

UNBALANCED GROWTH REDUX: SECTORAL PRODUCTIVITY AND CAPITAL MARKETS

Franklin Allen, Gerald R. Faulhaber, and A. Craig MacKinlay*

Abstract

The relatively poor measured productivity growth of services has led to concern that the growth of the service sector has caused the decline of aggregate U.S. productivity growth. Many authors have noted the difficulties in directly measuring services productivity. In this paper, we develop a highly simplified general equilibrium model linking economic productivity growth with capital market performance. We find that the conventional view that services have lagged in productivity is not supported by empirical results based upon capital market data.

* Associate Professor, Associate Professor, and Assistant Professor, respectively; The Wharton School, University of Pennsylvania. The authors would like to thank Martin N. Baily, William J. Baumol, Victor R. Fuchs, Zvi Griliches, Glen Hubbard, Lawrence R. Klein, William D. Nordhaus, Robert A. Pollak, Jiang Wang, and members of the NBER Productivity Program for their comments, critiques, and suggestions. The Fishman-Davidson Center for the Study of the Service Sector provided financial support. The first author is grateful to the NSF for financial support (Grant No. SES-8813719).

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I. Introduction

In his seminal article "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis" (1967), William Baumol used a highly simplified, stylized model to explain a powerful idea: in an economy in which one sector (say, manufacturing) realizes higher productivity growth than its complement (say, services), the less productive sector eventually dominates the economy in terms of employment and of dollar value. As the wage rate is pushed up by productivity increases in the "progressive" sector (as Baumol calls it in later work), output in the "stagnant" sector becomes more expensive. The paradoxical result is that the sector which appears to be the more robust may be growing not because of an increase in true output, but rather an increase in the price of that output, the net result of which is to reduce the economy's overall rate of productivity growth.

In later work, Baumol, Blackman, and Wolff (1985) found that Baumol's earlier characterization of services as the stagnant sector required modification. Some industries within services have shown very great measured productivity growth, such as telecommunications. In addition, they identified other industries, such as computational services, as "asymptotically stagnant." In these industries, stagnant inputs (programmers) eventually outweigh the progressive inputs (microchips), and dominate their costs. They also calculated rates of productivity growth based on BEA data, which they found to

confirm the modified hypothesis that labor had shifted to stagnant services but not progressive services.

This powerful idea has entered the mainstream of not only economic thought but of public policy discourse as well. A number of recent policy commentators (see, for example, Bluestone and Harrison (1982)) suggest that a national economy cannot be based on services, and that the growing size of the service sector is a sign of national weakness and decline. Somewhat unfairly, many take the unbalanced growth model as the intellectual underpinning of this view.

The power of the idea comes not only from the intuitive plausibility of the model but both the seemingly hard data and the familiarizing metaphors that support it. Baumol's examples, such as a "half hour horn quintet calls for the expenditure of 2 1/2 man hours in its performance..." (Baumol (1967)) and "Purcell wrote Dido and Aeneas in the 1680's and today it takes as many person-hours and instruments to perform live as it did then" (Baumol, Blackman, and Wolff (1985)), are quite compelling. Further, they are supported by productivity calculations based on the National Income Accounts which indicate that many industries in the service sector have indeed lagged substantially in productivity growth.

However, the "hard" productivity data have been suspect for some time. Many authors have surveyed a variety of theoretical and empirical problems related to the measurement of productivity, particularly in services (Kendrick (1977) and (1985); Kendrick and Vaccara (1980); Griliches (1987); and Siniscalco (1988)). A thorough review of these problems is beyond the scope of this paper, but suffice it to say that (i) the more serious problems center on the measurement of services' outputs, and (ii) there is some agreement (by no

means universal) that measurement error tends in the direction of underestimating services output and therefore of underestimating their productivity growth.

In general, the two methods used to measure service outputs are (i) deflating industry sales using a price index, and (ii) extrapolating from a base year measure using a related indicator (often an input measure, such as employment). The deflation method, even at its best, fails to account for changes which improve the benefits received by consumers of the service in question (higher quality, more customization to individual need, more product choice, etc.), and price changes which reflect such quality changes are apt to be attributed to inflation in that particular industry. At its worst, the deflation method is often based on price indices that represent only a subset of services in the industry, or even indices in related industries.

The accuracy of the extrapolation method depends upon (a) the appropriateness of the quantity measure for the base year, and (b) the indicator used to extrapolate from base year to base year. In the first case, quantity measures are often chosen on the basis of data availability, not any direct measure of consumer utility for that measure. Health care output, for example, may be measured by doctor's visits, or hospital beds occupied (which can be measured), rather than by improved health and quality of life (which cannot be measured, but is likely to be what consumers of health services care about). It is not unreasonable to expect that improvements in medical technology increased (at least weakly) the value in health-giving to consumers of each doctor's visit; yet this improvement would not be measured if "doctor visits" were the unit of output used for base year calculations.

Even more suspect is the use of indicators to extrapolate from a base year quantity measure. Kendrick's (1985) survey showed that for those service industries whose output was measured by the extrapolation technique, 70 percent (in value terms) used indicators based on labor input. Since productivity growth is measured as the change in outputs divided by inputs, it is clear that this approach will by definition yield zero productivity growth!

This rather stark characterization of output and productivity measurement problems does not mean that these techniques are not the best available direct methods. They are the result of long-standing, diligent and continuing efforts of many economists and statisticians working in Central Statistical Organizations to overcome these problems. But the very size and duration of these efforts suggest that the problems are difficult ones. It also suggests that public policy conclusions and welfare results based on the allegedly low productivity growth rates of certain service industries may be questionable.

An example may help illustrate these points. Baumol, Blackman and Wolff (1985, pp. 813-814) cite electronic computation as an example of an "asymptotically stagnant" industry, in which hardware, the progressive input, is falling rapidly as a fraction of total expenses of, e.g., the Princeton Computer Center, while computer programming (measured by a salary proxy), the stagnant input, is rising rapidly. This view of software production as stagnant would seem to be borne out by the conventional wisdom in the computer field that the number of lines of "debugged" code produced in a day by a good computer programmer has remained constant since the 1950's. What this wisdom leaves out (but is alluded to in Baumol, Blackman and Wolff) is that the number of computations per line of code has increased dramatically. In the 1950's, a line of code produced one executable computer instruction. By the

1960's, the use of compilers (FORTRAN, PL/1) had increased this by an order of magnitude. In the 1980's, the use of fourth generation languages (e.g., RAMIS) and spreadsheet programs (e.g., LOTUS 1-2-3) have increased the number of computations per line of code by another order of magnitude. Would the deflation method have picked up this productivity increase? As long as the market for programmer services were competitive, prices for software projects would rise only as fast as costs, so that productivity growth would appear quite low. Would the quantity extrapolation method have picked up the productivity increase? Since lines of code per programmer-day is an easily-measured quantity index, it would most likely be used to establish a base year quantity, and thus miss the crucial improvement of computations per line of code¹. We focus attention on the output of services that produces benefit for consumers (such as computations), rather than a proxy output indicator more easily measured (such as lines of code) or even worse an input (such as programmer-days). Once we focus on benefits as well as costs, we cannot rule out the possibility that service industries otherwise thought to be stagnant may in fact be improving their productivity without limit².

Baumol's examples of stagnant activities, such as horn quintets, suggest that the labor intensity of such activities makes them peculiarly resistant to productivity improvement. Our example of compiler-writing programmers suggests quite the opposite. Which of these examples better characterizes individual service industries is, of course, an empirical issue.

Is improving the quality of products and services really a productivity gain? Baumol and Wolff (1988) have suggested that for some purposes, "crude" productivity (that is, not adjusted for quality) is exactly what is called for. They give the example of planning the number of classrooms to build for

training musicians (an industry with low crude productivity growth) vs. the number for video game assemblers (an industry with high crude productivity growth); they argue that the appropriate measure for this purpose is crude productivity, not quality-adjusted productivity³. However, from a welfare perspective, both quality and quantity must be part of the productivity picture.

Taking this one step further, Fuchs (1968) argues persuasively that in the long run, the welfare changes in a post-industrial economy are only poorly measured by counting outputs. It is health, education, and quality of life that should be our concern, not the number of video games or even concerts. We are sympathetic with this view; our basic approach is to focus on difficult-to-measure quality as opposed to easy-to-measure quantity. We attempt to move in the direction of accommodating Fuchs' view that quality of life (and services) is the important issue, without abandoning measurement altogether.

A related literature has looked quite closely at differences in services among countries (rather than over time), and noted that services in developed countries tend to be more expensive than in developing countries (see, for example, Kravis, Heston and Summers (1978) for a definitive analysis). This has been attributed by some to differential productivity among countries, a position first advanced by Balassa (1964) and Samuelson (1964). Alternate hypotheses have been advanced; see Bhagwati (1987). The work of Summers (1985) suggests that when properly adjusted for quality changes and price effects, the share of services in national output tends to be the same among countries (rather than constituting a larger share in developed countries, as was previously thought). The time series analog of this cross-sectional

result is essentially Baumol's observation: "true" output of services has not grown; it's increasing (relative to goods) price simply make its share of measured GNP appear to be growing. However, there is no reason to suspect that the cross-sectional data of international comparisons are relevant to the time-series problem of intertemporal comparison. In fact, differential productivity over time (as new knowledge becomes available) seems more plausible than differences in productivity among countries at the same point in time; after all, it is far easier to borrow technical innovations from other countries than it is to borrow such innovations from the future!

What can be said about the growth of the service sector and its implications for the economic health of the nation without relying on direct measurement of sectoral productivity growth? In this paper, we attempt merely to point the way to a new direction of research. We first present new data which show that the long-run stock market performance of the service sector has been better than that of the manufacturing sector. In the spirit of Baumol's original article (1967), we then present a quite stylized two-sector macroeconomic model whose empirical implications are consistent with the data, and further implies that the actual, as opposed to measured, productivity growth in services may have outstripped that in manufacturing over the last twenty-five years.

We have recently constructed an index of service sector stock prices, which measures the total return (dividends plus capital gains) of the stock of every service firm traded on the New York Stock Exchange, the American Stock Exchange, and the NASDAQ market, from 1963 to 1987. We describe below the details of this index; the salient result that emerges from this historical analysis is that a \$1.00 investment in the service index in 1963 would have

been worth \$14.27 at the end of 1987, whereas a \$1.00 investment in the Standard & Poor's 500 index would have been worth \$10.57. This capital market performance is difficult to reconcile with the conventional view that services have been poor economic performers relative to goods.

This disparity of rates of return could be interpreted by some as evidence that stock markets are not efficient and therefore do not reflect information about the profitability of traded firms. The difficulty of explaining, say, the crash of October 19, 1987 using the efficient market hypothesis could suggest that stock markets are too noisy to be useful as economic indicators. However, unless stock markets are pure noise, the appropriate remedy is to increase the sample size. The fact that the service sector index, consisting of several thousand firms, outperformed the market over a twenty-five-year period suggests it is unlikely to be a market fad, random noise, or "bubble." One need not be a strict adherent of stock market efficiency to be persuaded that such a broadly-based financial market performance reflects economic performance of the service sector as a whole equal or superior to that of manufacturing.

How does this empirical result relate to the productivity debate? In reality, productivity growth occurs as a result of product or process innovation, capital deepening, or the achievement of scale economies. In perfectly competitive markets, any potential profits from, say, innovation are competed away, and show up as lower prices and/or greater benefits to consumers. More realistically, innovation may lead to greater profits, because few markets are perfectly competitive. In practice, therefore, we would expect that firms that are consistently successful innovators would, ceteris paribus, have consistently better profit performance. And over the long run, we would

expect that such firms would have consistently better stock market performance⁴.

While economists may have difficulty measuring incremental benefits and costs of innovations, consumers have no such difficulty: they know their own preferences and are willing to pay for new or improved products. This willingness to respond positively to all forms of innovation, whether measurable by economists or not, translates into superior profit performance by innovative firms. In the long run, this superior economic performance by those firms which most improve total productivity (benefits and cost) is reflected in superior performance in capital markets.

The logic of our argument should now be clear; if productivity improvement cannot be measured directly, we must look for its tracks in market behavior elsewhere in the economy. We argue that those sectors in which actual productivity improvement (directly measurable as well as not directly measurable) is greatest will, ceteris paribus, have the best profit performance and the best stock market performance. Hence, we should see the evidence of actual productivity improvement in capital markets, and the evidence we do see suggests that the service sector has outperformed the economy as a whole, contrary to the evidence of direct measurement.

In Section II, we discuss the development of the service sector stock price index and derive the rates of return, both raw and risk-adjusted, for the service sector index as well as the market as a whole. In Section III, we construct a highly simplified two-sector macro model, in the spirit of Baumol's (1967) original model, that is consistent with the "stylized facts" above and in which services productivity grows faster than manufacturing productivity. In Section IV, we evaluate the empirical implications of the

model. In Section V, we present the conclusions of this exercise, and suggest directions for future research.

II. The Empirical Evidence.

We use stock return data provided by the Center for Research in Security Price (CRSP) of the University of Chicago to construct indices of return for fifteen industry groups of the service sector, as well as an overall index of returns for the service sector as a whole. The groups are:

1. Utilities
2. Financial services
3. Insurance
4. Consumer services
5. Business services
6. Real estate
7. Airlines
8. Surface transportation
9. Wholesale Trade
10. Retail Trade
11. Lodging
12. Professional services

13. Health care
14. Telecommunications
15. Broadcasting and entertainment.

Firms are placed in an industry group on the basis of their SIC code. Large holding companies (two-digit SIC code 67) are assigned to groups on the basis of their major line of business.

Monthly total return (appreciation plus dividends) of the stock of each firm in the index is calculated, and the return of each firm is weighted using the beginning-of-month market value of equity to determine the return index of its industry group. The aggregate index is constructed using all fifteen groups, with each group's return weighted by its 1985 contribution to GNP. Using GNP weighting ensures that industries such as utilities with heavy capital market needs are not overrepresented in the index compared to industries such as health care and professional services which draw less heavily on the capital markets, but make up a significant fraction of GNP.

The time period considered is January 1963 to December 1987. The data set includes all firms listed on the New York Stock Exchange, the American Stock Exchange, and the NASDAQ market (for which the data covers January 1973 to December 1987). For each month, a firm is included if complete return and shares outstanding data are available in the database, in order to minimize survivor bias.

Summary data for the industry groups and the aggregate index is presented in Table 1. For comparison, we include the data for the Standard & Poor's 500 Index, a broad-based index often used as a measure of overall market

performance, as well as the Consumer Price Index (CPI) (included as a benchmark to gauge the real rates of return associated with each index). For each index, mean annual return, the standard deviation of return, the capital asset pricing model (CAPM) beta (β), and the CAPM alpha (α). The raw return data say little about the performance of an index vs. the S&P 500, since a riskier index must on average do better to compensate investors for its risk. The CAPM α is a risk-adjusted measure of performance, using the S&P 500 as a benchmark.

In Figure 1, we plot the services index, 1963 to 1987, against the S&P 500 index, as well as the CPI, all normalized to unity on January 1, 1963. The value of the services index on December 31, 1987 is 14.27 compared to the value of the (normalized) S&P 500 of 10.57.

Generally, the results suggest that services overall certainly do no worse than the market, and probably outperform it. The aggregate services index annualized CAPM α is 1.38 percent, indicating that this index did marginally better (risk-adjusted) than the market as a whole (though the difference is not statistically significant). Of the fifteen industry groups, all but one (financial services) outperformed the S&P 500 index (that is, the group's CAPM α is positive). In fact, four groups -- consumer services, professional services, health care, and broadcast & entertainment -- had CAPM α 's in excess of 4 percent: economically if not statistically significant. On average, the service sector tends to be riskier than the market as a whole; the aggregate service index β is 1.15, compared to an overall market β of 1.00.

Overall, we cannot conclude that services have done substantially better than the market, although the data support the conclusion that services have marginally outperformed the S&P 500 on a risk-adjusted basis. This conclusion

is further supported by the finding that all but one of the industry groups individually outperformed the S&P 500 on a risk-adjusted basis. The data appear to refute the implications of the conventional view that services have been productivity laggards. To the extent that stock market performance reflects economic performance, services have been leaders.

III. The Model.

We consider a continuous-time economy with L identical workers/consumers/stockholders, two sectors (say, stagnant and progressive), and no capital stock (or other means to store output), as in Baumol (1967). Each worker offers his labor at a wage rate w per unit time, the same in both sectors. Each consumer has the same instantaneous utility function over the actual outputs of each sector. Each stockholder is endowed with a completely diversified portfolio of stocks across both sectors, and holds certain beliefs regarding the growth rates in the various sectors.

Each sector exhibits constant returns to scale in production. Productivity in each sector is growing (at least weakly), although at different rates, so that the constant marginal costs of production in each sector are (weakly) declining, but possibly at different rates. Each sector is imperfectly competitive, which we model as a symmetrical n -firm Cournot oligopoly, ($n \geq 1$). All firm profits are paid out in dividends to stockholders, whose total income consists of wages plus dividends, and is identical for all agents. Financial markets are perfectly competitive. To the extent that the profits of firms in the two sectors grow at different rates, investors are imperfectly informed about these growth rates, learning about them over time. The output of each sector is used only for final consumption in this model. We therefore do not capture the use of goods inputs to enhance services

productivity, or vice-versa, which is likely to be an important aspect of the real economy⁵.

As can be seen, the model follows Baumol (1967), differing in the following respects:

- we explicitly include consumer utility in our model; our approach is more general in that it includes Baumol's implicit formulation in his Propositions 2 and 3 as special cases;
- product markets are assumed to be imperfectly competitive, to permit a role for profits and a stock market;
- the stock market, while competitive, does not reflect full information; investors are learning over time. This assumption is essential if significant differences in ex post risk-adjusted rates of return between sectors are to be explained.

We start the analysis from the consumption side. There are two consumption goods: P is produced by the progressive sector and S by the stagnant sector. At time t, each consumer chooses the consumption bundle and the amount of labor offered to maximize the (indirect) utility function which we assume to be

$$V(p_P, p_S, w, D) = \frac{1}{\epsilon - 1} \sum_{P, S} a_i (p_i / w)^{1 - \epsilon} + D/w \quad (1)$$

where p_P , p_S are the prices of the goods produced by sectors P and S respectively, w is the wage rate per unit time, a_i and ϵ are positive

constants, and D is the lump-sum dividend income from endowed stockholdings. Since there are no inventories, time t income is consumed at time t .

The choice of the utility function is simply analytic ease; it leads to constant price elasticity demand functions, which greatly simplify the Cournot equilibrium price results. We do not argue for its empirical realism, but simply that it is representative⁶.

Note that the prices p_i are what consumers pay for the benefit (utility) that the good produces. For example, if there were an increase in the quality of one of the goods that doubled consumers' benefit with no change in nominal price, we would view that as reducing the real price of the good by one-half.

The resulting product demand functions are isoelastic:

$$X_i = a_i p_i^{-\epsilon} w^\epsilon L \quad (2)$$

where, again, the good is denominated in benefit (utility) terms.

Note that the implicit hypotheses of Baumol (1967) are special cases of this formulation. In his Proposition 2, elasticity is unity⁷, which leads to constant GNP shares; in his Proposition 3, elasticity is zero, leading to constant output shares.

It is convenient to use the inverse demand function

$$p_i = X_i^{-1/\epsilon} w [a_i L]^{1/\epsilon} \quad (3)$$

From (1), the labor supply function is

$$1 = L \cdot [\sum a_i (p_i/w)^{1-\epsilon} - D/w] \quad (4)$$

Turning now to firm behavior, in each sector we have n symmetric firms, $k = 1, \dots, n$, which behave as a symmetric Cournot oligopoly, each of which faces constant marginal cost c_i . It can be shown that with the demand functions of (3) and that output in sector i (using "*" to denote equilibrium value) is

$$X_i^* = \left[\frac{c_i}{(1-1/n\epsilon)} \right]^{-\epsilon} w^\epsilon a_i L . \quad (5)$$

A necessary condition for the existence of a Cournot equilibrium is that $n\epsilon > 1$.

At the profit-maximizing Cournot quantities X_i^* , prices are

$$p_i^* = \frac{c_i}{1 - 1/n\epsilon} , \quad (6)$$

and firm profits are

$$\pi_{ik}^* = c_i^{1-\epsilon} \frac{w^\epsilon a_i L}{n} \left[\frac{1}{n\epsilon-1} \right] \left[1 - \frac{1}{n\epsilon} \right]^\epsilon . \quad (7)$$

It is useful to define a special parameter for the product of the last two terms,

$$K = \left[\frac{1}{n\epsilon - 1} \right] \left[1 - \frac{1}{n\epsilon} \right]^\epsilon , \quad (8)$$

which is a measure of firms' (short-run) profitability. We may use it in expressing total sectoral profits:

$$\pi_i^* = K c_i^{1-\epsilon} w^\epsilon a_i L . \quad (9)$$

Labor demanded in sector i is

$$l_i^* = c_i X_i^* = c_i^{1-\epsilon} w^\epsilon a_i L (1 - 1/n\epsilon)^\epsilon . \quad (10)$$

The equilibrium value of the variables above are determined from individual firm and consumer maximization and the clearing of product markets. In addition, (a) dividend income must equal total dividend payments, and (b) the labor market must clear. We use the first condition to determine D^* , the dividend rate, and the second condition to determine w^* , the wage rate, which lead to:

$$D^* = K(\epsilon - 1) \cdot \sum a_i w^\epsilon c_i^{1-\epsilon} \quad (11)$$

and

$$w^* = 1 , \quad (12)$$

so that labor is the numeraire. Equations (5), (6), (9), (10), (11), and (12) define the equilibrium.

We now introduce time explicitly into the model. We assume that the rate of household growth is γ per unit time, and that productivity in sector i is growing at the rate of θ_i per unit time. Productivity improvements can be either increases in the benefits the product delivers to consumers, decreases in the costs to produce those benefits, or (most likely) both simultaneously. Since we view output in benefit (utility) terms, productivity growth is modeled as a rate of reduction in the cost incurred in producing a given level of consumer benefit, either as a direct reduction of production costs, as an increase in the benefit consumers receive, or both.

Since the progressive sector has faster productivity growth than the stagnant sector by definition, $\theta_p > \theta_s$. Household growth and sectoral unit costs behave as

$$L(t) = Le^{\gamma t} , \tag{13a}$$

$$c_i(t) = \bar{c}_i e^{-\theta_i t} . \tag{13b}$$

As several of the parameters of the model are a function of time, all endogenous variables are also functions of time. For example, substituting $c_i(t)$ from (13b) into sector i 's labor requirements (equation (10)), relative sectoral growth in employment is seen to be:

$$\begin{bmatrix} \dot{l}_P^* \\ \dot{l}_S^* \end{bmatrix} = \dot{l}_P - \dot{l}_S = (\theta_P - \theta_S)(\epsilon - 1) . \quad (14)$$

Whether or not growth in employment is greater in high productivity growth industries or in low productivity growth industries can be seen to depend upon the elasticity of demand in the product markets. For $\epsilon < 1$, the stagnant sector will have the greater employment growth; this is the case considered by Baumol (1967). In the other case, $\epsilon > 1$, the progressive sector will experience greater employment growth. This case is consistent with Kendrick's (1961) evidence that long-term employment growth in industries with high productivity growth is faster than in those with low productivity growth⁸.

In addition, declining unit costs also affects the behavior of firms' profits over time. Substituting from (13b) and (12) into (7), it can be seen that equilibrium firm profits as a function of time are

$$\pi_{ik}^*(t) = \frac{K(\epsilon-1)L(t)}{n} \cdot c_i^{1-\epsilon} = \frac{K(\epsilon-1)}{n} \bar{c}_i e^{[\gamma + \theta_i(\epsilon-1)]t} . \quad (15)$$

In the noiseless world implicit in the model, the rate of growth of profits may differ among firms, but risk-adjusted rates of return on stocks will be identical across all firms in equilibrium. Any differences in growth rates of profits are capitalized in the stock value at start-up. Therefore, if differences in long-run rates of return are observed, it must be due to investors' revising their conditional expectations as information is revealed over time. At each time t , investors can observe the actual profits of each

firm, given by (15). Since year-to-year profits are noisy, it may take some time for investors to discern the signal (θ_i) from the accompanying noise. We capture the effects of this learning by using the full-information equivalent rate θ'_i , defined to be the rate which yields the observed stock value when applied in the net present value formula:

$$\begin{aligned}
 W_{ik}(t) &= \int_0^{\infty} \pi_{ik}^*(t) e^{[\gamma + (\theta'_i(\epsilon - 1))\tau]} e^{-r_i\tau} d\tau \\
 &= \frac{K(\epsilon - 1)}{n} \bar{c}_i \frac{e^{[\gamma + \theta'_i(\epsilon - 1)]t}}{r_i - [\gamma + \theta'_i(\epsilon - 1)]} \quad . \quad (16)
 \end{aligned}$$

Thus, the rate θ'_i is the full-information equivalent of investors' conditional expectations about firms in sector i , as revealed by the stock price. The discount rate r_i adjusts for sector-specific risk, and the θ'_i 's allow learning to differ between sectors. The value of the entire sector is $W_i(t) = nW_{ik}(t)$, by symmetry.

Equation (16) provides evidence, within the context of the model, of the sign of $\epsilon - 1$; stock values grow faster than the population if and only if $\epsilon > 1$. In Section II, we found that the aggregate stock market values rose in real terms at a rate in excess of 5 percent, which is significantly greater than the U.S. population growth rate. Therefore, this suggests that $\epsilon > 1$.

We follow the usual practice of calculating the stock price index assuming that all dividends are reinvested in the index. This is counterfactual, in that the model assumes dividends are consumed instantaneously. If, however, a

marginal investor had m_0 shares at time 0, continuous dividend reinvestment in sector i would yield $m_i(t)$ shares at time t , where

$$m_i(t) = m_0 e^{\{r_i - [\gamma + \theta'_i(\epsilon - 1)]\}t} \quad , \quad (17)$$

and so the value of the index at t relative to $t = 0$ is

$$I_i(t) = \frac{n_i(t)W_i(t)}{n_0W_i(0)} = e^{[r_i + (\theta_i - \theta'_i)(\epsilon - 1)]t}$$

$$\dot{I}_i = r_i + (\theta_i - \theta'_i)(\epsilon - 1) \quad . \quad (18)$$

In a full-information model, $\theta'_i = \theta_i$ and each sectoral index grows at its risk-adjusted rate r_i . However, with learning ($\theta'_i \neq \theta_i$), the indices for the different sectors grow at rates different from their risk-adjusted rates. Their relative growth rate is

$$\left[\frac{\dot{I}_P}{I_S} \right] = \dot{I}_P - \dot{I}_S = r_P - r_S + [(\theta_P - \theta'_P) - (\theta_S - \theta'_S)](\epsilon - 1) \quad . \quad (19)$$

IV. Empirical Implications of the Model

We turn now to an examination of the empirical implications of the model in light of the data reported in Section II.

The first and most striking implication of the model emerges from considering equations (14) and (16). Equation (16) and the evidence of Section II are

consistent with the elasticity of demand in the product markets being greater than unity. From (14), it is clear that the sector, progressive or stagnant, which has the higher rate of employment growth depends critically upon this demand elasticity. For $\epsilon > 1$, this equation implies that the rate of increase of employment in the progressive sector is greater than that in the stagnant sector. Of course, the fraction of labor in the service sector in the U.S. economy has been growing for some decades, which is consistent with services being the more productive sector. This is in sharp contrast to earlier work, discussed above, which concludes that services are the less productive sector.

This surprising result suggests a need to determine if other empirical implications of the model are borne out by the data. Equation (18) together with data from Section II can be used to estimate the relation between θ_i and θ'_i . For $\epsilon > 1$, the data suggest that during the study period, investors underestimated the productivity growth of the service sector ($\theta'_{\text{services}} < \theta_{\text{services}}$) and overestimated the productivity growth of the manufacturing sector ($\theta'_{\text{goods}} > \theta_{\text{goods}}$). This result, together with $\epsilon > 1$, can be used in equation (19) to show that the absolute growth rate of the service index is greater in risk-adjusted terms than the absolute growth rate of the manufacturing index. This is consistent with our findings of Section II.

V. Conclusions.

The model presented in this paper includes that of Baumol's (1967) paper ($\epsilon \leq 1$), but also permits demand elasticities greater than unity, which is consistent with equation (16) and the stock market evidence of Section II. For $\epsilon > 1$, it is the progressive sector for which employment grows more quickly, rather than Baumol's conclusion that employment in the stagnant sector may grow faster. The "stylized fact" upon which the Baumol result

depends is that direct measurement suggests that productivity growth in some services is less than that for goods. Many authors have questioned the validity of these direct measurements, thus implicitly calling into question the earlier result. There is perhaps more style than fact in the assertion of lower productivity growth in the service sector as a whole.

We put aside the evidence of direct productivity measurement, and draw instead on a new set of facts, regarding the long-term performance of each sector in the stock market. We argue that the total productivity growth of a sector, including that portion not amenable to direct measurement, can be captured in the sector's long-run profit and capital market performance. We find that this evidence is consistent with services having greater productivity growth than manufacturing, as shown in Section IV. It suggests the possibility that the unmeasured product improvements in, e.g., software, financial services, etc. have been greater than the well-measured (and well-publicized) process improvements in manufacturing. Capital market data would appear to have a role to play in the measurement of productivity.

It should also be noted that direct measures differ from indirect capital market measures in that the former examines past productivity while the latter reflects investors' expectations of future productivity as well as present performance. At any point in time, these two may differ significantly; over the long term, such as the twenty-five years of our sample, this difference is likely to be small.

It might be argued that at any moment, the performance of a firm's stock is only loosely tied to its profit prospects and therefore its own specific productivity-enhancing activities. However, the performance over twenty-five years of an index consisting of every service firm listed on the major

American exchanges is not subject to the vagaries of random shocks, information asymmetries, etc., that might affect an individual stock at a particular moment. Therefore, we can expect that the long-term productivity effects that broadly affect each sector will be reflected in the index. The conventional view of low productivity growth of services implies that the service index must be relatively poor. Instead, we find its performance to be strong, suggesting that growth in the productivity of services has at least kept pace with that of manufacturing.

We note that highly simplified models such as this (and Baumol's) ignore a number of factors which in reality may be quite important, in order to illustrate a basic idea. Such models cannot be used as a foundation for policy unless and until more serious empirical research tests such models against alternative explanations of the phenomena observed. Our model is open to several alternative explanations regarding the performance of service sector stock returns relative to the market: (i) over the sample period, industry structure has changed, so that manufacturing is now more competitive and hence less profitable. (ii) Capital markets are so noisy that little information about the real economy is revealed in stock prices, so that this result may simply be a "lucky draw."

On the face of it, we find neither of these arguments compelling. While there is no doubt that the U.S. manufacturing sector has faced increasing competition, principally from foreign firms, service sector firms have also been subject to increasing competition as a result of (a) deregulation (in airlines, telecommunications and surface transportation), and (b) entry of foreign competitors (especially in financial services). It is not clear that manufacturing firms have been harmed more than service firms by these trends.

The conjecture that capital markets are "mostly noise" is compelling for inferences about a small group of firms over a short period of time; but data on many thousands of firms over a twenty-five year period can smooth out a great deal of noise, leaving only the underlying economic signal.

Nevertheless, the issue is ultimately an empirical one. Our analysis suggests that (i) the thorny problem of direct measurement of output and productivity can be finessed; (ii) capital markets can be a source of information for use in calculating indirect productivity measures; and (iii) services may well have experienced productivity growth exceeding that in manufacturing, despite the evidence from direct measurements. Our work is certainly not conclusive; it simply points the way to further, more serious empirical analysis that undertakes to examine this challenging hypothesis.

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- - NOTES - -

1. Even number of computations per line of code is an oversimplification of actual software productivity. Perhaps even more important is the fact that certain computer programs greatly increase the productivity of other programming efforts. Measuring the productivity of the inventors of spreadsheet programs by the number of lines of code they produced per day is almost ludicrous, in that their programs led to great improvements in the productivity of the users of their code, the spreadsheet programs themselves.

2. On the other hand, it could be the case that some services that appear to be stagnant really are stagnant. Baumol points out that the software example of improving productivity does not seem to apply to TV broadcasting of soap operas, for example.

3. Even in this example, quality cannot be escaped. Suppose that musicians and therefore concerts were improving in quality over time, so that the demand for concert attendance was soaring despite the increased prices. School planners might underestimate musician classroom demand substantially, since output proportions were changing.

4. While the use of capital market data to make inferences regarding productivity is unusual, we are not the first to do so. Baily (1981) uses the market value of assets to estimate the flow of capital services in his highly original approach to explaining the recent productivity slowdown.

5. We thank Lawrence Klein for pointing this out.

6. This function is a proper indirect utility function in the region $w^\epsilon \sum a_i p_i^{1-\epsilon} \geq D$, in that for $\epsilon > 0$ ($\epsilon \neq 1$) it is increasing in D and w , decreasing in p_i , and it is homogeneous of degree zero in (p, w, D) . A sufficient condition that it be quasi-convex is $\epsilon \leq 2$. Within this region, the resulting demand functions satisfy the Slutsky conditions. It can be shown that equilibrium prices and dividends lie in this region. Asymptotically, however, as prices become vanishingly small, only a unitary elasticity can be supported.

7. At $\epsilon = 1$, (1) is not defined; it is necessary to use the Cobb-Douglas indirect utility function in order to obtain constant elasticity of unity.

8. We thank William Nordhaus for suggesting this source.