62905.7	77.667	14.9736	14.1043	8.3798
1930	59921.4	72.549	15.3459	14.4371	8.4000
1931	55467.4	66.580	15.8651	14.9130	8.4198
1932	50688.4	59.087	16.4378	15.4647	8.4396
1933	50579.2	58.520	17.0194	16.0329	8.4595
1934	53479.3	62.921	17.5927	16.5898	8.4794
1935	55228.8	66.401	18.1593	17.1342	8.4994
1936	58084.5	71.462	18.7217	17.6737	8.5194
1937	60710.0	75.999	19.2620	18.1882	8.5395
1938	57610.1	69.484	19.7739	18.6684	8.5596
1939	59679.1	73.135	20.2515	19.1243	8.5798
1940	61977.7	76.727	20.7432	19.5963	8.6000

TABLE 9 (Continued)

Quality-Adjusted Private Employment and Hours, Years Since Migration, and Median Education 1900-1979

Year	Quality-Adjusted Private Employment QAPE	Quality-Adjusted Private Hours QATHWP	Years since Migration Males AM	Years since Migration Females ZF	Median Education E
1941	65567.7	83.480	21.2646	20.0962	8.6676
1942	69423.1	90.208	21.8240	20.6353	8.7357
1943	69413.7	93.226	22.3895	21.1831	8.8043
1944	69286.4	92.731	22.9470	21.7151	8.8734
1945	68669.9	88.817	23.4941	22.2115	8.9432
1946	73541.0	90.704	23.9784	22.4542	9.0134
1947	77447.4	93.923	24.3396	22.6387	9.0842
1948	79364.1	94.926	24.6321	22.7764	9.1556
1949	78480.9	91.960	24.8572	22.8908	9.2275
1950	80406.3	93.849	24.8947	22.9062	9.3000
1951	82230.8	98.061	25.0187	23.0240	9.4225
1952	83413.6	100.012	25.0171	22.9757	9.5466
1953	85932.7	101.539	25.2558	23.1282	9.6723
1954	84990.3	98.431	25.3708	23.2031	9.8000
1955	88311.3	102.200	25.3932	23.2120	9.9287
1956	90668.0	104.057	25.1838	23.0372	10.0595
1957	91180.0	103.378	24.9862	22.8423	10.1920
1958	89857.0	100.000	25.0246	22.7806	10.3262
1959	92583.0	103.893	25.0292	22.7106	10.4622
1960	94413.0	105.538	25.0162	22.6320	10.6000
1961	96286.0	106.387	24.9688	22.5489	10.9927
1962	99939.0	111.287	24.8591	22.4574	11.4000
1963	101860.0	112.876	24.7028	22.3030	11.5499
1964	104460.0	115.742	24.6130	22.1592	11.7000
1965	106803.0	119.463	24.5116	22.0063	11.8000
1966	109417.0	123.261	24.3272	21.8089	12.0000
1967	110564.0	124.772	24.0511	21.5300	12.0000
1968	112961.0	127.142	23.5628	21.0640	12.1000
1969	115492.0	129.834	23.2771	20.8785	12.1499
1970	116095.0	127.015	22.9404	20.6916	12.2000
1971	116022.0	127.206	22.6392	20.5103	12.2000
1972	119019.0	130.250	22.3128	20.3140	12.2000
1973	123084.0	135.403	21.9676	20.0986	12.3000
1974	124682.0	136.016	21.6471	19.9108	12.3000
1975	121653.0	130.721	21.3589	19.7535	12.3000
1976	126290.0	134.864	21.1000	19.8000	12.4000
1977	130682.0	140.578	20.6000	19.4000	12.4000
1978	135750.0	148.357	19.9000	18.9000	12.4000
1979	140376.0	154.452	19.6000	18.7000	12.5000

TABLE 9 (Continued)

Quality-Adjusted Private Employment and Hours, Years Since Migration, and Median Education 1900-1979

Sources: QAPE was computed using equations (1) through (5) as explained in the text and data from Darby (1984). QATHWP = (QAPE * AHWP)/$QAPE_{1958}$ so that the base year (1958) is 100.0. ZM and ZF were computed using equation (4), 1909 and 1970 benchmarks, and data from Darby (1984). Missing values for E were logarithmically interpolated between the following observations: 1910, 1920, 1930 Folger and Nam (1964, p. 253); 1900, Extrapolated by author from above values; 1940, 1950, 1960, CPR #356; 1962, 1964, 1965, 1966, CPR #158; 1967, CPR #169; 1968, CPR #182; 1970, CPR #207; 1971, CPR #229; 1972, CPR #243; 1973, 1974, CPR #274; 1975-1979, CPR #356; where CPR is short for U.S. Bureau of the Census, Current Population Reports, Series P-20, and the issue dates of the reports are #158 December 19, 1966, #169 February 9, 1968, #182 April 28, 1969, #207 November 30, 1970, #229 December 1971, #243 November 1972, #274 December 1974, and #356 August 1980.

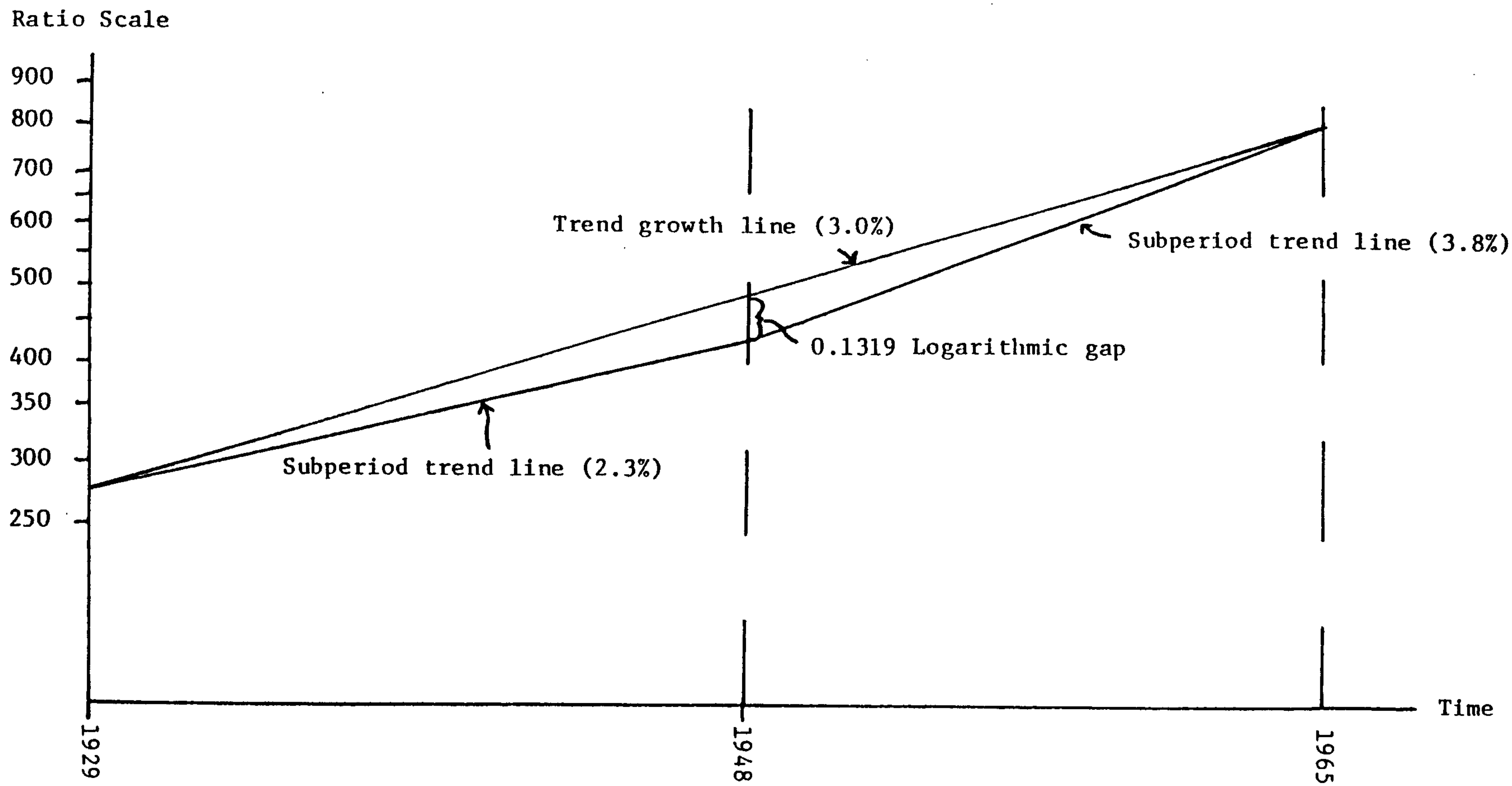

FIGURE 1

Growth Trends of Gross Private Product, 1929-1965

FIGURE 2

Logarithm of Hourly Productivity
log(GPP/THWP)

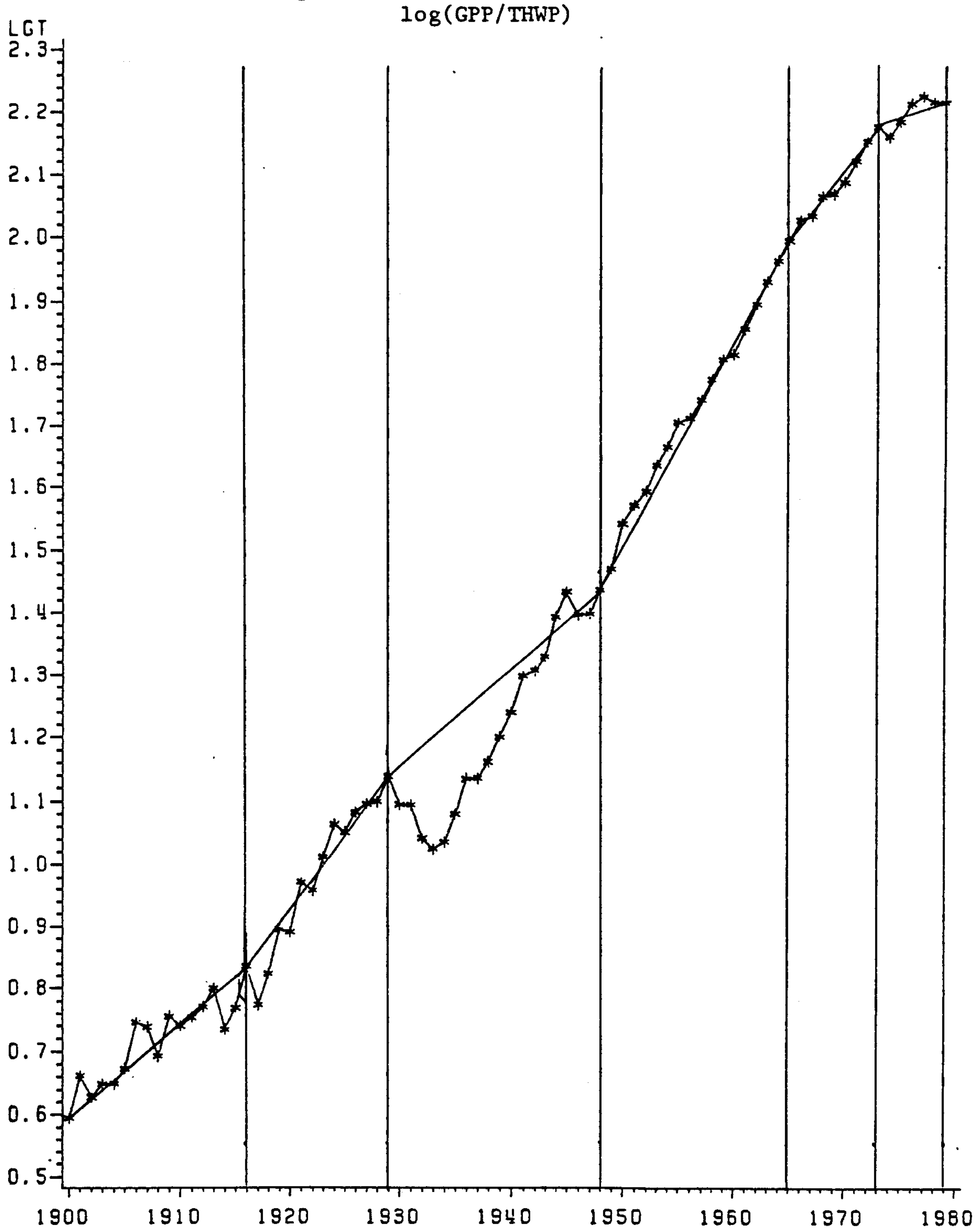

FIGURE 3

Logarithm of Quality-Adjusted Hourly Productivity, 1900-1979
log (GPP/QATHWP)