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UNBALANCED GROWTH REVISITED: ASYMPTOTIC STAGNANCY AND NEW EVIDENCE

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ABSTRACT

This paper provides empirical evidence supporting the conclusions of the unbalanced growth model. This analysis attributes the shift to the services of the labor force and the share of an economy's expenditures not to a rise in relative quantity of services purchased but to a pronounced lag in productivity growth of a substantial group of services. The paper also analyzes a group of activities, like TV broadcasting and computing, which use in relatively fixed proportions two sets of intermediate inputs, one whose production involves very rapid productivity growth while the other's is very low. It is shown that the share of latter (stagnant) input in the activity's overall budget will grow, and that while the real unit cost of the activity may initially fall rapidly it will eventually have to rise.

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1. Manifest Destiny of Relative Costs and Sectoral Inputs

Some years ago one of us presented a model of unbalanced growth (Baumol [1967]) in which an oversimplified economy was divided into productivity growth sectors, one "stagnant" and one "progressive." It was argued that relative costs and prices in the stagnant sector would tend to rise persistently and cumulatively, and that _if_ the output proportions of the two sectors happened to remain fairly constant, the share of the economy's inputs used by the stagnant sector and the share of consumer expenditure devoted to outputs of the stagnant sector must both rise toward 100 percent. Finally, it was concluded that the net result must be a _ceteris paribus_ decline in the economy's overall productivity growth rate.

Since then a variety of pertinent empirical materials and some further analysis have suggested that the model needs modifications, some of them of interest in themselves. But the behavior of prices, input use patterns and consumer outlays have followed the model's scenario to a remarkable degree.

In this paper we show that our earlier equation of the service sector of reality with the stagnant sector of the model requires modification. But there is a subclass of the services which is a better approximation to the model's stagnant activities. We also introduce a third set of economic activities, which we label "asymptotically stagnant," which are neither completely stagnant nor progressive. They use, in fairly fixed proportions, some inputs from the progressive sector and some from the stagnant sector. We will show that in their initial phases such activities are often outstanding in their rapid productivity growth and declining costs. However, with the passage of time, the cost and price behavior of these asymptotically stagnant activities necessarily approaches that of the stagnant sector.

We will also examine the empirical evidence relating to the model, showing that:

(i) In real terms, there has been little shift in output shares between manufacturing and the services, not only with time, but with increasing wealth as one goes from less-developed to industrialized countries;

(ii) As the model predicts, there was a marked simultaneous rise in relative prices and share of total expenditure on the services both with the passage of time and with increased industrialization (much of the intercountry information is derived from a remarkable paper by Summers [1982]);

(iii) The service sector contains some of the economy's most progressive activities as well as its most stagnant;

(iv) As the model predicts, the U.S. labor force has been absorbed increasingly not just by the services generally, but predominantly by their stagnant subsector; and

(v) Television broadcasting and electronic computation (data processing) are examples of asymptotically stagnant activities and the empirical budget and cost patterns for these activities are perfectly consistent with the model's predictions.

2. Basic Theorems on Stagnant and Progressive Outputs

We begin by summarizing the basic behavioral propositions to be evaluated by the empirical evidence. But first, we must emphasize two crucial qualifications. First, the model is obviously a gross oversimplification. Outputs, firms and industries do NOT fall into neat categories in terms of stagnancy and progressivity. They are all shades of gray rather than black and white, and even the most stagnant sectors of the economy have benefitted from some technological change. Moreover, their relative shade of gray varies from one period of time to another. Second, an activity which is, say, relatively stagnant need not stay so forever. It may be replaced by a close substitute which is considerably more progressive, or it may benefit from an outburst of technological innovation for which it would not previously have been thought eligible. Thus, we do not deny the possibility of radical changes in the time paths predicted by the model. History surely shows the foolishness of predicting that some field of endeavor is beyond the scope of human inventiveness and ingenuity. When we speak of manifest destiny here our claim is more modest. We merely maintain that things must go as predicted only so long as there is no major qualitative change in the distribution of innovation among industries.

We start with some results on stagnant and progressive activities, turning later to the case of asymptotic stagnancy. Our first proposition generalizes a result now well-known -- that the unit cost of a product of a persistently more stagnant activity must rise without limit in comparison with that of a more progressive activity. This is, of course, the basic manifestation of what has been called the "cost disease" of the personal services. Next, we show that, even if there is absolutely no shift in consumer tastes and demands toward the more stagnant sector, inputs and consumer expenditures will automatically move in that direction. These results will be shown to be consistent with the empirical evidence.

We use the following notation:

y_{it} = output of product i in period t

x_{kit} = quantity of input k used in producing i in period t

p_{it} = (real) price of i in period t

w_{kt} = (real) price of k in period t

$\pi_{fit} = y_i/\Sigma w_{kt}x_{kit}$ = total factor productivity in output i

$\pi_{kit} = y_i/x_{kit}$ = the productivity of input k in the production of output i

$*$ = rate of growth, i.e., for any function, f(t), $f^* \equiv \dot{f}/f$.

Proposition 1. Let y_{1t} and y_{2t} be two outputs produced by single product firms. Then, if $\pi^*_{f1t} \leq r_1 < r_2 \leq \pi^*_{f2t}$, so that output 1 is relatively stagnant (and output 2 is relatively progressive), the ratio of the average cost of output 1 to that of output 2, AC_{1t}/AC_{2t} will rise without limit.

Proof. By definition,

$$AC_{1t}/AC_{2t} \equiv \pi_{f2t}/\pi_{f1t}$$

so that by the standard proposition on the growth rate of a fraction,

$$(AC_{1t}/AC_{2t})^* = \pi^*_{f2t} - \pi^*_{f1t} \geq r_2 - r_1 > 0. \qquad \text{Q.E.D.}$$

Proposition 2. Let the proportion between two outputs, 1 and 2, be constant so that $y_{2t} = vy_{1t}$. If, in addition, for any t,

$$\max_k \pi^*_{k1t} \leq r_1 < r_2 \leq \min_k \pi^*_{k2t},$$

then product 1's share of any input k used in the production of both goods will approach the limit unity as $t \to \infty$. Moreover, for any value g however small, $0 < g < 1$, there will exist a T such that for any $t > T$ that ratio satisfies $1 \geq x_{k1t}/(x_{k1t} + x_{k2t}) \geq 1-g$.

Proof. Consider any input k. Then

$$(y_{1t}/x_{k1t})^* \leq \max_k \pi^*_{k1t} \leq r_1 \qquad (y_{2t}/x_{k2t})^* \geq \min_k \pi^*_{k2t} \geq r_2$$

so that

$$(1) \quad y_{1t} \leq a_{1k}x_{k1t}e^{r_1 t} \qquad y_{2t} \geq a_{2k}x_{k2t}e^{r_2 t}$$

where

$$a_{1k} = y_{10}/x_{k10}, \text{ etc.}$$

Then, writing $a = a_{1k}/a_{2k}$ and $x_{kt} = x_{k1t} + x_{k2t}$, we obtain dividing $y_{2t} = vy_{1t}$ by y_{1t} in (1),

$$v \geq ae^{(r_2-r_1)t}(x_{kt} - x_{k1t})/x_{k1t}$$

or

$$1 + e^{(r_1-r_2)t}va \geq x_{kt}/x_{k1t} \geq 1.$$

That is,

$$1 \geq x_{k1t}/(x_{k1t} + x_{k2t}) \geq 1/[1+e^{(r_1-r_2)t}va].$$

Since $r_1 < r_2$, the RHS will approach unity asymptotically, which yields our result.

Proposition 3. Under the circumstances of Proposition 2, competitive equilibrium requires the share of consumer expenditure on relatively stagnant product 1 to approach the limit unity as $t \to \infty$. Moreover, for any g however small, $0 < g < 1$, there will exist a finite T such that for any $t > T$,

$$1 \geq p_{1t}y_{1t}/(p_{1t}y_{1t} + p_{2t}y_{2t}) \geq 1 - g.$$

Proof. Let m be the value of k for period t that minimizes $x_{k1t}/(x_{k1t} + x_{k2t})$. In competitive equilibrium

$$1 \geq \frac{p_{1t}y_{1t}}{p_{1t}y_{1t}+p_{2t}y_{2t}} = \frac{\Sigma w_{kt}x_{k1t}}{\Sigma w_{kt}(x_{k1t}+x_{k2t})} \geq \frac{x_{m1t}\ w_{kt}}{(x_{m1t}+x_{m2t})\Sigma w_{kt}}$$

$$= \frac{x_{m1t}}{x_{m1t}+x_{m2t}}.$$

The result now follows by Proposition 2.

3. Intersectoral Shifts and the Economy's Productivity Growth

Proposition 2 tells us that there is a powerful force for absorption of increasing shares of an economy's inputs by its stagnant sectors. With fixed output proportions, this is an arithmetic tautology. Thus, imagine a two-sector economy which uses only one input, labor, where both sectors initially employ the same quantity of labor. If, in T years, sector A's hourly productivity doubles while B's is constant, fixed output proportions mean that at the end of the period stagnant sector B must employ twice as many worker-hours as A.

Next, we prove two results on overall productivity. First, where the productivity growth rates of the different sectors of the economy are unequal, it is impossible for both input and output proportions to remain constant. Second, even if productivity growth in each sector of the economy remains perfectly unchanged, and there is absolutely no change in the relative outputs, the resulting intersectoral input shifts must slow the economy's overall rate of productivity growth.

Proposition 4.[1] In any economy in which the productivity growth rates of its different sectors are unequal it is impossible for both output ratios and input ratios to remain constant.

Proof. Proposition 4 follows immediately as a corollary to Proposition 2.

For the remaining two propositions of this section we need additional notation, because they deal with productivity growth for the entire economy and, hence, require some aggregation of outputs and of inputs with the aid of prices. First, we obtain some expressions for the overall productivity growth rate. Let

$y_t = \Sigma p_{i0} y_{it}$ = value of total output in period t using base period prices

$x_t = \Sigma\Sigma w_{k0} x_{kit}$ = value of the inputs used by the economy in base period prices

$r_{it} = \sum_k w_{k0} x_{kit}/x_t$ = i's share of the economy's total inputs, in base period prices

$\pi_t = y_t/x_t$ = the economy's total factor productivity

$\pi_{it} = p_{i0} y_{it}/\Sigma\Sigma w_{k0} x_{kit}$ = value productivity of inputs used to produce i

$\phi_{it} = p_{i0} y_{it}/y_t$ = i's share of the value of total output in base period prices.

Following wide usage, we value outputs in base period prices, and because it avoids the need to differentiate prices with respect to time. Before getting to the theorems on unbalanced growth and the productivity of the economy as a whole, we use the preceding expressions to provide a sharper variant of Proposition 2, which we will also need later:

<u>Proposition 5</u>. If its proportion of the economy's output is constant, activity i's share of the economy's inputs, r_{it}, will decline monotonically with π^*_{it}, the rate of growth of the activity's productivity. Its input share will be constant ($r^*_{it} = 0$) if and only if its productivity growth rate exactly equals that of the economy as a whole, π^*_t; i's input share will increase if and only if its productivity growth rate is below that of the economy, and decrease only in the opposite case.

<u>Proof</u>. By the definitions we have immediately

(2) $r_{it}/\phi_{it} \equiv \pi_t/\pi_{it}$.

Recalling the standard result for the percentage rate of growth of a fraction $[(A(t)/B(t)]^* = A(t)^* - B(t)^*$, we have from (2)

(3) $r^*_{it} - \phi^*_{it} = \pi^*_t - \pi^*_{it}$.

But with output shares constant $\phi^*_{it} = 0$. Thus,

(4) $r^*_{it} = \pi^*_t - \pi^*_{it}$

where $\pi^*_t - \pi^*_{it}$ is, obviously, the difference between the economy's productivity growth and that of activity i. Q.E.D.

We obtain at once

Proposition 6. If output composition is fixed and the productivity growth rates of the various outputs are constant and unequal, the economy's rate of productivity growth must decline with the passage of time (because inputs will be shifted toward the more stagnant sectors).

Proof. Since output shares are constant all $\phi^*_{it} = 0$ and (4) holds. Note also that since r_{it} is activity i's input share,

(5) $\sum_i r_{it} \equiv 1$ and $\Sigma \dot{r}_{it} = 0.$

Multiplying (4) through by r_{it} and summing over i we then have by (5),

$$\Sigma \dot{r}_{it} = \pi^*_t \Sigma r_{it} - \Sigma r_{it} \pi^*_{it} \quad \text{or} \quad \pi^*_t = \Sigma r_{it} \pi^*_{it}.$$

Differentiating with respect to time to see whether π^*_t is declining, we obtain

(6) $\dot{\pi}^*_t = \Sigma \dot{r}_{it} \pi^*_{it} + \Sigma r_{it} \dot{\pi}^*_{it} = \Sigma \dot{r}_{it} \pi^*_{it},$

because the sectoral productivity growth rates are constant ($\dot{\pi}^*_{it} = 0$).

Since by (5), $^*_t \ \dot{r}_{it} = 0$, we have, subtracting this from (6),

(7) $\dot{\pi}^*_t = \Sigma \dot{r}_{it}(\pi^*_{it} - \pi^*_t) = - \Sigma r_{it} r^*_{it} < 0$ by (4). Q.E.D.

Corollary. Under the circumstances of Proposition 6, except that the sectoral productivity growth rates are all the same, the economy's productivity growth rate will remain constant.

Proof. This follows by (7), since with uniform productivity growth we must have $\pi^*_{it} = \pi^*_t$ for all i.

4. On Asymptotically Stagnant Activities

We turn now to the asymptotically stagnant activities. Pure asymptotic stagnancy is the case of an activity whose inputs are used in fixed proportions, with one group of inputs produced by progressive activities while the others are produced by stagnant activities. A prime example is television broadcasting, with its progressive component (electronic transmission) and its stagnant element (performance or program production). Similarly, electronic computation (data processing) is made up of relatively stagnant computer software and extremely progressive computer hardware. Characteristically, these, like other asymptotically stagnant activities, are "high tech" industries, at the frontier of technical progress.

Asymptotically stagnant activities have several noteworthy behavior patterns. In their early stages, when progressive inputs dominate their budgets, their costs and prices fall rapidly, like those of progressive activities. Later, their fixed input proportions and the rapid fall in the relative prices of their progressive inputs inevitably give the stagnant inputs an ever-rising share of the total budget of the asymptotically stagnant activity, as a simple matter of arithmetic. Third, as the stagnant component comes to dominate the budget the price of the activity must approach that of its stagnant component, and therefore has to rise, so succumbing to the cost disease. Finally, the date when the activity sheds its progressive characteristics comes more quickly the more rapid the decline in the price of its progressive component. That is, the more spectacularly successful is productivity enhancement in the production of the progressive inputs, the more rapidly they will extinguish themselves as significant components of the asymptotically stagnant activity's budget and, consequently, the more rapidly the relative cost of this activity will begin to rise.

These results are encompassed in the following propositions:

Proposition 7. Suppose an asymptotically stagnant activity, A, uses stagnant input x_1 and progressive input x_2 in fixed proportion v, so that $x_{2t} = vx_{1t}$. If w_{1t}, the unit price of x_{1t}, increases at a rate at least equal to r_1 and w_{2t} increases at a nonnegative rate no greater than r_2, where $r_2 < r_1$, then the share of total expenditure by A that is devoted to x_{1t} will approach the limit unity. Moreover, for any positive g, however small, $0 \leq g < 1$, there exists a T such that for all $t > T$,

$$1 \geq w_{1t}x_{1t}/(w_{1t}x_{1t} + w_{2t}x_{2t}) \geq 1 - g.$$

Proof. We are given

$$w_{1t} \geq w_{10}e^{r_1 t} \qquad w_{2t} \leq w_{20}e^{r_2 t}, \qquad\qquad x_{2t} = vx_{1t}.$$

Then, writing $k = w_{20}/w_{10}$,

$$1 \leq \frac{w_{1t}x_{1t} + w_{2t}x_{2t}}{w_{1t}x_{1t}} = 1 + \frac{vw_{2t}}{w_{1t}} \leq 1 + kve^{(r_2 - r_1)t}. \qquad \text{Q.E.D.}$$

Proposition 8. Let the asymptotically stagnant activity of Proposition 7 be supplied under conditions of perfect competition, and let its outputs, y_t, satisfy $y_t = ux_{1t}$, u = a constant, and let its price be p_t. Then p_t^* will approach w_{1t}^* asymptotically, i.e., the growth rate of p_t will approach that of the price of its stagnant input.

Proof. $p_t = (w_{1t}x_{1t} + w_{2t}x_{2t})/y_t = (w_{1t} + vw_{2t})/u.$

Then, writing $a = 1/u$, $b = v/u$, we have

$$p_t^* = \frac{\dot{p}_t}{p_t} = \frac{a\,\dot{w}_{1t} + b\,\dot{w}_{2t}}{a\,w_{1t} + b\,w_{2t}} = \frac{\dot{w}_{1t}}{w_{1t}}\,\frac{a\,w_{1t}}{a\,w_{1t} + b\,w_{2t}} + \frac{\dot{w}_{2t}}{w_{2t}}\,\frac{b\,w_{2t}}{a\,w_{1t} + b\,w_{2t}}.$$

But $aw_{1t}/(aw_{1t} + bw_{2t})$ approaches unity asymptotically by Proposition 7 while $\dot{w}_{2t}/w_{2t} \leq r_2$ and $bw_{2t}/(aw_{1t} + bw_{2t})$ approaches zero asymptotically (since its reciprocal $= 1 + aw_{1t}/bw_{2t} \geq 1 + kae^{r_1 t}/be^{r_2 t}$. Consequently, from the preceding equation, p_t^* must approach $\dot{w}_{it}/w_{it} = w_{it}^*$ asymptotically. Q.E.D.

Corollary. The smaller the upper bound, r_2, of w_{2t}^*, i.e., the growth rate of the price of the progressive input of the asymptotically stagnant activity, the more rapidly the behavior of the latter's price will be forced to approximate that of its stagnant input.

5. Empirical Evidence from the U.S. Economy

We turn now to our empirical evidence -- to test, first, the implications of the basic model of unbalanced growth and, then, the asymptotic stagnancy construct. The first of these tasks requires classification of the actual sectors of the economy into progressive and stagnant categories, a division which is inevitably somewhat arbitrary. We base the classification on input and output data for the U.S. economy for 1947-1976, since consistent national account data and input-output tables are available. A variety of measures of productivity growth rates were used to test the sensitivity of our classification scheme.

In Table 1, column 1 shows calculations of annual (compounded) rates of labor productivity growth using official National Income and Product Account (NIPA) figures.[2] The corresponding sectoral productivity concept is GPO per person employed, and that of aggregate productivity is the ratio of gross domestic product (GDP) to total persons employed. The average annual rate of aggregate productivity growth was 2.16 percent over the period. Sectoral rates of productivity growth ranged from a high of 5.42 percent in communications and broadcasting, a service sector, to a low of - 0.51 percent in government enterprises. Though there is a fairly wide spread in sectoral rates of productivity growth, there also appears to be a sharp break between the construction sector at 1.66 percent and the narrowly-defined "general services" sector, at 0.93 percent. By this criterion and these data, four sectors are stagnant: services (0.93 percent), finance and insurance (0.50 percent), government industry (0.31 percent), and government enterprises (- 0.51 percent). Productivity growth in the remaining sectors was fairly rapid, putting them in the progressive group. Note that this group includes three service sectors -- communications, trade and real estate.[3]

Table 1:
Average Annual Rate of Productivity Growth by Sector, 1947 - 76

INDUSTRY	(1) GPO/L	(2) GDO/L	(3) ρ	(4) λ	(5) λm	(6) $\bar{\beta}$	(7) $p/\bar{p}$
. Agriculture	3.59%	4.47%	1.56%	3.95%	3.66%	2.05%	1.6
. Mining	2.70	2.76	0.08	1.38	1.09	-0.51	-1.6
. Construction	1.66	1.19	-0.34	1.49	1.42	0.64	-0.7
. Manufacturing-Durables	2.52	2.80	0.58	3.08	2.87	1.77	0.8
. Manufacturing-Non-durables	3.21	3.23	0.41	2.56	2.43	1.34	0.2
. Transportation and Warehousing	1.74	2.74	0.68	2.42	2.45	1.33	0.3
. Communication and Broadcasting	5.42	5.50	3.99	5.21	4.62	2.76	1.3
. Utilities	4.96	4.77	1.53	2.96	2.62	1.05	0.0
. Trade		2.17	1.09	2.19	2.09	1.47	0.5
a) Wholesale Trade	2.37						
b) Retail Trade	1.99						
. Finance and Insurance	0.50	0.31	-0.27	0.57	0.50	-0.26	-1.1
. Real Estate	2.72	3.10	2.87	4.86	4.81	3.21	0.5
. General Services	0.93						
a) Hotels, Personal and Repair (except auto)		1.37	-0.31	1.35	1.36	0.65	-0.4
b) Business and Professional Services		1.70	0.83	2.30	2.09	1.60	-1.1
c) Auto Repair and Services		1.45	-0.84	1.04	-0.09	-0.18	-0.6
d) Movies and Amusements		0.99	-0.56	0.64	0.57	-1.08	-1.0
e) Medical, Educational and Non-Profit		-0.46	-1.14	-0.19	0.03	-0.86	-1.6
f) Household Workers		-0.21	-0.21	-0.21	-0.21	-0.21	-0.8
. Government Enterprises	-0.51	1.10	-0.52	0.99	0.96	0.56	-1.0
. Government Industry	0.31	-0.18	0.08	-0.18	-0.18	0.31	-2.4
OVERALL: GDP	2.16						
GNP		2.18	1.17	2.18		1.17	0.0
NNP					1.99		

urces:

) Bureau of Economic Analysis, The National Income and Product Accounts of the United States, 1929-76 Statistical Tables, September 1981, Tables 6.2 and 6.11.

) GDO for 1947 was obtained from the standard 87-order Bureau of Economic Analysis input-output table for 1947. GDO for 1976 was obtained from Bureau of Labor Statistics, Time-Series Data for Input-Output Industries, Bulletin 2018, 1979.

) - (7) The source is U.S. input-output data. See footnote 5 for details.

The second column of Table 1 uses gross domestic output (GDO) in constant dollars as its sectoral output and number of persons employed as its labor input. GDO in constant dollars, an input-output concept, equals gross value of a sector's output or sales deflated by the sectoral price deflator. The estimated rates of sectoral productivity growth are changed slightly by switching to GDO from GPO, except in the construction, transportation, and government enterprise sectors. This definition of productivity assigns the construction sector a rate of productivity growth considerably below the other sectors previously classified here as progressive, and so it is reclassified as stagnant when this productivity concept is used. Government enterprise, while its rate of productivity growth is now increased, is still considerably below that of the economy overall, so the sector is kept in the stagnant group.

The input-output data also permit disaggregation of general services into six subsectors and evaluation of their degrees of stagnancy. These are (i) hotels, personal and non-auto repair services, (ii) business and professional services, (iii) auto repair and services, (iv) movies and other amusements, (v) medical and educational services and non-profit institutions, and (vi) domestic servants and other household workers. The range of sectoral productivity growth rates of these subsectors is fairly wide, though they all lie below the economy's 2.18 percent rate. The last three subsectors all seem clearly to be stagnant. The first three are more marginal, though we will, somewhat arbitrarily, draw the line between business and professional services (1.70 percent) and the other two (1.37 and 1.45 percent), placing only the former in the progressive group.

Our third measure of productivity growth rates requires several new symbols to describe the input-output framework. Let

X = (column) vector of gross output by sector

Y = (column) vector of final demand by sector

a = matrix of interindustry technical coefficients

ℓ = (row) vector of labor coefficients showing employment per unit of output

k = (row) vector of capital stock coefficients showing the capital stock required per unit of output

q = (row) vector of prices showing the (current) price per unit of output of each industry.

In addition, we use the following scalars:

w = the annual wage rate, in current dollars

r = the rate of profit on the capital stock

$z = pY$ = gross national product at current prices

$L = \ell X$ = total employment

$K = kX$ = total capital stock.

The aggregate rate of total factor productivity (TFP) growth is given by

(8) $\pi^* = (q dY - w dL - r dK)/z$

where "d" refers to the differential. The rate of TFP growth for sector j is given by

(9) $\rho_j \equiv -(\sum_i q_i da_{ij} + w d\ell_j + r dk_j)/q_j$.

This is the continuous analog of Leontief's measure of sectoral technical change [1953].[4]

U.S. input-output data for 1947 and 1976 were used to estimate this third set of growth rates [column (3), Table 1].[5] Since these involve total factor productivity (TFP), they are generally lower than the corresponding labor productivity measures since capital-labor ratios were increasing. The overall rate of TFP was 1.17 percent per year, about a point lower than that of labor productivity, and the sectoral rates behaved similarly. However, their relative magnitudes leave the classification of the sectors as progressive and stagnant unchanged from that of the preceding measure, with the exception of mining.[6] The rate of TFP growth in mining was nearly zero, and so by this measure the mining sector was stagnant.

So far, our productivity measures evaluate productivity improvements within any one sector; one can also examine the changes in total input usage, direct and indirect, per unit of a sector's output. This also reflects productivity growth of the sector's input suppliers.

Three such total factor requirement measures are reported in columns (4) through (6) of Table 1. The measure λ shows the total (direct plus indirect) labor requirements per unit of final output:

(10) $\lambda = \ell(I - a)^{-1}$.

The measure λ_m in column (5) of Table 1 differs from (4) only in λ_m's Marxian accounting framework. Capital, as a produced means of production, is valued by its depreciation rate (see Wolff [1979]).

The measure in column (6) of Table 1, β, is the total factor requirement analog of ρ. Let

(11) $\gamma = k(I - a)^{-1}$,

be the total capital requirements per unit of final output. Then the rate of change of total factor requirements per unit of final output can be estimated from

(12) $\tilde{\rho}_j \equiv -(wd\lambda_j + rd\gamma_j)/q_j$.

Productivity growth based on λ and λ_m is quite similar to that in column (2), Table 1, since changes in total factor requirements are dominated by those in direct factor requirements.[7] The classification of sectors is therefore identical with that of column (2), except that the mining sector now falls into the stagnant category. Similarly, the classification of sectors on the basis of $\tilde{\rho}$ is identical with that based on ρ.

The last column in Table 1 uses the change in the (real) relative price of a sector's output to measure its relative rate of productivity growth. (The variable p is based on the GNP deflator, whose rate of change over time is standardized to equal 0.0.) For a decline in relative prices can be interpreted in a competitive market, as a corresponding decline in the growth of total factor requirements.[8] Of course, in reality, other developments influence relative prices. Nevertheless, all sectors that were classified as progressive by the measure $\tilde{\rho}$ showed declines in relative prices [that is, positive values in column (7)], and conversely, except for business services, where relative price increased. By this measure, all general services were classified as stagnant.

In Table 2, an x indicates that a sector is classified as stagnant by the corresponding measure of relative productivity growth (panel A). The average annual rates of productivity growth for the two aggregated sectors are shown in panel B.

Table 2:
Share of Employment and Output in Stagnant Sector, 1947 and 1976

	MEASURE:						
	(1) GPO/L	(2) GDO/L	(3) ρ	(4) λ	(5) λm	(6) $\tilde{p}$	(7) p
A. Stagnant Sectors:							
2. Mining			x	x	x	x	x
3. Construction		x	x	x	x	x	x
10. Finance & Insurance	x	x	x	x	x	x	x
12. General Services							
a. Hotels, Personal & Repair (except auto)	x	x	x	x	x	x	x
b. Business & Professional	x						x
c. Auto Repair & Service	x	x	x	x	x	x	x
d. Movies & Amusements	x	x	x	x	x	x	x
e. Medical, Educational and Non-profit	x	x	x	x	x	x	x
f. Household Workers	x	x	x	x	x	x	x
13. Government Enterprises	x	x	x	x	x	x	x
14. Government Industry	x	x	x	x	x	x	x
B. Annual Prod. Growth Rate, 1947-1976:							
a. Progressive Sectors (all)	2.94%	3.04%	1.09%	2.92%	2.73%	1.95%	0.59%
b. Stagnant Sectors	0.64	0.56	-0.84	0.73	0.61	-0.57	-1.26
c. Progressive Service Sectors	2.71	2.79	1.63	2.79	2.64	2.12	0.67
d. Overall	2.16	2.18	1.17	2.18	1.99	1.17	0.0
C. Percent of Employed Persons in Stagnant Sectors:							
a. 1947	27.6	30.7	32.4	32.4	32.4	32.4	34.6
b. 1976	41.2	42.0	43.0	43.0	43.0	43.0	47.2
D. Stagnant Sector Share of Final Output (1958 $):							
a. 1947	21.4	31.2	31.5	31.5	31.5	31.5	32.1
b. 1976	21.2	29.2	28.9	28.9	28.9	28.9	29.9
E. Stagnant Sector Share of Final Output (Current $):							
a. 1947	17.9	26.8	27.0	27.0	27.0	27.0	27.6
b. 1976	29.9	38.6	38.1	38.1	38.1	38.1	39.3
F. Stagnant Sector Share of GDO (1958 $):							
a. 1947	16.8	21.9	24.2	24.2	24.2	24.2	26.4
b. 1976	16.8	19.8	21.3	21.3	21.3	21.3	24.9
G. Stagnant Sector Share of GDO (Current $):							
a. 1947	13.7	18.3	20.4	20.4	20.4	20.4	22.2
b. 1976	22.9	24.5	26.7	26.7	26.7	26.7	31.1
H. Percent of Employed Persons in Progressive Services:[a]							
a. 1947	21.3	23.5	23.5	23.5	23.5	23.5	21.3
b. 1976	22.5	26.7	26.7	26.7	26.7	26.7	22.5

[a] In columns (1) and (7) progressive services are defined as communications and broadcasting, trade, and real estate. In columns (2)-(6) they include the same three sectors, and, in addition, business and professional services.

6. Tests of the Model's Basic Implications

We are now in a position to test as hypotheses the main implications of our model. The first of these is the cost disease prediction that relative prices of the stagnant sector's outputs will rise at about the same rate as the shortfall in its rate of productivity growth. This is, indeed, confirmed by the data. By the first six measures of Table 2, the rate of productivity growth of the stagnant sector is from about 2 to $2\frac{1}{2}$ percentage points below that of the progressive sector.[9] By the last measure of Table 2, the price of stagnant output relative to progressive output increased at about 2 percent per year.

The next hypothesis is not an implication of the model, but was previously only a casual observation. This is the view that in real terms output shares have remained constant over time. This was examined using both final output and GDO shares (Panels D and F in Table 2). The first classification scheme tells us that the real output shares remained constant over the period in terms of both final output and GDO. The other definitions, however, indicate a slight decline in the stagnant sector's real share of final demand and gross output.

We can now examine the other two main implications of the model. The first is that, since output shares have been fairly constant, the share of employment in the stagnant sector will rise over time. By all four definitions, the share of employment in the stagnant sector rose by over 10 percentage points over the period and, by the first definition, by almost 14 percentage points (panel C). The third basic prediction of our model is that, with output shares roughly constant in real terms, the share of output produced by the stagnant sector will rise in nominal terms over time. This is confirmed in panels E and G, which exhibit increases that range from 6 to 12 percent.[10]

One final set of implications of the model can also be tested. As has been shown, the service sector includes both progressive and stagnant industries. In panel B, we have calculated separately the rate of productivity growth for progressive services. We find that the progressive services experienced slightly lower rates of growth of labor productivity than progressive goods producers but higher rates of total factor productivity growth. Moreover, (panel H) we find that while employment in progressive services increased over the 1947-1976 period, it rose very modestly, as our analysis might lead us to expect. Thus, progressive services behaved very differently from stagnant services over the postwar period and behaved very much like progressive goods sectors, and while it is true that the nation's labor forced moved toward services, both stagnant and progressive, it was the former whose labor force increased most substantially. While the labor force of the progressive services rose somewhere between 5 and 14 percent, that of the stagnant services rose 32 and 50 percent.

7. Some International Evidence

Additional confirmation of the model's predictions is provided by (1975) cross-sectional international data (Summers [1982]). Real GDP per capita, the services' proportion of total real GDP expenditures, and their proportion of total nominal GDP expenditures were collected for a sample of 34 countries, ranging from very poor countries such as Malawi and India to highly industrialized states like Germany and the United States.

Our model predicts that if the real share of GDP devoted to services remains roughly constant among countries, the nominal share devoted to services will rise with real GDP per capita.[11] Figures 1 and 2 are consistent with these predictions, as are the corresponding regression results:

$$\underset{}{\text{SERVREAL}} = \underset{(23.51)}{37.95^*} - \underset{(1.23)}{0.039}\ \text{GDPCAP} \qquad R^2 = 0.04$$

$$\text{SERVNOM} = \underset{(12.85)}{25.77^*} + \underset{(4.62)}{0.184^*}\ \text{GDPCAP} \qquad R^2 = 0.40$$

where

SERVREAL = share of services in real GDP expenditure

SERVNOM = share of services in nominal GDP expenditure

GDPCAP = real GDP per capita

* = significant at the 1 percent level

and t-ratios are shown in parentheses. The coefficient of GDPCAP

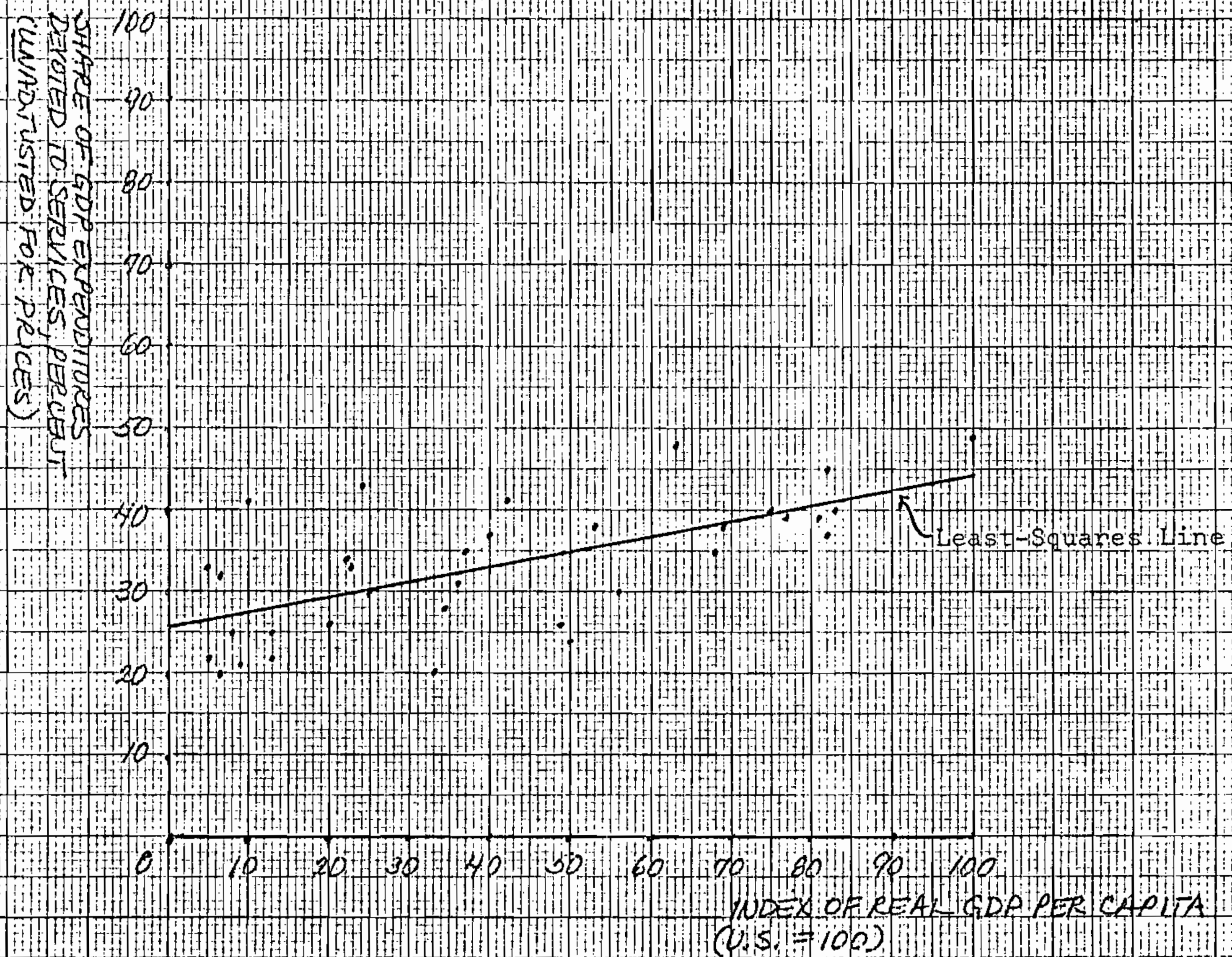

Figure 1 (Source: Summers [1982])

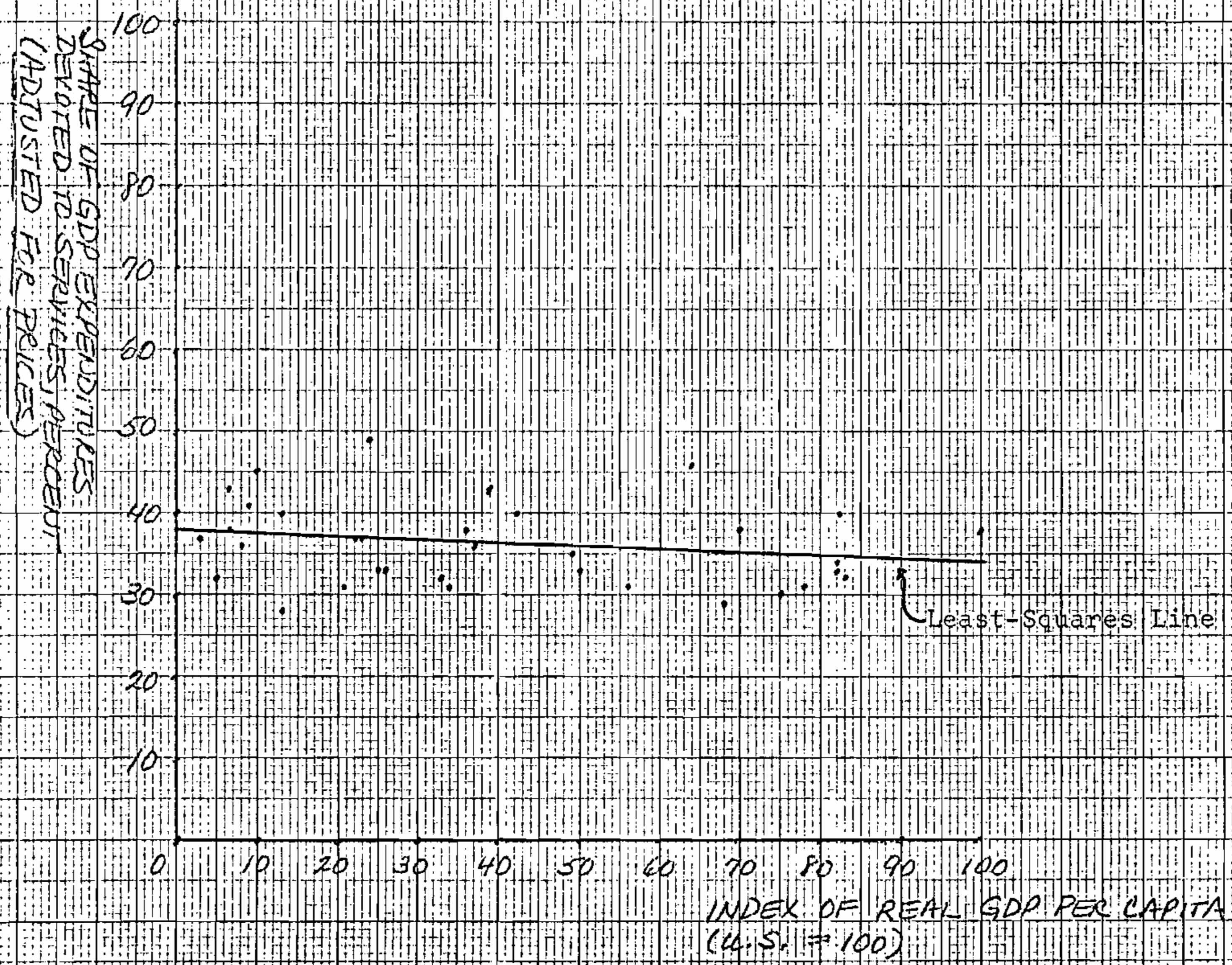

Figure 2 (Source: Summers [1982])

in the first regression is statistically insignificant, but, in the second equation, it is significant at the one percent level, and the R^2 of the second equation is ten times larger than that of the first. The results indicate that, in real terms, the share of GDP devoted to services remained roughly constant as real income per capita increased, whereas, in nominal terms, the share of total expenditures in the services grew markedly with income. This result obviously is completely consistent with the model's predictions.

8. Broadcasting, Computation and Asymptotic Stagnancy

We turn now to empirical evidence on two asymptotically stagnant activities, television broadcasting and data processing (a.k.a., information processing or computer services). We will see that in both activities the progressive component has a continually shrinking share of total costs, while the stagnant components have increased in real terms and as shares of total costs. We will also see that the time path of broadcasting cost per unit of output now behaves like that of a stagnant product.

(a) Electronic Computation. Computer hardware in the last twenty years has been characterized by plummeting cost per unit of processing power -- a fall of some 25 percent per year is frequently reported (see, for example, Kubitz [1980], Triebwasser [1978], Noyce [1977], and Burns [1977]). But as computer hardware cost fell, the cost of software -- the labor-intensive component -- has assumed an ever-greater share of a computer system's total cost. Ten or fifteen years ago, computer software was a relatively minor cost element -- IBM once gave away software with its machines. It seems generally agreed by knowledgeable observers that this is now reversed. It is a common assessment that computer hardware is actually becoming an incidental matter in total computation cost (see Gordon and Munson [1980]). Kubitz [1980] estimates that in 1973 software represented only 5 percent of system costs. By 1978 this had increased to 80 percent. Schindler [1979] predicted that software cost would exceed 90 percent by 1980, and Walter Doherty of IBM's Yorktown Research Laboratory now puts the cost of human time at their computer terminals at more than seven times that of their hardware (Minicucci [1982]). Grabscheid of Mathematica Products Group writes that by 1985, "it will probably pay to substitute one hour of computer time for six minutes of staff time" (page 6, [1982]). Software development remains essentially a fairly primitive, handicraft activity, and may so far constitute a stagnant service.

These reports can be supplemented by more systematic data. Figure 3 shows shares of computer personnel costs and computer hardware costs at the Princeton University Computer Center, between 1970 and 1983. It is dramatically evident from the graph that (though staff size at the Center has varied little) labor costs have assumed an ever-greater share of total expenditures while the hardware component dropped almost continuously.[12] Figure 4 shows the actual costs of the Center's computer hardware and personnel, which, again, show the pattern of rising relative labor costs and decreasing equipment costs. Over the period in question total real labor costs rose at a compounded rate of 2.6 percent per annum, while total real equipment costs fell at a compounded annual rate of 4.6 percent. With the volume of computations rising rapidly, equipment cost per unit of

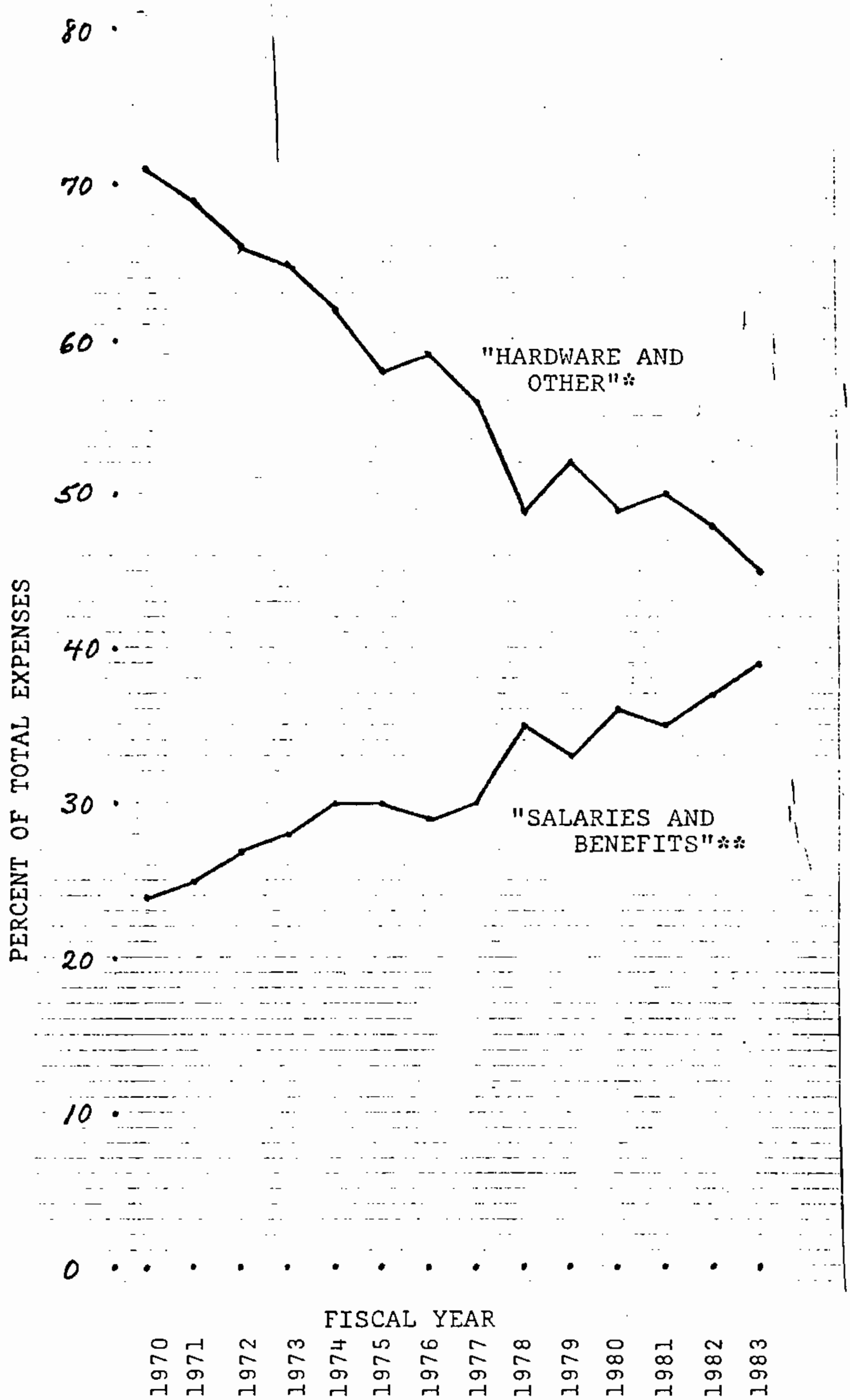

Figure 3: Labor Costs vs. Hardware Costs, as a Percentage of Total Costs, at the Princeton University Computer Center, 1970-1983***

(See next page for source and notes.)

Figure 3 continued

Source: Dr. James Poage, Director, Princeton University Computer Center.

Notes:

* The cost category "hardware and other" is made up of approximately 80 percent computer hardware costs and 20 percent other costs such as disposable supplies. Increases in hardware costs in 1976, 1979 and 1981 are largely ascribable to either the purchase of major new equipment or the refinancing of equipment costs.

** Staff size at the Center has remained essentially unchanged over the period.

*** Data for 1983 are estimates.

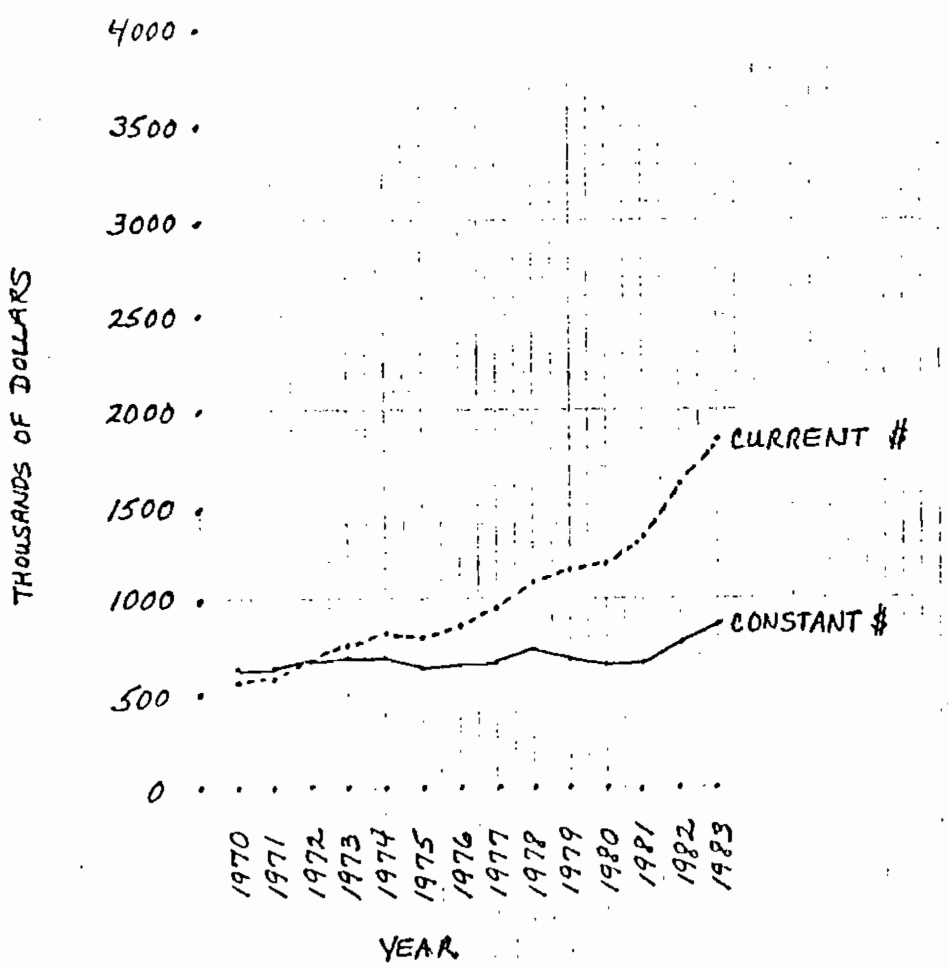

Figure 4a:
Salaries and Benefits Expenses,
Princeton University Computer Center,
1970-1983, in current and constant dollars

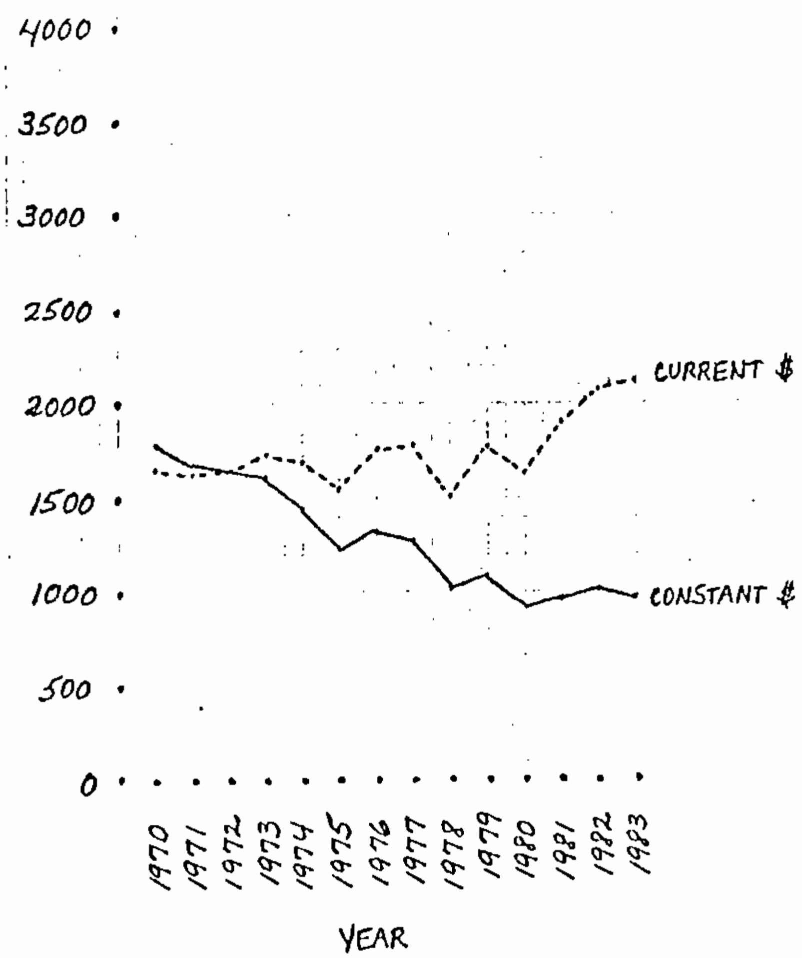

Figure 4b:
Hardware and "Other Costs,"
Princeton University Computer Center
1970-1983, in Current and Constant Dollars

Sources: Computer Center financial data: Mr. James Poage, Director, Princeton University Computer Center; GNP Implicit Price Deflator: Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, various issues.

Notes: Deflated figures are calculated by dividing by the GNP price deflator and multiplying by 100. The category "hardware and Other" is made up of approximately 80 percent computer hardware costs and 20 percent other costs such as disposable supplies (computer cards, paper, printer ribbons), travel expenses of the Director, etc. Data for 1983 are estimates.

output has fallen far more rapidly (and per unit labor costs have risen more slowly).[13]

Princeton University's experience is apparently replicated throughout the data processing industry. The industry, consequently, is seeking ways to further enhance the productivity of its personnel, for example, by finding ways to substitute hardware time for costly staff time and creating software in so-called "fourth generation" computer languages which minimize the user's time and permit less-skilled (and lower-paid) operators to use the computer.[14]

b. Television Broadcasting. Television broadcasting also has progressive and stagnant components -- transmission, which includes circuit costs, and programming, dominated by human labor. Here, too, the evidence on trends in costs is striking. TV broadcasting costs have increased dramatically. Levin's [1980] figures show that the cost of a half-hour episode of a new prime-time program, when deflated by the wholesale price index, were a full $90,759 in 1976 compared to $51,633 in 1960, an increase of over 75 percent (an average rise of 3.5 percent per annum). Over a longer period, and again adjusting for inflation, a typical half-hour film cost $14,466 in 1952 (1967 dollars) and $73,079 in 1974, a rise of 405 percent or 7.4 percent per year (Levin, p. 28). Total network program expenditures (unseparated from technical) rose comparably -- from $404,731,000 in 1960 to $1,273,241,000 in 1975, some 215 percent, or 7.6 percent per year!

The split between technical broadcasting expenses and program expenses has changed, like that between hardware and software costs. One independent TV producer comments, "In a 'typical' educational TV show of the past, hardware costs took so much money that producers had no way of hiring good talent for appearances or research.... The result was talking head after talking head" (Paik [1979], p. 23). New hardware developments have reduced costs; thus, "A new 1-inch recorder...is supposedly better than the 2-inch recorder.... The price reduction from $2,500 a day for 2-inch to about $500 a day for the 1-inch system will pay the new equipment off in 35 days, or roughly 10 TV shows" (pp. 23-24). Figure 5, using FCC data, shows average expenses of TV stations between 1960 and 1980 (in both current and inflation-adjusted dollars) and confirms the steep rise in broadcasting costs. It also shows trends in the two relevant components of broadcasting expenses -- technical and program expenses -- showing that real program costs have climbed steadily, while real technical expenses have remained about constant over the twenty-year period. Table 4 shows that, as a percent of total expenditures, technical costs have dropped continuously from 16.5 percent in 1960 to 10.8 percent in 1980. In constant dollars, over the twenty years in question total technical expenses per station have actually risen, but at the modest rate of 0.8 percent per year. However, the average rate of increase of real programming cost was 3.1 percent, and total real expenses increased at virtually the same annual rate, 2.9 percent.

Figure 5: Broadcasting Expenses Per Average Television Station* in current and constant dollars, 1960-1980

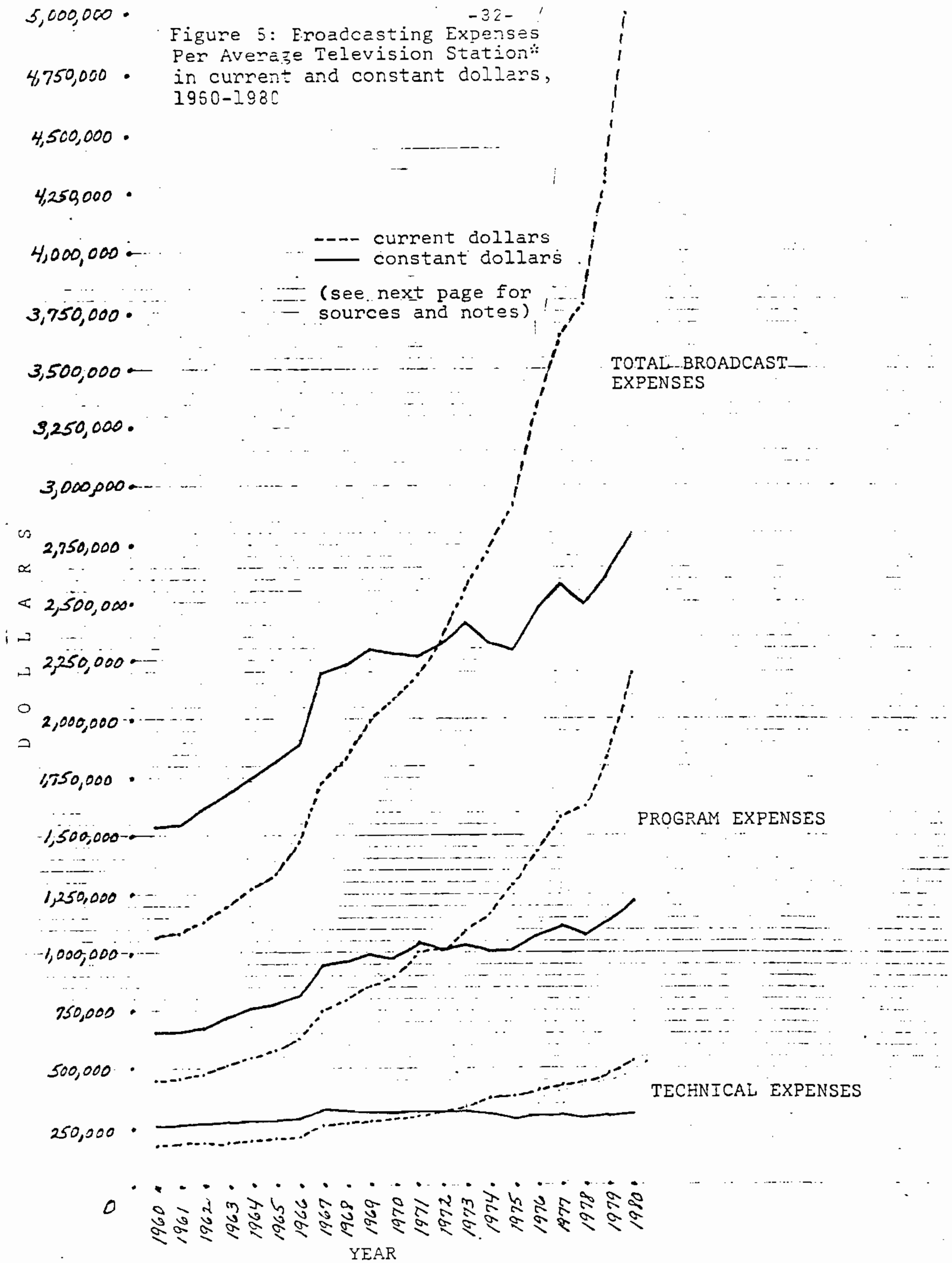

Figure 5 continued

Sources: Federal Communications Commission, Annual Report, various years, and "Television Financial Data 1980, FCC Financial Figures," Broadcasting, Vol. 101, No. 6, August 10, 1981, p. 54. Source for price deflator: Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, various years.

Notes:

* Data excludes the three major networks, but includes network owned and operated television stations.

Table 4:
Technical and Program Expenses as a Percentage of Total Television Broadcasting Expenses, 1960-1980

Year	Total Broadcast Expenses (All TV Stations*)	Technical Expenses	Tech. Expenses as a percentage of Total	Program Expenses	Program Expenses as a percentage of Total
1960	$563304000	$92851000	16.5%	$239117000	42.4%
1961	579523000	96150000	16.6	245209000	42.3
1962	626587000	101329000	16.1	265411000	42.3
1963	674520000	106334000	15.8	290515000	43.1
1964	725443000	113795000	15.7	315118000	43.4
1965	787739000	120234000	15.3	338788000	43.0
1966	884970000	131070000	14.8	380112000	43.0
1967	948322000	141403000	14.9	409212000	43.2
1968	1040132000	151473000	14.6	449160000	43.2
1969	1176442000	161359000	13.7	504870000	42.9
1970	1245158000	170570000	13.7	534720000	43.0
1971	1303740000	179550000	13.8	599156000	46.0
1972	1457640000	196508000	13.5	628639000	43.0
1973	1577915000	210547000	13.3	677906000	43.0
1974	1706738000	228307000	13.4	733719000	43.0
1975	1830017000	229586000	12.5	805333000	44.0
1976	2108077000	256674000	12.2	912282000	43.3
1977	2297132000	270311000	11.8	995093000	43.3
1978	2705400000	318400000	11.8	1162500000	43.0
1979	3100600000	346300000	11.2	1343600000	43.3
1980	3614600000	390000000	10.8	1588300000	43.9

* Does not include the three major networks but does include network owned and operated television stations.

Categories: Technical expenses includes technical payroll and other technical expenses such as circuit costs incurred in delivering programs to local stations. Program expenses includes "talent" employees, other employees, rent and amortization of film and tape, records and transcripts,

Table 4 continued

outside news service costs, payment to talent, music license fees, other performance and program rights, and all other program expenses. Other categories not listed in the table are selling expenses and general and administrative expenses (which includes general and administrative payroll, depreciation and amortization, interest, allocated costs of management from home office of affiliate(s), and other general and administrative expenses) These descriptions are taken from "Television Financial Data 1980, FCC Financial Figures," Broadcasting, Vol. 101, No. 6, August 10, 1981.

Sources: FCC Annual Reports, various issues and "Television Financial Data 1980, FCC Financial Figures," Broadcasting, Vol. 101, No. 6, August 10, 1981, p. 54.

9. Concluding Comments

All the empirical data we have found seem consistent with the predictions of the amended unbalanced growth model. The "rising share of services" turns out to be somewhat illusory. The output shares of the progressive and stagnant sectors have in fact remained fairly constant in the postwar period, so that with rising relative prices, the share of total expenditures on the (stagnant) services and their share of the labor force have risen dramatically (prices rose at about the same rate as its productivity lags behind the progressive sectors), just as the model suggests. Similar trends are also found internationally.

We have also introduced into the model a type of activity we call asymptotically stagnant -- economic enterprises which seem among the most "high tech" and progressive one can imagine. They contain both a technologically sophisticated component and a relatively irreducible labor-intensive component. Starting out as innovative activities dominated by their very productive technological side, as the labor component assumes an ever-larger share of total cost (because the progressive component is innovating itself out of its cost-dominating position), ultimately the activity assumes all the characteristics of the stagnant services. Empirical data on two such activities -- TV broadcasting and electronic computation -- are also consistent with the model's predictions. This suggests that the progressivity of such activities may well prove transitory and somewhat illusory. In sum, the cost disease of the stagnant services may affect even more of the economy than was previously thought, and may play a larger role in the recent productivity growth slowdown than many observers have judged.

FOOTNOTES

* Princeton and New York Universities. ** Princeton University.

*** New York University. The authors are extremely grateful to the Division of Information Science and Technology of the National Science Foundation for its support of the research reported here.

1 We are very grateful to David Dollar for this result.

2 Here, as the total value of goods and services produced domestically, irrespective of ownership, GDP is actually preferable. The level of industry disaggregation was determined by the available statistics for the period. The output variable is gross product originating (GPO) in constant (1972) dollars. GPO in constant dollars is defined as the difference between the deflated value of output and the deflated value of interindustry inputs. The input concept is "persons engaged in employment" (L), defined as the sum of the number of full-time-equivalent employees and self-employed workers. This is perhaps the best available measure of labor input.

3 The real estate data must be interpreted cautiously, since part of the "output" is the rent imputed to owner-occupied housing. However, where imputed rent enters official GNP and GDP statistics, the reported rate of productivity growth in real estate is the appropriate datum.

4 Also, see Peterson [1979] and Wolff [1983] for more details. Because discrete time periods are employed, a Turnquist-Divisia Index is used to estimate sectoral and the overall rate of TFP (see Gollop and Jorgensen [1980] or Wolff [1983]).

5 The 1947 input-output table is the standard 87-order Bureau of Economic Analysis version. (See, for example, Bureau of Economic

Analysis [1974] for methods and a listing of sectors.) The 1976 table was estimated using the so-called R.A.S. method on the 1972 table, with the gross domestic output figures in Bureau of Labor Statistics [1979a]. Estimates of the total capital stock in each input-output sector appear in Bureau of Labor Statistics [1979b]. Full capital coefficient matrices for 1947 were obtained from the Brandeis Economic Research Center (BERC); sectoral 1947 depreciation rates from BERC, and those for 1976 estimated from Internal Revenue Service Corporation Tax Returns. Sectoral price indices for 1947 were provided by BERC and for 1976 by the Bureau of Economic Analysis. Additional details on data sources and methods are available from the authors.

The accounting framework was then modified as follows:

(1) An "endogenous export column" was created to balance the non-competitive import row (sector 80).

(2) For the estimation of Marxian labor values, the depreciation row that is normally part of value-added was treated as an endogenous input row (sector 88), and an "endogenous capital replacement" column was included to balance this row.

(3) Five sectors -- research and development (74), business travel (81), office supplies (82), scrap and used goods (83), and inventory valuation adjustment (87) -- appeared in the 1947 table but not in the 1976 table. In order to assure consistency of the accounting framework, these sectors were eliminated from both gross and final output in 1947 by distributing their inputs to other sectors.

(4) Indirect business taxes in value-added were eliminated in order to remove the biassing effect of indirect business taxes on relative prices.

(5) The input-output matrices were finally converted to constant (1958) prices by multiplying each row of the matrix by the appropriate sectoral price deflator.

For details, see Wolff [1983].

6 This reflects a large postwar influx of capital equipment into mining and increases in intermediate inputs. The mining sector is rather different from a more standard stagnant sector, since it is a process industry whose output is not directly related to its labor (or capital) input. Its low rate of TFP growth is attributable primarily to the nature of extraction, in which more accessible ores and petroleum are mined first and less accessible deposits later. The increasing difficulty of mining would have yielded a negative growth rate in TFP if technology had remained constant. The fact that TFP growth was zero in this sector over the period 1947-1976 suggests that technical change (or the discovery of new accessible deposits) did occur.

7 It should be noted that the overall level of productivity growth corresponding to λ_m is the ratio of NNP to employment, since depreciation is treated as endogenous. The rate of growth is lower than that of GNP per worker.

[8] In a Leontief framework, the prices are, essentially, the duals of the total factor requirements:

$$p = v(I-a)^{-1}$$

where v is the row vector of value-added coefficient.

[9] Both sectoral values of ρ are below the overall rate of TFP growth, P. This is correct, because as demonstrated in Peterson [1979] or Wolff [1983],

$$\pi^* = \sum_i \frac{q_i X_i}{z} \rho_i ,$$

the ratio of total GDO to total final output (in current dollars), is about 2.0 in both years.

[10] We also found that the share of total capital stock in the stagnant sector declined by about 5 percentage points, indicating that the capital-labor ratio grew faster in the progressive sector. This result is consistent with the spirit of our model, since the progressive sector is characterized by more rapid changes in technology which can be expected to involve a more rapid displacement of labor by capital.

[11] Technically speaking, our model's prediction on nominal share of expenditures relates only to stagnant services. Though Summers did provide a breakdown of service expenditures by type of service, it was not possible to fit his data into the progressive and stagnant categories. Therefore, the calculation here refers to the entire service sector.

[12] In the three years, 1976, 1979, and 1981, in which the downward trend was interrupted, the increased share of hardware cost is ascribable

to major equipment purchases and changes in equipment financing, rather than to increases in hardware prices. The Director of the Center does caution that, although the bulk of the drop in Center expenditures on hardware is attributable to actual hardware cost decreases, some part of it is the result of more favorable lease-purchase arrangements and an increase in the percent of equipment owned rather than rented.

13 Although the number of computations performed at the Center is not recorded, according the the Director of the Center, this number has clearly increased dramatically. In particular, as the computer programs handled at the Center became ever more complex (i.e., as the "captured intelligence" in each program grew), each keystroke punched into the computer gave many more commands to the machine.

We should note here that the other side of the phenomenon of the increasing domination of labor costs in computer budgets is the extraordinary boost in labor productivity brought about by computerization. New computer technologies permit users to accomplish much more much faster. For example, a company which once paid a roomful of workers to tabulate year-end accounts can now computerize those operations and retrain the workers to analyze the data the computer puts out, accomplishing far more for the company. At the Princeton University Computer Center the budget for salaries used to be dominated by keypunch personnel; today the staff there is far more skilled and professional.

14 Some industry figures produce results that are less clear-cut. For instance, the Diebold Group/[1982] has studied computer operations

of large U.S. corporations over the ten-year period 1971-1981. Their surveys showed that the average share of computer operations budgets devoted to hardware fell from 35 percent in 1971 to 27 percent in 1981; the share of expenditures on operations personnel (people like keypunchers whose work is most susceptible to automation and productivity increases) fell from 29 percent in 1971 to 18 percent in 1981; while the share of the budget spent on systems development personnel (the "brainpower" employees) remained essentially the same over the ten-year period (25 percent in 1971 and 24 percent in 1981).

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