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Unbalanced Growth Revisited: Asymptotic Stagnancy and New Evidence

By WILLIAM J. BAUMOL, SUE ANNE BATEY BLACKMAN, AND EDWARD N. WOLFF*

Some years ago, Baumol (1967) presented a model of unbalanced growth 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.

I. Manifest Destiny of Relative Costs and Sectoral Inputs

In this paper we show that Baumol's 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 that is a better approximation to the model's stagnant activities. We also introduce a third set of economic activities, that 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 happens to have 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. The model does not predict this, but the trend is not inconsistent with it.

(*ii*) As the model predicts, with these constant output proportions 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.

(*iii*) The service sector happens to contain 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 predominantly by the stagnant subsector of the services rather than the services as a whole.

(*v*) Television broadcasting and electronic 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.

II. Basic Results on Stagnant and Progressive Outputs

Before summarizing the basic propositions to be evaluated empirically, we emphasize two crucial qualifications. First, the model is

*Baumol: Princeton and New York universities; Blackman: Princeton University; Wolff: New York University. We are extremely grateful to the Division of Information Science and Technology of the National Science Foundation, the Exxon Education Foundation, the Fishman-Davidson Center for the Study of the Service Sector, and the C. V. Starr Center for Applied Economics at New York University for support of the research reported here. We also thank David Dollar for his valuable suggestions.

obviously a gross oversimplification. Outputs, firms, and industries do *not* fall into black and white categories of stagnancy and progressivity—they are all shades of gray. Even the most stagnant sectors of the economy have undergone some technological change, varying from one period to another. Second, an activity which is, say, relatively stagnant need not stay so forever. It may be replaced by a more progressive substitute, or it may undergo an outburst of innovation previously thought very unlikely. Thus, there may be radical changes in the time paths predicted by the model. History shows the folly of predicting that some field of endeavor is beyond human inventiveness. 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.

The earlier paper on unbalanced growth provided some basic propositions whose proofs can now be generalized considerably. However, here we merely restate them and a few corollaries:

1) With the passage of time, the cost per unit of a consistently stagnant product (for example, live concerts) will rise monotonically and without limit relative to the cost of a consistently progressive product (for example, watches and clocks).

The reason for this phenomenon, which has been called the cost disease of the stagnant services, is obvious—the growing relative productivity of a more progressive output means that it will use relatively smaller and smaller input quantities per unit of output as time passes.

2) If the output ratio of a stagnant to a progressive product (the number of concerts performed divided by the number of watches produced) happens to remain constant or does not fall, the share of the combined inputs used by the stagnant activity must rise without limit.

This, too, is a tautology, since the progressive output must by definition employ relatively less and less input per unit of output, and the relative decline in its input use must compound with the passage of time.

3) If relative prices correspond to relative unit costs and if the ratio of the stagnant to the progressive output does not fall, then relative expenditure on the stagnant product must rise monotonically with time.

An example will make this clear and suggest the magnitudes that may be involved. Between the 1670's and the 1970's, the output per watchmaker in Geneva is estimated to have risen from about 12 watches to over 1,200 watches per year. Purcell wrote *Dido and Aneas* in the 1680's and today it takes as many person-hours and instruments to perform *live* as it did then. Hence, if the ratio of watches produced to performances of Dido had remained exactly the same, both the relative input quantities devoted to the musical performance and the relative expenditures on the performances must have risen about one-hundredfold.

From all this we conclude:

4) In an economy in which the productivity growth rates of the different sectors are unequal, it is impossible for both the output ratios and the input ratios to remain constant.

III. On Asymptotically Stagnant Activities

We come now to our third type of activity which was not included in the earlier 1967 model. These are the asymptotically stagnant activities like TV broadcasting and data processing that we think of as outstandingly progressive, but whose progressivity, as we will show, carries the seeds of its own destruction.

A pure asymptotically stagnant activity is one that uses in fixed proportions one group of inputs produced by progressive activities and another set of inputs produced by stagnant activities. A prime example is television broadcasting with, roughly, one hour of its progressive component (electronic transmission) required for one hour of its stagnant input (performance or program production). Characteristically, these are "high tech" industries, at the frontier of technical progress.

These activities are noteworthy for their 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 *in-*

evitably give the stagnant inputs an ever-rising share of the total budget of the asymptotically stagnant activity, as a simple matter of arithmetic. For example, if the progressive input's cost is initially 80 percent of the budget and falls 25 percent per year, while the stagnant input is 20 percent of the budget and rises 6 percent per year (these, as we will see, are approximate figures for data processing), a pocket calculator will confirm that in just about ten years the budget proportions *must* be reversed, with the stagnant output now about 80 percent of the total. Third, as the stagnant component *must* come to dominate the activity's budget, its output cost and price must approach those of its stagnant component, and therefore have to rise, 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. This is so because the more spectacularly successful is productivity enhancement in the production of the progressive inputs, the more rapidly they will distinguish themselves as significant components of the asymptotically stagnant activity's budget and, consequently, the more rapidly the relative cost of this activity must begin to rise.

These results can also all be derived via formal mathematics, but this is not the place to do so.

IV. Empirical Evidence from the U.S. Economy

We turn now to our empirical evidence—to test the implications of the basic model of unbalanced growth, and 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 that is inevitably somewhat arbitrary. We base the classification on input and output data for the U.S. economy for 1947–76, 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 the official *National Income and Product Accounts*... (BEA, 1981).[1] The corresponding sectoral productivity concept is gross product originating (*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.[2]

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 new

[1]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.

[2]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.

TABLE 1—AVERAGE ANNUAL RATE OF PRODUCTIVITY GROWTH BY SECTOR, 1947–76[a]

	Measure			
Industry	GPO/L (1)	GDO/L (2)	ρ (3)	λ (4)
1. Agriculture	3.59	4.47	1.56	3.95
2. Mining	2.70	2.76	0.08	1.38
3. Construction	1.66	1.19	−0.34	1.49
4. Manufacturing-Durables	2.52	2.80	0.58	3.08
5. Manufacturing-Nondurables	3.21	3.23	0.41	2.56
6. Transportation and Warehousing	1.74	2.74	0.68	2.42
7. Communication and Broadcasting	5.42	5.50	3.99	5.21
8. Utilities	4.96	4.77	1.53	2.96
9. Trade		2.17	1.09	2.19
a. Wholesale Trade	2.37			
b. Retail Trade	1.99			
10. Finance and Insurance	0.50	0.31	−0.27	0.57
11. Real Estate	2.72	3.10	1.21	4.86
12. General Services	0.93			
a. Hotels, Personal and Repair (except auto)		1.37	−0.31	1.35
b. Business and Professional Services		1.70	0.83	2.30
c. Auto Repair and Services		1.45	−0.84	1.04
d. Movies and Amusements		0.99	−0.56	0.64
e. Medical, Educational and Nonprofit		−0.46	−1.14	−0.19
f. Household Workers		−0.21	−0.21	−0.21
13. Government Enterprises	−0.51	1.10	−0.52	0.99
14. Government Industry	0.31	−0.18	0.08	−0.18
Overall: *GDP*	2.16			
GNP		2.18	1.17	2.18

Sources: Col. 1: BEA, *The National Income and Product Accounts of the United States*, 1929–76 Statistical Tables, September 1981, Tables 6.2 and 6.11. Col. 2: *GDO* for 1947 was obtained from the standard 87-order BEA input-output table for 1947; *GDO* for 1976 was obtained from BLS, *Time-Series Data for Input-Output Industries*, Bulletin 2018, 1979. Cols. 3–4: U.S. input-output data. See fn. 4 for details.
[a]Shown in percent.

estimated rates of sectoral productivity growth differ somewhat from those in column 1, though the rank orders are quite close. The major exception is the construction sector, whose 1.19 percent rate now places it in the stagnant category. The input-output data also permit disaggregation of general services into six subsectors, as shown in Table 1, and evaluation of their degrees of stagnancy. 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 in this group 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) on the one hand, and hotels, personal and repair services (1.37) and auto services (1.45 percent) on the other, placing only the former in the progressive group.

Our third measure of productivity growth rates requires several 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; $k =$ (row) vector of capital stock coefficients; and $p =$ (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; $y = pY = GNP$ at current prices; $L = lX =$ total employment; and $K = kX =$ total capital stock.

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

$$(1) \qquad \rho = (pdY - wdL - rdK)/y,$$

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

$$(2) \quad \rho_j \equiv -\left(\sum_i p_i da_{ij} + wdl_j + rdk_j\right)/p_i.$$

This is the continuous analog of Wassily Leontief's 1953 measure of sectoral technical change.[3]

The U.S. input-output data for 1947 and 1976 were used to estimate this third set of growth rates (col. 3, Table 1).[4] The *TFP* measures were all lower than the corresponding labor productivity measures since capital-labor ratios were increasing. The overall rate of *TFP* growth was 1.17 percent per year, about one point lower than that of labor productivity, and the sectoral rates behaved similarly. Their relative magnitudes were virtually unchanged, except for mining.[5] By this measure, the line between the progressive and stagnant categories was drawn between nondurable manufacturing (0.41 percent), and government industry and the mining sector (both at 0.08 percent).

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. One such total factor requirement measure (reported in col. 4, Table 1) is λ, which shows the total (direct plus indirect) labor requirements per unit of final output:

$$(3) \qquad \lambda = l(I - a)^{-1}.$$

Productivity growth based on λ is quite similar to the figures in column 2, Table 1, since changes in total factor requirements are dominated by those in direct factor requirements.[6] The classification of sectors uses cut-

[3]Also, see William Peterson (1979) and Wolff (forthcoming) 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 Frank Gollop and Dale Jorgensen, 1980, or Wolff, forthcoming).

[4]The 1947 input-output table is the standard 87-order Bureau of Economic Analysis (BEA) version. (See, for example, BEA *Survey of Current Business*, 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 (BLS, 1979a). Estimates of the total capital stock in each input-output sector appear in BLS (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 BEA. Additional details on data sources and methods are available from the authors.

The accounting framework was then modified as follows: 1) An "endogeneous export column" was created to balance the noncompetitive 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 biasing 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 (forthcoming).

[5]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 1947–76 suggests that technical change (or the discovery of new accessible deposits) did occur.

[6]Three other measures were also used. The first, λ_m, differs from col. 4 only in λ's Marxian accounting framework. Capital, as a produced means of production, is valued by its depreciation rate (see Wolff, 1979). The second is ρ^*, the total factor requirement analog of ρ. Let $\gamma = k(I - a)^{-1}$ 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 $p_j^* \equiv -(wd\lambda_j + rd\gamma_j)/p_j$. The third

TABLE 2—SHARE OF EMPLOYMENT AND OUTPUT IN STAGNANT SECTOR, 1947 AND 1976[a]

	Measure			
	GPO/L (1)	GDO/L (2)	ρ (3)	λ (4)
A. Stagnant Sectors:				
2. Mining			×	×
3. Construction		×	×	×
10. Finance and Insurance	×	×	×	×
12. General and Services				
a. Hotels, Personal and Repair (except auto)	×	×	×	×
b. Business and Professional	×			
c. Auto Repair and Service	×	×	×	×
d. Movies and Amusement	×	×	×	×
e. Medical, Educational and Nonprofit	×	×	×	×
f. Household Workers	×	×	×	×
13. Government Enterprises	×	×	×	×
14. Government Industry	×	×	×	×
B. Annual Prod. Growth Rate, 1947–76:				
a. Progressive Sectors (all)	2.94	3.04	1.09	2.92
b. Stagnant Sectors	0.64	0.56	−0.84	0.73
c. Progressive Service Sectors	2.71	2.79	1.63	2.79
d. Overall	2.16	2.18	1.17	2.18
C. Percent of Employed Persons in Stagnant Sectors:				
a. 1947	27.6	30.7	32.4	32.4
b. 1976	41.2	42.0	43.0	43.0
D. Stagnant Sector Share of Final Output (1958 $):				
a. 1947	21.4	31.2	31.5	31.5
b. 1976	21.2	29.2	28.9	28.9
E. Stagnant Sector Share of Final Output (Current $):				
a. 1947	17.9	26.8	27.0	27.0
b. 1976	29.9	38.6	38.1	38.1
F. Stagnant Sector Share of *GDO* (1958 $):				
a. 1947	16.8	21.9	24.2	24.2
b. 1976	16.8	19.8	21.3	21.3
G. Stagnant Sector Share of *GDO* (Current $):				
a. 1947	13.7	18.3	20.4	20.4
b. 1976	22.9	24.5	26.7	26.7
H. Percent of Employed Persons in Progressive Services:[b]				
a. 1947	21.3	23.5	23.5	23.5
b. 1976	22.5	26.7	26.7	26.7

[a] Panels B–H results are shown in percent.
[b] In col. 1, progressive services are defined as communications and broadcasting, trade, and real estate. In cols. 2–4, they include the same three sectors and, in addition, business and professional services.

off points of 2.19 percent for the progressive category and 1.49 percent for the stagnant category, and is identical with that of column 2, except that the mining sector now falls into the stagnant category.

In Table 2, × indicates that a sector is classified as stagnant according to the measure of productivity growth (panel A). The average annual rate of productivity growth for the two aggregated sectors are shown in panel B.[7]

measure uses the rate of change in the (real) relative price of a sector's output to measure its relative rate of productivity growth. All three measures yielded the same classification scheme as shown in cols. 3 and 4 of Tables 1 and 2.

[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.

V. 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 measures of Table 2, the rate of productivity growth of the stagnant sector is from about two to two and one-half percentage points below that of the progressive sector.[8] Independently selected price data show that 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, Table 2). The classification scheme of column 1 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 ten percentage points over the period and, by the first definition, by almost fourteen 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.[9]

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 1947–76 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 force 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 between 32 and 50 percent.[10]

[8]Both sectoral values of ρ are below the overall rate of *TFP* growth. This is correct, because as demonstrated in Peterson, $\rho = \Sigma_i (p_i X_i / y)\rho_i$, the ratio of total *GDO* to total final output (in current dollars) is about 2.0 in both years.

[9]We also found that the share of total capital stock in the stagnant sector declined by about five 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 that can be expected to involve a more rapid displacement of labor by capital.

[10]Some remarkable cross-sectional international comparisons provided by Robert Summers (1985) also offer

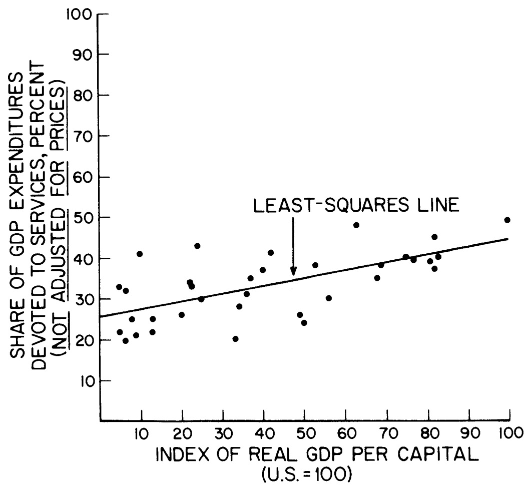

FIGURE F1

at least suggestive support for our model. The services' proportion of total real *GDP* expenditures, and their proportion of total nominal *GDP* expenditures were compared with real *GDP* per capita 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. As Figure F1 reports, at least in 1975, the real share of the services did not increase with a country's real per capita *GDP*, contrary to widespread belief. However, as our model suggests, since the real share of *GDP* devoted to services remained roughly constant among countries, the nominal share devoted to services nevertheless rose markedly with real *GDP* per capita (Figure F2). The results of a regression were completely consistent with these conclusions.

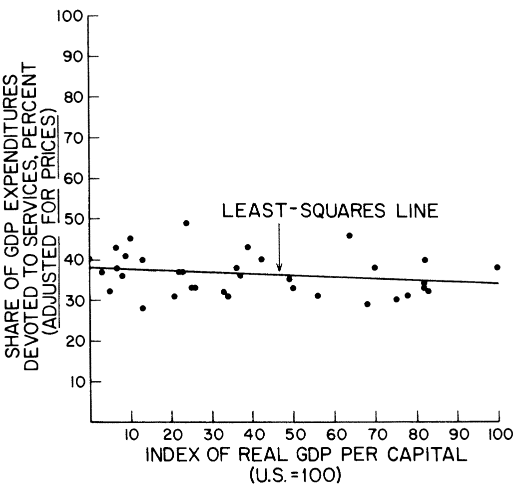

FIGURE F2

VI. Broadcasting, Electronic Computation, and Asymptotic Stagnancy

Our empirical evidence on two asymptotically stagnant activities, television broadcasting and data processing (computer services), shows that in both activities the progressive component's share of total costs diminished continually, while the stagnant component increased both in real terms and as a share of total cost.

A. *Electronic Computation*

In the last twenty years the cost of computer hardware per unit of processing power apparently fell some 25 percent per year (see, for example, W. J. Kubitz, 1980; S. Triebwasser, 1978; R. N. Noyce, 1977; and C. Burns, 1977). Meanwhile, the cost of (labor-intensive) computer software assumed an ever greater share of a computer system's total cost. Software was once a relatively minor element in computing cost—indeed, IBM once gave software away with its machines. Now, it is the hardware that is becoming almost incidental in total computation cost (see T. J. Gordon and T. R. Munson, 1980). By some estimates, software represented only 5 percent of system costs in 1973, had increased to 80 percent by 1978, and exceeded 90 percent by 1980 (see Kubitz; M. Schindler, 1979; and R. A. Minicucci, 1982). P. Grabscheid writes, that by 1985, "it will probably pay to substitute one hour of computer time for six minutes of staff time" (1982, p. 6). Software development remains essentially a handicraft activity, and is, so far, a stagnant service.

Some operating data from the Princeton University Computer Center (Figure 1) substantiate dramatically the growing importance of labor costs in total Center expenditures and the accompanying sharp drop in the dominance of the hardware component.[11] Between 1970 and 1983, total real labor costs at the Center rose at a compound rate of 2.6 per annum, while total real equipment costs fell at an annual rate of 4.6 percent.[12] Since the volume of computations has risen rapidly,

[11]In the three years (1976; 1979; 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.

[12]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, 1971–81. 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 (i.e., 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).

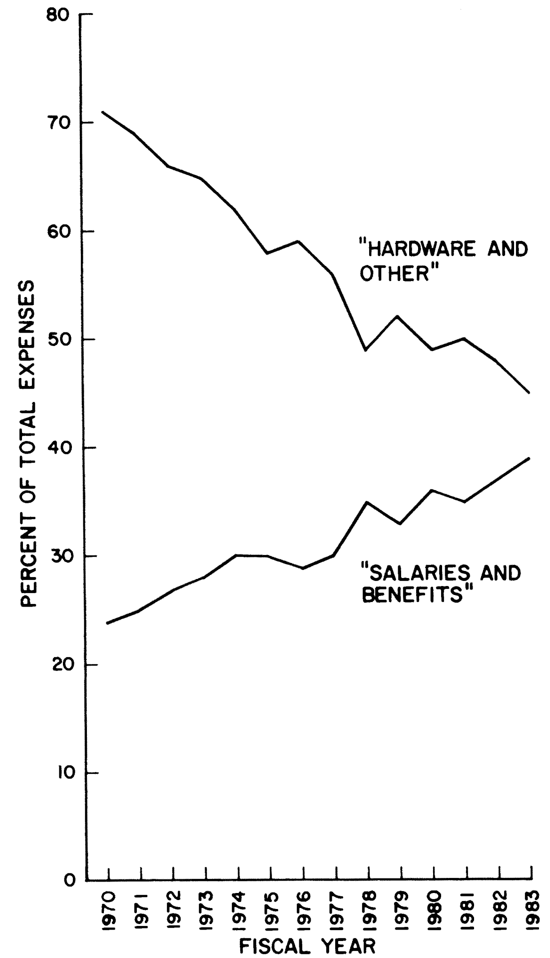

FIGURE 1. LABOR COSTS VS. HARDWARE COSTS AS A PERCENTAGE OF TOTAL COSTS, PRINCETON UNIVERSITY COMPUTER CENTER, 1970–83

Source: 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.

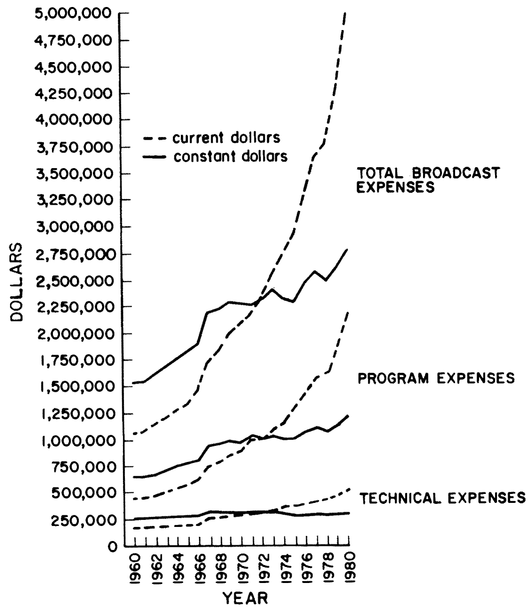

FIGURE 2. BROADCASTING EXPENSES PER AVERAGE TELEVISION STATION[a]

[a]Shown in current and constant dollars. Data exclude the three major networks, but include network owned and operated television stations.

Sources: U.S. Federal Communications Commission, *Annual Report*, various years, and "Television Financial Data 1980, FCC Financial Figures," August 10, 1981, No. 6, Vol. 101, p. 54. Source for price deflator is *Survey of Current Business*, various years.

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

[13]Although the number of computations performed at the Center is not recorded, according to 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 increase in labor productivity brought about by computerization. Computer technology permits users to accomplish much more much faster. For example, a company that 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. 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. The data processing industry is seeking ways to enhance further the productivity of its personnel, for example, by finding ways to substitute hardware time for costly staff time and by 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.

TABLE 3—TECHNICAL AND PROGRAM EXPENSES AS A PERCENTAGE OF TOTAL TELEVISION BROADCASTING EXPENSES, 1960–80

Year	Total Broadcast Expenses (all TV stations,[a] in millions of dollars)	Technical Expenses (mil. of $)	Technical Expenses as Percent of Total	Program Expenses (mil. of $)	Program Expenses as Percent of Total
1960	563.3	92.9	16.5	239.1	42.4
1961	579.5	96.2	16.6	245.2	42.3
1962	626.6	101.3	16.1	265.4	42.3
1963	674.5	106.3	15.8	290.5	43.1
1964	725.4	113.8	15.7	315.1	43.4
1965	787.7	120.2	15.3	338.8	43.0
1966	885.0	131.1	14.8	380.1	43.0
1967	948.3	141.4	14.9	409.2	43.2
1968	1040.1	151.5	14.6	449.2	43.2
1969	1176.4	161.4	13.7	504.9	42.9
1970	1245.2	170.6	13.7	534.7	43.0
1971	1303.7	179.6	13.8	599.2	46.0
1972	1457.6	196.5	13.5	628.6	43.0
1973	1577.9	210.5	13.3	677.9	43.0
1974	1706.7	228.3	13.4	733.7	43.0
1975	1830.0	229.6	12.5	805.3	44.0
1976	2108.1	256.7	12.2	912.3	43.3
1977	2297.1	270.3	11.8	995.1	43.3
1978	2705.4	318.4	11.8	1162.5	43.0
1979	3100.6	346.3	11.2	1343.6	43.3
1980	3614.6	390.0	10.8	1588.3	43.9

Source: U.S. Federal Communications Commission, *Annual Report*, various years.
Notes: Technical expenses include payroll and other technical expenses such as circuit costs incurred in delivering programs to local stations. Program expenses include "talent" employees, other employees, rent and amortization of film and tape, records and transcripts, 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 affiliates(s), and other general and administrative expenses). These descriptions are taken from "Television Financial Data 1980, FCC Financial Figures," *Broadcasting*, August 10, 1981, Vol. 101, No. 6.
[a]Does not include the three major television networks but does include network owned and operated television stations.

B. *Television Broadcasting*

Television broadcasting also has progressive and stagnant components, such as transmission, which includes circuit costs, and programming, dominated by human labor. Here, too, the evidence on trends in costs, and trends in cost shares, is striking. Figure 2, using U.S. Federal Communications Commission data, shows the steep rise in average expenses of TV stations between 1960 and 1980 (in both current and constant dollars), and portrays the 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. In Table 3 we see 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.

VI. 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 (their prices rose at about the same rate as their productivity lagged 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 more of the economy than was previously thought.

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