The Changing Role of Capital in the U.S. Private Business Sector: Evidence for a "New Economy"

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ABSTRACT

Economists differ in their explanation of changes in the rate of U.S.economic growth in the latter half of the 20th century—particularly for the "new economy" period from 1982-2000. Adherents of the Neoclassical Growth Model have emphasized that with the increase in the capital/labor ratio the aggregate production function would be subject to diminishing returns so that economies would asymptotically approach a steady state in terms of output per worker and output per unit of capital. Endogenous Growth theorists have emphasized upward shifts in production functions offsetting diminishing returns. Both theories have neglected to incorporate into their growth models the effects of systematic shifts in the composition of output that accompany economic growth.

The paper analyzes the Private Business Sector (exclusion of Government, Residential Housing, and Not For Profit), uses a more restrictive measure of output, Net National Income, rather than Gross Domestic Product and a more general measure of labor input, Persons Engaged in Production, rather than Full Time Equivalent Employment or labor hours in analysis. Using BEA data sets for the stock of physical capital and gross product originating by SIC sector and industry, the paper demonstrates that about half the increase in labor and capital productivity in the new economy has been the result of endogenous growth within sectors and industries and the other half is attributable to shifts in the composition of output away from more physical capital-intensive industries to more labor-intensive industries.

After falling steadily from 1966 to 1982, both the nominal output/capital (Y/C) and real output/capital ((Q/K) ratios rise steadily from 1982 to 2000. Growth in the real capital/labor (K/N) ratio slows during this period so that in marked contrast to earlier periods, half of the growth in real output per worker (Q/N) is attributable to increases in capital productivity. Increase in the Y/C ratio is shown, by counterfactual analysis, to depend partly on the shift of output from more to less capital intensive industries. The paper also demonstrates that half of the change in the nominal Y/C ratio is due to "real" rather than relative price changes and that changes in capacity utilization over the business cycle explain only a negligible part of the increase.

INTRODUCTION

Amidst the economic boom of the 1990s, some apologists for the "irrational exuberance"[1] of U.S. stock markets claimed that the historically high price/earnings ratios of U.S. equities actually reflected fundamental changes in the U.S economy. Claims were made that observed and anticipated technological and organizational changes would accelerate both the growth of the economy and corporate earnings and, hence, justify the rapidly rising market valuations of U.S. corporations. Anecdotal discussion about the new economy, for example, emphasized how computers would increase the productivity of both labor and capital in all parts of the economy;or how use of the emerging internet would lower transactions, inventory and distribution costs; or how biotechnology would transform agriculture and the health sciences. The post-2000 decline in stock prices justified the "irrational exuberance" phrase—but what did happen in the U.S. economy during the booming 1990s?

Both critics of and apologists for capitalism have always cited its capacity for changing methods of production. The U.S. economy has been growing and changing for two centuries. So what was new about the 1990s? I will argue in this paper that what was new in the 1990s was the acceleration of productivity growth—output per unit of labor—by increasing rather than decreasing returns to capital in some industries and sectors of the economy coupled with the continuing shift in the output structure of the U.S. economy. During the last quarter of the 20th century this shift in output (and input) structure decreased the relative size of physical capital intensive industries, e.g. railroads and steel mills to industries that employed less physical capital but more "human capital" and "knowledge capital," e.g., pharmaceuticals, computer software, or health care. Specifically, I will present evidence that in the last two decades of the 20th century these shifts were strong enough to offset the traditional pattern of decreasing returns from increased capitalization and resulted, even if temporarily, in an increase in the aggregate ratio of output to capital – the value of the annual flow of output per dollar of fixed capital in a sector of the economy referred to as the Private Business Sector.

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1 A phrase used by Federal Reserve Chairman, Alan Greenspan, in 1995 to discuss stock market behavior. It later became the title of a book by Robert Schiller (Shiller,2000).

Economists' theorizing about the process of economic growth has traditionally emphasized the importance of capital – particularly reproducible physical capital – factories, buildings, machines, transport vehicles, etc. Conventional theory[2] has assumed "production functions" – relationships between the growth in capital inputs per unit of labor and per unit of output – that would show a decelerating rate of growth of output with the increase in capital per worker. This, in turn, led to the Neoclassical theory of economic growth: productivity growth would increase asymptotically toward some maximum level as the combined result of diminishing marginal returns to capital with the increase in the capital/labor ratio and a simultaneous decline in the rate of net savings and capital formation.

Of course it was always acknowledged that this process could be (temporarily) interrupted with technological and organizational change that could shift production functions to increase output per unit of labor and per unit of capital. In the 1980s, "Endogenous Growth" (Romer, 1986) theorists emphasized that upward shifts in the productivity of an economy could be facilitated by systematic investment in the production of knowledge capital and human capital so that the asymptotic slowdown could be postponed indefinitely.

Were there fundamental changes in the performance of the American economy in the last decade of the 20th century? Was there an acceleration in productivity growth *across* the economy? Or a substantial change in the composition of output in particular industries that increased aggregate productivity? Further, is it possible for an economy to avoid the long-term decline in the rate of economic growth entailed by the Neoclassical theories of diminishing marginal productivity and consequent declining net savings and capital growth rates? Or will endogenous growth—facilitated by investment in knowledge and human capital—make continuing, or even accelerating growth possible?

This paper attempts to address these questions with some historical evidence on the pattern of capital growth and the determinants of productivity growth in the Private Business Sector of the U.S. economy since World War II. I will present evidence to support the assertion that there was a "new economy" based on endogenous growth in the 1990s. I will also show, however, that this new economy really had its beginnings in the early 1980s and depended upon a structural shift in the composition of output from more to less physical capital-intensive industries as well the accelerating productivity growth from technological and organizational change within industries that led to increasing returns to capital.

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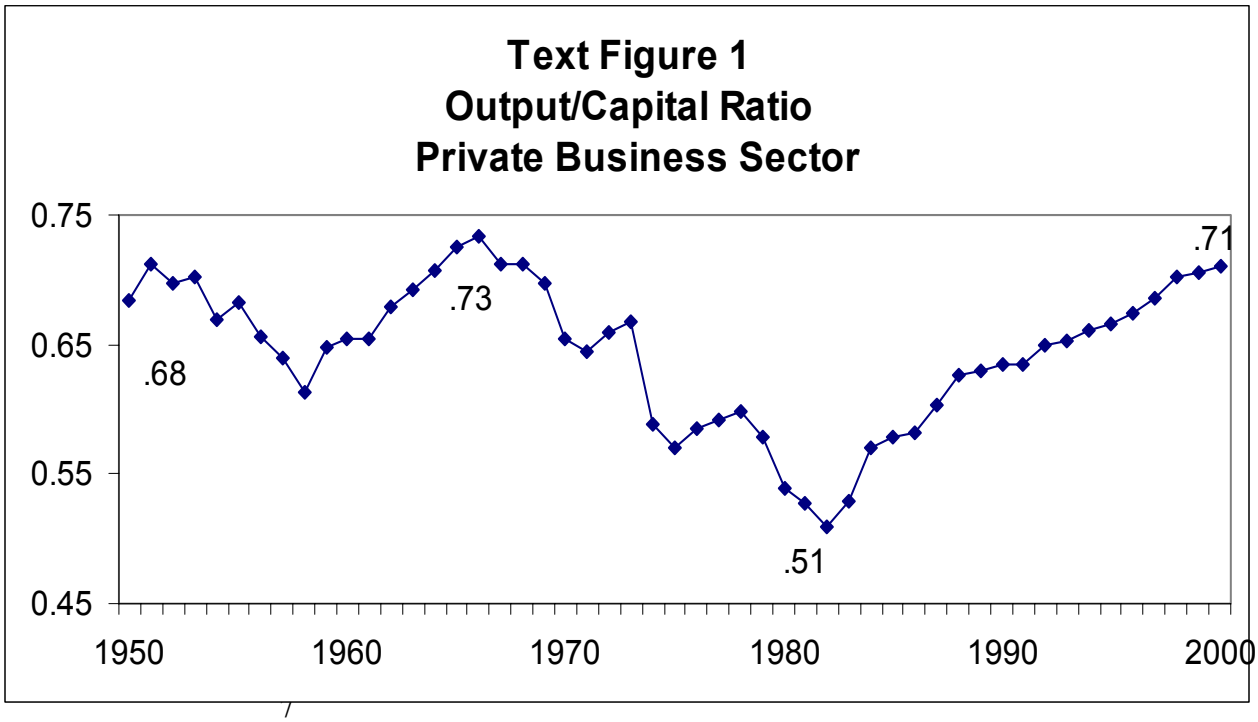
2 A brief review of conventional economic growth theory is presented in Appendix I.

I begin with a graphic presentation of the evidence for a new economy.



Source: U.S. Department of Commerce, 2001.

Discussion of Text Figure 1: Conventional economic growth theory posits that the economy's output/capital ratio will fall, over time, with the increase in capital per worker, because of diminishing returns to the variable factor (capital).[3] The theory appears to hold from 1950 to 1982 (and, indeed for a half-century before, although the data are more tentative). However, note the dramatic reversal in 1982.[4] Figure 1 may be interpreted as showing that between 1982 and 2000, annual net output per dollar of physical assets rose from $.51 to $.71, a 40% increase in capital efficiency in the Private Business Sector! The aggregate evidence from time series evidence for the existence and importance of the dramatic reversal in the output capital ratio is presented and discussed in Section I.

This significant reversal of trend in the output/capital ratio evident in Figure 1 could be attributable to any combination of four causes: (1) a rise in capital productivity *within a* large enough share of sectors and industries (endogenous growth) to produce an upward shift in the aggregate production

3 Using small-case letters for rates of change in the variables (q=output, k=capital stock, n=labor) and the relationship q/n=k/n+q/k, dimishing marginal productivity implies that k/n>q/n. If k/n>q/n, q/k is negative, i.e. q/k, the output/capital ratio will be declining.

4 The rates of change for the data underlying Figure 1 are presented in Text Table 2. Variables and index problems are discussed in conjunction with Text Table 1.

function; (2) a shift in the composition of output from more to less capital intensive industries (structural shift); (3) cyclical variations in the utilization of capital;, (4) different rates of change in the prices of capital goods and final output. These alternative explanations are evaluated in Section II.

I AGGREGATE EVIDENCE

The reversal of historical trend is shown in Text Figure 1; output per unit of capital increases in

Text Table 1
Decennial Growth Rates for Alternative NIA Aggregates
Compound Annual %Rates of Change in Real Income and Ratios

Decade	1950s	1960s	1970s	1980s	1990s	*95-2000*
Priv. Business Sector NNI/PEP	**0.022**	**0.020**	**0.006**	**0.009**	**0.022**	***0.033***
Total Economy GDP/FTE	0.017	0.015	0.012	0.012	0.015	*0.019*
Total Economy NNI/FTE	0.014	0.014	0.009	0.012	0.014	*0.014*
Total Economy NNI/PEP	0.019	0.017	0.009	0.013	0.016	*0.017*
Well Measured Sector NNI/PEP	0.023	0.031	0.019	0.025	0.034	*0.040*

Sources: Peterson, 1986, U.S. Dep't of Commerce, 2001.

the Private Business Sector after 1982. This increase in output per unit of capital reverses the normal, expected outcome of decreasing marginal productivity. Growth in capital productivity accelerates the rate of growth in output per worker. Accelerating productivity growth in the Private Business Sector and the relationship of the productivity growth per Person Engaged in Production in the Private Business Sector to more popularly used measures of economic growth are presented in Text Table 1.

Discussion of Text Table 1: Contemporary economists differ on whether there have been fundamental changes in the efficiency and composition of output of the American economy over the past several decades.[5] While arguments *pro* and *con* are evidenced on the same primary national income data sources,

5 Economists disagree about the changes in growth rates; for the 1970s and 1980s, c.f. "Symposium: , The Slowdown in Productivity Growth, *The Journal of Economic Perspectives* 2, Fall, 1988. For the last decade, Robert Gordon, one of the leading skeptics on the new economy, has argued that all of the acceleration of productivity in the economy in the 1990s has been in computer manufacturing – in the rest of the economy, productivity is stagnant. (The *Economist*, 7/22/99). On the other hand, William Nordhaus has argued that the productivity growth of the late 1990s has been

they are often evidenced on the basis of different (NIA) concepts, price indexes, and different measurements of labor and capital inputs. Since my analysis uses a less widely used set of NIA variables, I have included some alternative series for comparison. Alternative series on compound annual rates of change in real output per worker for selected National Income Accounting (NIA) aggregates for the last half of the 20th century by decennial periods (and 1995-2000) are presented in Text Table 1.

First, note the different type face size for the periods pre- and post-1980. This is intended to signal differences in the price index deflators used to convert nominal to "real" (inflation adjusted) output: the pre-1980 figures are downward biased by the use of a Paasche price index based on 1982 while those after 1980 utilize a Chain-linked price index with a 1996 base.[6] If a Chain index were available for the decades from 1950 to 1980 for the various NIA aggregates, I would expect it to show higher rates than those presented in Text Table 1.[7]

My evidence for a "new economy" in this paper is based on productivity data for the Private Business Sector. The Private Business Sector differs from the Total Economy in the exclusion of output from government, residential housing, domestic household employment, and the not-for-profit sector. Excluding these sectors eliminates the quarter of the economy where output is measured largely by imputation and no measured productivity growth is possible because of the accounting conventions used.[8]

Most popular discussion of economic performance centers on rate of growth of Gross Domestic Product (GDP) per hour or per Full Time Equivalent (FTE) worker.[9] This aggregate (Row 2) shows

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substantial and "not narrowly focused in a few new-economy sectors." *NBER Working Paper No. 8096*. See, also, Gordon, 1999, Jorgenson, 1999)

6 The Real NNI per PEP figures in Text Table I are based on Real GDP figures. (Source Milo Peterson,"Gross Product by Industry; Revised and updated Estimates" Survey of Current Business 66/4 April 86. The $82 deflator was used. To arrive at NNI, the proportion of NNI/GDP in current dollars was used. Residential housing income was excluded from Financial Services and Not for Profit from the Service Sector to conform to the PBS definition.
It is interesting to note that the use of the 1982 Paasche Index gives a higher measure of productivity growth than the Chain index for a period when both indexes are available: e.g. between 1977 (first year of availability for the Chain lined index and 1985 (last year for the $82 based index) the Manufacturing Sector had a growth rate of real output of .0204 measured by the Chained index and .0240 measured with the Paasche index.
For the Transportation,Communication, and Public Utility Sectors the growth rates were .022 with the Chain Index and .025 with the $82 weights.

7 Using a slightly different set of labor inputs for FTE and a 1958$ Paasche index, my own calculations (Bjork, 1999) for the growth rate in the 1950s were .019 v. .017 in the table. Similarly, for the 1960s, using a 1972$ base, the growth rate was .017 v. .015 in the table.

8 In the excluded sectors output is valued as the sum of factor inputs. Further, it seems misleading to include output from residential housing (most of it owner-occupied) when there is no labor input recorded for this sector.

9 Some popular discussion fails to distinguish between aggregate growth and growth per worker. Other popular discussion confuses output per capita with output per worker. Productivity data are frequently based on BLS output per worker hour in the non-farm sector and exclude the self-employed..

relatively small variations in decennial change rates over the past half century; the growth rate for the 1990s is a little above the 1970s and 1980s and a little below the 1950s and 1960s but the changes in decennial growth rates of GDP per worker are relatively small. This series shows an acceleration for the second half of the 1990s but there have been several earlier periods when productivity growth accelerated cyclically at similar rates. This series, like all series on real output, is sensitive to the type and base of the price indexes used to deflate nominal output.

There are more substantial changes in the decennial growth rates for the different NIA aggregates in the following rows. NNI differs from GDP by the subtraction of depreciation and indirect taxes to arrive at net, rather than gross, output. Net National Income (NNI) grows more slowly than GDP because depreciation has been increasing as a percentage of GDP[10] as the output/capital (Y/C) ratio increased until 1982 and shifted toward more rapidly depreciating assets—e.g., from railroad roadbeds and rolling stock to computers and computer software.[11] I posit that net rather than gross output is the more appropriate concept for the measurement of output because the social objective in increasing output is increasing the level of present consumption and the possibility of increased future consumption through net investment.[12]

I have used Bureau of Economic Analysis (BEA) workers rather than Bureau of Labor Statistics (BLS) hours for my labor input variable. Persons Engaged in Production (PEP) differs from Full Time Equivalent (FTE) workers by including self-employed persons – farmers, merchants, lawyers – in the measurement of the employed labor force and by defining full-time employment by industry practice rather than using a standard work week across the economy. The difference between NNI per FTE and NNI per PEP is the difference in the growth rates for the different labor force estimates for the two NNI lines. For example, in the 1950s the FTE measure of labor input grew by .5% per year faster than the PEP measure

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10 Between 1950 and 2000 the ratio of Depreciation/Gross Domestic Product for the Private Business Sector more than doubled from 6% to 13%.

11 In their explanation of productivity change in the new economy, Jorgenson and Stiroh , (2000) have adjusted capital input measures to emphasize that the shift from structures to equipment (and especially software) increases the intensity of capital use and the user cost of capital due to higher depreciation. My use of net, rather than gross output, avoids this effect.

12 The basis for the selection of GDP rather than NNI in most intertemporal and international comparisons has been the lack of uniformity or agreement about the quantitative measure of depreciation because of the lack of transactions in the underlying accounting data. I think this is a less important objection for the intermporal comparison of U.S. data where conventions for depreciation have been consistently applied by the Bureau of Economic Analysis of the Department of Commerce. These are not the depreciation conventions conformed to IRS regulations. Using NNI rather than GDP actually reduces the rate of growth (and works against my argument) because depreciation is increasing as a proportion of gross output in the Private Business Sector.

because farmers and other small proprietors were becoming employees. FTE grew .001 faster than PEP in the 1990s because independent practitioners, such as doctors and lawyers, were becoming employees.

I posit that Persons Engaged in Production (PEP) is a better measure of labor input than BLS hours paid for, hours worked, or hours worked by employees. The conceptual implication of this input measurement is that human capital is treated like physical capital where there are *assumed* normal annual rates of utilization. PEP estimates are developed from the same establishment survey that estimates output and value added. PEP is comprised of full-time equivalent employees and proprietors. Full-time equivalent employees are constituted from industry standard full time employees plus the hours worked by part-time employees divided by normal full-time employment in the surveyed industry rather than 40 hours per week. Thus, employees in manufacturing may be considered full-time if they work 40 hours per week for 50 weeks per year while elementary teachers may be considered full-time although working less than 40 hours per week and only 36 weeks per year at school. Using BEA PEP rather than BLS hours worked reduces the growth of measured labor productivity that occurs as hours worked per year decline because of the shift from agriculture and manufacturing to service industries where by industry practice employees work less than 40 hours per week.

The "Well-Measured" portion of the Private Business Sector further excludes Construction, Retail, Financial Services, and other Services on the rationale that there are significant measurement problems in measuring output in these excluded private sectors. Excluding these sectors provides even stronger evidence of the upward movement in productivity growth in the new economy. (I have included this aggregate for comparative purposes but it is not used in subsequent discussion.)

In addition to being a more conceptually appropriate measure of productivity, the NNI/PEP data for the PBS show a sharp upward shift in aggregate productivity growth in the 1990s. If we were to consider only the rate of growth in output per engaged person (PEP) in the Private Business Sector (PBS), I think it would be reasonable to label the last decade of the 20th century a new economy. But an even more important reason for recognizing this period as a new economy is the source of the acceleration of aggregate productivity growth. This is identified in Text Table 2.

Text Table 2
Changes in Ratio Variables and Prices for Private Business Sector
Compound Annual Rates of Change by Decade

Decade		1950s	1960s	1970s	1980s	1990s	*95-2000*
Price index deflated input and output variables							
Output per worker	**q/n**	**0.022**	**0.020**	**0.006**	**0.009**	**0.022**	***0.033***
Capital per worker	**k/n**	0.034	0.016	0.014	0.009	0.014	*0.015*
Output per capital unit	**q/k**	-0.011	0.004	-0.008	0	0.008	*0.019*
Nominal and Real Output and Capital Ratios and Relative Price Change							
Nominal Y/C ratio	**y/c**	**-0.004**	**0**	**-0.019**	**0.016**	**0.011**	***0.013***
Real Q/K ratio	**q/k**	-0.011	0.004	-0.008	0	0.008	*0.019*
Y prices-C prices	**y-c**	0.007	-0.004	-0.011	0.016	0.003	*-0.006*

Sources: Peterson, 1986, U.S. Department of Commerce. 2001.

Text Table 2 presents compound annual rates of growth in labor and capital input and net output variables for the Private Business Sector. Output per worker (q/n) is equal to the sum of the rates of growth in capital per worker (k/n) and output per unit of capital (q/k) . Growth in capital per worker can be thought of as movements along a production function while growth in output per unit of capital could be understood as an upward shift in the production function.

Note the secular decline in the rate of increase of capital per worker – the line labeled (k/n). The slowdown in the rate of growth of capital per worker is what economic theory would predict; however, the reasons for the behavior of the k/n ratio are more complex than those that result from the assumptions used in the Neoclassical growth model. There are four interrelated reasons for the decline in the rate of growth of the capital/labor ratio (k/n): (1) an acceleration of growth in the labor force after 1960;[13] (2) a reduction in net investment through declining gross saving after the 1970s[14];(3) a continuing increase in the ratio of depreciation/output;[15] and (4) a shift in the structure of the economy from more capital intensive industries, e.g. railroads, agriculture, and steel to less capital intensive industries, e.g. trucking, computer software, and health services.

13 PEP in the PBS grew by .006 in the 1950s, accelerated to .016 in the 1960s and .023 in the 1970s before decelerating to .018 in the 1980s and 1990s.
14 Real capital growth for the PBS decelerated from .037 in the 1970s to .028 in the 1980s and .032 in the 1990s.
15 Depreciation in the PBS increased from 6% to 13% of NNI between 1950 and 2000.

Standard economic theory posits that the growth rate of output per unit of capital—the q/k ratio in Text Table 2—would be increasingly negative. Note that it does appear to decline, secularly, (the upward blip in the 1958-1966 period was primarily a result of increased cyclical utilization of the capital stock[16]) until the 1980s when decline is slowed to zero and then turns positive in the 1990s![17] If the decade of the 1990s is to be called a new economy, it is in the behavior of output per unit of capital (q/k) ratio that the "new economy" is most evident. Note that for the 1995-2000 period, the increase in output per worker depends more on the increased productivity of capital than the increase in capital per worker. *The noteworthy feature of the new economy was the acceleration of growth in labor productivity based on the increasing productivity of capital; the positive rate of change in the q/k function signals shifts of– rather than movements along –the aggregate production function.*

This is one feature of growth in the new economy which sets it apart from the old economy where growth in output per worker depended on increases in capital per worker that were partially offset by diminishing returns to capital rather than increases in output per unit of capital. This increase in the aggregate output/capital (q/k) ratio for the Private Business Sector is an outcome that might first appear to be explained by endogenous growth theory. However, endogenous rowth theory— the upward shift in production functions—is posited to occur for the production functions of particular firms or industries as a result of the technological progress resulting from increases in research and development and investment in human capital.[18] In Section III of the paper, which presents productivity data disaggregated by Standard Industrial Classification (SIC), I will show that about half the increase in capital productivity in the Private Business Sector has resulted from shifts in the composition of output (e.g., steel to computer software or hairdressing to health services) rather than the increases in the productivity of capital within specific industries. This increase in aggregate capital productivity from intersectoral shift in the composition of output is different from conventional endogenous growth theory that attributes growth to the favorable

16 Evidence not supplied in this paper but available from the author.
17 The q/k ratio actually turns sharply positive in the period after 1982 – its lower rate for the entire decade results from the sharp downturn in the economy between 1980 and 1982. I will incorporate the period from 1982 to 2000 in my analysis of the sources of productivity change in the new economy.
18 As a heuristic example, a farmer increases his output (grain) by adding a computer and software to his existing stock of natural resource assets (land), and physical assets (tractors). His college-educated son (knowledge capital) uses the computer programs to determine what combination of genetically modified seed and fertilizer, herbicides, fungicides, pesticides (knowledge capital) to use in farming production and thereby increases output per acre, per man hour, and per dollar of physical capital.

effects of research and development and improved labor force on the production functions of individual firms and industries.

Text Table 2 presents the decennial rates of change in the nominal output/capital (Y/C) ratio and its constituents—the real output/capital ratio (Q/K) and relative price changes in output and capital (Py-Pc). Note that in the decade of the 1990s, the nominal output/capital ratio (Y/C) increased by 1.1% per year during the decade while the real output/capital ratio (Q/K) increased by only .8% per annum. The additional .3% was provided by output prices rising relative to capital prices. Part of this differential growth in relative prices was due to the shift in the composition of output from manufacturing to services. The other part was due to the fall in the relative prices of capital goods such as computers and software and their increase in relative importance in the capital stock. (Note that capital prices are the prices of the capital stock—not just new investment.) The fall in prices of information technology- computers and software- were compensating for the much larger but declining proportion of long-lived structures and equipment in the capital stock. Output prices relative to capital prices rose even more rapidly in the 1980s.

The fall in the relative price of capital has been an important feature of the new economy and it is important to understand its implications. If the price of the capital goods a firm uses to produce output falls (or rises more slowly) relative to the price received by the firm for its output, the firm gets more revenue per dollar of capital as well as physical output per dollar of capital. This is because the relative prices in the two sectors are determined by differential productivity growth in using the real resources of capital and labor in the two sectors. The same holds true for the economy.[19]

To summarize the evidence from Table 2, growth in output per worker did accelerate in the decades between 1980 and 2000. The explanation of this increase in productivity growth is potentially explainable by four sources of change in the aggregate production function reflected in the output/capital (Y/C) output/capital ratios:

1. Upward shifts from technological or organizational change in the microeconomic production functions for firms and industries offsetting conventional decreasing returns. This is the conventional endogenous growth amendment to neoclassical growth theory.

19 The price of capital of a capital good is different than the user cost of capital. For example, the annual cost of a capital asset (e.g. a machine) is equal to the purchase price of the asset times the sum of the depreciation rate and financing rate less the projected change in the resale price of the asset.

2. Structural change in the composition of output which changes the relative shares of more and less capital intensive sectors of the economy.
3. Changes in the utilization of the capital stock arising from cyclical movements in demand.
4. Changes in the output/capital ratio that result from differential change in prices in capital goods and final output.

II Disaggregated Evidence[20]

The U.S. economy consists of a number of firms that have been classified by sector and industry on the basis of their final output – gross output originating by industry. The relative size of sectors and industries changes over time as a result of both changes in the composition of final demand and changes in the input/output structure of individual firms. It is important to remember that changes in the output/capital ratios and labor productivity within sectors and industries results from outsourcing that changes the organization of production as well as internal reorganization to improve productivity.(Bjork,1999)

As an example, consider a hypothetical manufacturing firm; suppose that the firm initially owns its factory, employs a sales force to sell its output to wholesalers and retailers, and has janitorial and bookkeeping functions performed by its own employees. Then it leases the factory, switches its distribution to independent manufacturers' agents, hires a janitorial services firm to handle maintenance and an information services firm to perform internal accounting.

The result of leasing the factory would be to decrease the contribution of the firm's fixed capital to output and the output of the capital represented by the factory would be recorded in the Commercial Real Estate Sector; employment and value added within the sector would be decreased by the outsourcing of marketing to the Wholesale Sector and maintenance and information services to the Business Services Sector.

Within the SIC Manufacturing Sector and Industry, the effect of the reorganization of production would be to increase the ratio of output to fixed capital and (probably, depending upon the compensation of the employees replaced by outsourcing) increase output per worker within within the manufacturing sector.

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20 All of the data used in this section are taken from the U.S. Department of Commerce, Bureau of Economic Analysis data tapes. References in Tables 4,5, 6 and Figures 3,4 are to transformations of the data in my data files.

Text Table 3
Compound annual rates of Growth in Output per Worker by Modified SIC Sector
Net Output Per Person Engaged in Production Private Business Sector

Decade	1950s	1960s	1970s	1980s	1990s	95-2000	Proportion PBS, 1990	Contribution 1990
Private Business Sector	**0.022**	**0.020**	**0.006**	**0.009**	**0.022**	***0.033***	**1**	**0.022**
Agriculture	0.031	0.034	0.004	0.063	0.018	0.062	0.019	0.000
Mining	0.036	0.051	-0.054	0.026	0.011	-0.014	0.017	0.000
Construction	0.046	-0.015	-0.030	-0.003	0.001	0.002	0.083	0.000
Manufacturing	0.020	0.024	0.025	0.032	0.036	0.038	0.252	0.009
Transp.,Comm.&PU	0.030	0.033	0.025	0.016	0.018	0.015	0.097	0.002
Wholesale	0.009	0.031	0.018	0.030	0.033	0.008	0.078	0.003
Retail	0.009	0.014	-0.001	0.005	0.032	0.030	0.111	0.004
Fin Service exc Res RE	-0.008	0.013	0.005	-0.003	0.031	0.038	0.106	0.003
Services exc NonProfit	0.008	0.012	0.030	-0.003	-0.003	0.004	0.249	-0.001

Sources: Peterson, 1986, U.S. Department of Commerce, 2001.

Output and employment would be shifted from the Manfacturing Sector to the Commercial Real Estate, Wholesale, and Business Services Sectors. The effect of the outsourcing of labor and capital services on aggregate output, employment, and productivity would depend on whether the reorganization increased or decreased the efficiency of labor and capital. But, presumably, the increase in efficiency from specialization is the reason for the reorganization of production. With this explanation in mind, let us turn attention to the disaggregated evidence on productivity growth by sector.

Discussion of Table 3: Table 3 is a first step in the sectoral disaggregation of the macroeconomic evidence for the Private Business Sector presented in the previous section in Text Tables 1 & 2. Row 1 has the same aggregate growth rates presented in the previous tables. The rows below exhibit annual rates of growth in real net output (NNI) per person employed (PEP) by modified SIC Sector for the last half century.[21] Rates of growth in the PBS aggregate are the sum of the weighted sectoral rates of growth and intersectoral shifts. Once again, the different type size for the decades prior to 1980 indicates the use of a different method and base for price deflation.

The last two columns of Table 3 display the proportions of net output by sector for 1990 and their contribution to the aggregate growth of the Private Business Sector for the decade of the 1990s. Thus, the

21 The Financial Services Sector excludes Residential Real Estate. The Services Sector excludes private education, domestic employment, and such not-for-profit entities as churches, museums, foundations, etc. In following tables breakdown, the Transportation, Communication, and Public Utilities are broken out from their aggregate and Health Services and Business and Professional Services are broken out from Services.

Manufacturing Sector constituted 25.2% of the output of the PBS in 1990 and in the decade of the 1990s; the sector contributed .9% or about 40% ot the total growth in productivity of 2.2% for the PBS.[22] The sum of the sectors is .020 rather than .022 because an intersectoral shift contributes the remaining .002 to growth in the aggregate.

The important sectors to note in the 1990s because of their relative size and growth rates are Manufacturing, Transport, Communications, Wholesale and Retail Trade, and Financial Services. Productivity in the Manufacturing Sector continually accelerates during the second half of the 20th century as the sector decreases in relative size. Within the Manufacturing Sector (disaggregation to be shown in subsequent tables) Machinery, Electronics, and Chemicals (including pharmaceuticals) account for about three-quarters of the productivity growth in the Manufacturing Sector in the 1990s. Acceleration of growth rates within sectors during the decades of the 1980s and 1990s also comes in Wholesale and Retail Trade and in Financial Services. The Services Sector (where productivity growth measures are inadequate) shows close to zero growth as it does over a longer period.

Text Table 3 provides longitudinal evidence on sectoral contributions to productivity growth but does not permit analysis of the relative importance of the increase in capital intensity, upward shifts in the production function, intersectoral shifts in the composition of output, or cyclical changes in the the utilization of capital. For this analysis, we must do further disaggregation.

1: Conventional Decreasing Returns v. Endogenous Growth[23]

The macroeconomic evidence for the relative importance of changes in the K/N and Q/K ratios for the new economy has been presented in Table 2 in the previous section. In Table 2 disaggregation of the macroeconomic variables indicated that growth in the productivity of capital (q/k) contributed .8% of a total of 2.2% of productivity growth in the new economy decade of the 1990s although nothing to the

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22 Growth within sectors accounted for 2.0% of the growth while intersectoral shifts in output added an additional .2% for a total growth of 2.2% for the decade. While the positive contribution of intersectoral shift is small, intersectoral shifts in the composition of output dragged down the growth rate in the decades of the 1970s and 1980s for different NIA aggregates.. (See, Bjork, 1999, Text Table 5.2, p. 114)

23 Strictly speaking, the conventional production function is based on the individual firm rather than an industry or economic sector. It would be possible for every firm in an industry to be subject to decreasing returns with the industry displaying increasing returns over time if less efficient firms were replaced by more efficient firms. It would be possible for every industry within a sector to have decreasing returns but for the sector to have increasing returns if output was being shifted from more to less capital-intensive industries within the sector. For example, within the Transportation Sector most industries display decreasing returns but the shift from capital-intensive railroads to less capital-intensive air and truck transport results in the Transportation Sector displaying increasing returns.

growth in the 1980s. However, decennial measurement periods conceal cyclical changes. There was a deep recession between 1980 and 1982 which depressed recorded productivity growth for the decade of the 1980s. For this reason, my disaggregation of productivity change for evidence of endogenous growth for the new economy in Tables 4,5, and 6 take the longer period of 1982 to 2000.

Text Table 4

Compound annual rates of growth in variables & ratios: Private Business Sector: 1982-2000

	Real NNI Growth q	Real K Growth k	pep Growth n	Productivity Growth q-n	Capital Growth k-n	Capital Producitivty q-k
Private Business Sector	**0.039**	**0.030**	**0.021**	**0.019**	**0.010**	**0.009**
Agriculture, forestry, and fishing	**0.030**	**-0.003**	**0.002**	**0.027**	**-0.005**	**0.033**
Farms	0.017	-0.010	-0.022	0.039	0.012	0.027
Agricultural services, forestry, and fishing	0.063	0.050	0.046	0.017	0.004	0.013
Mining	**-0.004**	**0.000**	**-0.040**	**0.036**	**0.040**	**-0.004**
Metal mining	0.024	-0.011	-0.031	0.055	0.020	0.035
Coal mining	0.036	0.000	-0.061	0.097	0.061	0.037
Oil and gas extraction	-0.011	0.000	-0.045	0.034	0.045	-0.011
Nonmetallic minerals, except fuels	-0.040	0.007	0.001	-0.041	0.006	-0.047
Construction.	**0.036**	**0.022**	**0.030**	**0.006**	**-0.009**	**0.014**
Manufacturing.	**0.036**	**0.017**	**0.000**	**0.037**	**0.018**	**0.019**
Durable goods	0.051	0.017	0.001	0.050	0.017	0.033
Lumber and wood products	0.026	0.001	0.018	0.007	-0.018	0.025
Furniture and fixtures	0.029	0.022	0.016	0.013	0.006	0.007
Stone, clay, and glass products	0.040	0.008	0.001	0.039	0.007	0.032
Primary metal industries	0.017	-0.008	-0.014	0.031	0.006	0.025
Fabricated metal products	0.026	0.012	0.005	0.021	0.007	0.014
Machinery, except electrical	0.095	0.021	-0.003	0.098	0.025	0.073
Electronic equipment and instruments	0.083	0.044	-0.004	0.087	0.048	0.039
Motor vehicles and equipment	0.027	0.019	0.021	0.006	-0.002	0.007
Other transportation equipment	-0.007	0.019	-0.012	0.005	0.031	-0.026
Miscellaneous manufacturing industries	0.035	0.011	0.002	0.033	0.008	0.025
Nondurable goods	0.017	0.017	-0.002	0.019	0.020	-0.001
Food and kindred products	0.014	0.018	0.003	0.011	0.015	-0.004
Tobacco products	-0.149	0.010	-0.036	-0.113	0.046	-0.159
Textile mill products	0.015	-0.002	-0.017	0.031	0.015	0.017
Apparel and other textile products	0.001	0.008	-0.032	0.033	0.040	-0.007
Paper and allied products	0.005	0.018	0.000	0.005	0.018	-0.012
Printing and publishing	0.001	0.034	0.012	-0.011	0.022	-0.033
Chemicals and allied products	0.042	0.021	-0.002	0.045	0.023	0.021
Petroleum and coal products	0.024	0.000	-0.023	0.047	0.023	0.024
Rubber and miscellaneous plastics products	0.062	0.037	0.022	0.040	0.015	0.025
Leather and leather products	-0.027	-0.013	-0.057	0.030	0.044	-0.014
Transportation.	**0.045**	**0.008**	**0.025**	**0.020**	**-0.018**	**0.038**
Railroad transportation	0.035	-0.009	-0.039	0.074	0.030	0.045
Local and interurban passenger transit	0.013	0.018	0.030	-0.017	-0.012	-0.005
Trucking and warehousing	0.040	0.034	0.021	0.019	0.013	0.007
Water transportation	0.012	-0.019	-0.002	0.014	-0.018	0.032
Transportation by air	0.076	0.043	0.060	0.015	-0.017	0.032
Pipelines, except natural gas	-0.013	-0.006	-0.026	0.013	0.021	-0.008
Transportation services	0.053	0.041	0.045	0.008	-0.004	0.012
Communications	**0.043**	**0.046**	**0.008**	**0.035**	**0.038**	**-0.002**
Telephone and telegraph	0.046	0.039	-0.001	0.047	0.040	0.007
Radio and television	0.037	0.090	0.043	-0.006	0.047	-0.053
Electric, gas, and sanitary services	**0.023**	**0.017**	**-0.001**	**0.024**	**0.018**	**0.006**
Wholesale trade.	**0.052**	**0.058**	**0.015**	**0.037**	**0.042**	**-0.005**
Retail trade	**0.045**	**0.039**	**0.024**	**0.021**	**0.015**	**0.006**
Financial Services	**0.043**	**0.042**	**0.018**	**0.025**	**0.024**	**0.001**
Banking	0.023	0.063	0.010	0.013	0.053	-0.040
Security and commodity brokers	0.153	0.158	0.057	0.096	0.101	-0.005
Insurance carriers	0.011	0.091	0.011	0.000	0.080	-0.080
Insurance agents, brokers, and service	0.020	0.063	0.020	0.000	0.043	-0.044
Commmercial real estate	0.065	0.033	0.022	0.043	0.011	0.032
Holding and other investment offices	-0.241	0.088	0.036	-0.276	0.052	-0.328
Health services.	**0.018**	**0.074**	**0.030**	**-0.013**	**0.043**	**-0.056**
Business,misc professional,& other services	**0.069**	**0.060**	**0.063**	**0.006**	**-0.003**	**0.009**
Other Services	**0.027**	**0.050**	**0.026**	**0.001**	**0.025**	**-0.024**
Hotels and other lodging places	0.021	0.031	0.016	0.005	0.014	-0.009
Personal services	0.021	0.032	0.018	0.003	0.014	-0.011
Auto repair, services, and parking	0.033	0.052	0.031	0.003	0.021	-0.018
Miscellaneous repair services	-0.004	0.031	0.002	-0.006	0.029	-0.034
Motion pictures	0.051	0.083	0.051	0.000	0.033	-0.032
Amusement and recreation services	0.056	0.032	0.048	0.008	-0.016	0.024
Legal services	0.019	0.044	0.024	-0.005	0.020	-0.025

Source: YKN 2000:AT Ia

Discussion of Table 4: Begin the analysis of Table 4 by noting that, for the Private Business Sector, for this longer period of 1982-2000, nearly half (.9%/1.9%) of the growth in aggregate labor productivity (q-n) over the period is due to increases in the productivity of capital (q-k*).* Growth in the capital/labor (k-n) ratio contributes the other 1.0%. Note, also, that during this period compound annual output growth for the PBS was 3.9%, capital growth was 3% and persons engaged in employment rose 2.1%.

Turning our attention to individual sectors, it is in Manufacturing and particularly in the Durable Goods subsector that the endogenous growth of the new economy is most evident. For the sector as a whole, increases in capital productivity account for half (1.9% of 3.7%) of productivity growth. Upward shifts in the productivity are particularly important in the machinery and electronics industries. The electronics industry—computers and related equipment—contributed about one third of the productivity growth in Manufacturing. What is true for the Manufacturing Sector is also true for virtually all of the industries within the Durable Goods subsector and for the capital-intensive chemicals, petroleum and coal, and rubber and plastic industries within the Nondurable Goods subsector.

Growth in capital productivity in agriculture accounted for more than the total of the increase in labor productivity since capital growth and capital per worker were negative. There was productivity growth in the Mining Sector (largely oil and gas) but it came from increases in capital per worker in this heavily capital intensive sector. In the quantitatively and strategically important Construction Sector, growth in capital productivity compensated for the slower growth of capital than labor in the sector. In this sector, as in several other sectors and industries, some of the slower capital growth can be explained by the outsourcing of capital services; the Construction Sector leases heavy construction commitment from banks and insurance companies in the Financial Services Sector, which moves the assets and their contribution to output from one sector to the other.

Increasing capital productivity is important in the Transportation Sector, particularly in rail, water, and air transport. Surprisingly, it is not as important in the Communications Sector where deregulation and satellite and fiber-optic technology were changing the technology but not the capital intensity of the industry. In the electricity, gas, water, and sewer components of the the Public Utility sectors, it was capital deepening that was important.

It was noted in the discusioon of Text Table 3 that the acceleration of growth in the Wholesale, Retail, and Financial Services Sectors of the economy was an important contributor to the acceleration of productivity in the new economy. It will be seen from Text Table 4, however, that growth within these sectors was largely due to the conventional increase in the capital intensity of individual sectors.[24]

As noted above, productivity growth for commercial and investment banks and insurance companies in the Financial Services Sector came from large increases in their holding of physical assets leased to industries in other sectors. This increases output per worker in Financial Services and decreases it in the leasing sectors, while output per unit of capital is minimally changed.

In Health Services and Other Services Sectors of the economy productivity growth was nil or negative in the new economy but this outcome can be explained largely by the lack of an effective measure of changes in real output in these sectors—the services of doctors, lawyers, or hotels may be worth more or less but cannot be assessed when the output is counted in billable hours or procedures or occupancy nights (Bjork, 1999).

The fastest growing sector of the economy is Business Services - which is almost entirely the outsourcing of services performed for other sectors of the economy. This sector – which includes accounting, management consulting, computer services, and firms providing temporary workers – grows in relative importance from under 7% to over 11% of the Private Business Sector between 1982 and 2000. Its productivity growth—measured in terms of output per worker—grows at a rate of .6% per annum but we don't know whether this reflects productivity growth within the sector or changes in the relative size of lower and higher output industries within the Sector. It can be inferred that the growth of this sector reduces the size of other sectors and probably increases their productivity.[25]

Summarizing the sources of growth within sectors and industries for the 1982-2000 period in Table 4, the endogenous growth theories that emphasize the importance of upward shifts in the production functions of particular industries reflected by positive values for the q/k rations account for about half of

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24 As an example of growth in the Retail Sector, consider what has happened in gasoline stations. In new stations, one employee oversees 24 self-service pumps activated by credit cards in contrast to the traditional "service" station where one employee dispensed gas for 3 pumps (and cleaned windshields!). The outcome is an increase in labor productivity and a decline in capital productivity. Similar examples explain the effects of Walmart and McDonalds replacing traditional retail outlets. In Financial Services, autotellers replace human tellers and increase output per worker while decreasing output per unit of capital.

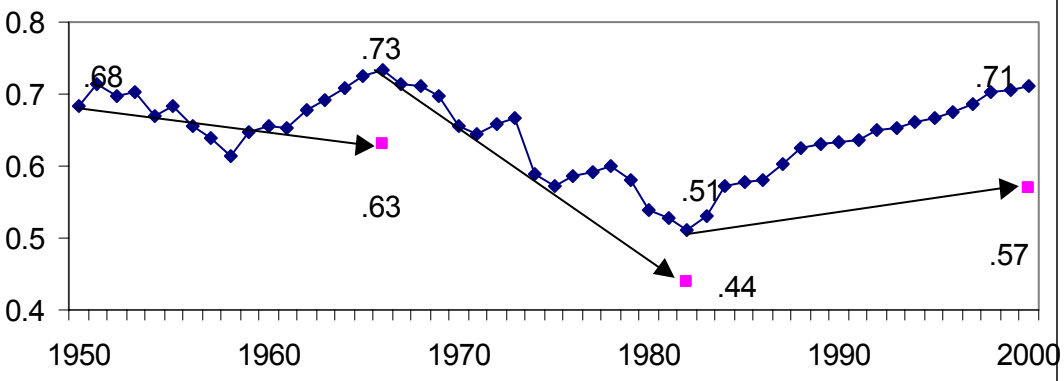
25 When the maufacturing firm hires the personnel services firm to do its janitorial services it increases its average gross product originating per worker if production workers are paid more than janitors.

the growth in the new economy. In the next section, however, I will show that most of the other half of the increase in the productivity of capital (Y/C) for the new economy of 1982-2000 noted in Figure 1 and Text Tables 1&2 can be explained by shifts in the composition of output in the economy. Additionally, I will show the importance of structural shifts in earlier periods in the second half of the 20th century in offsetting the fall in the Y/C ratio emphasied by traditional growth theories.

2. Structural Shifts and the Aggregate Production Function

The conventional theory of growth extrapolates from the production function of individual firms that diminishing marginal productivity will decrease the aggregate output/capital ratio over time. However, the structural change in the composition of output that occurs with economic growth from industries with higher ratios of physical capital to labor and output to less capital intensive industries counteracts this Tendency. This is illustrated in Figure 3.

Figure 3
Counterfactual Output/Capital (Y/C) Ratios: Private Business Sector



Source: U.S. Dep't of Commerce, 2001.

Figure 3 is based on the use of a counterfactual: what would have happened to the aggregate Y/C ratio during past periods of analysis if there had been no shifts in the composition of output.[26] The upper line indicates the actual movement in the Y/C ratio over the period of analysis – the Y/C ratios are the same as those presented earlier in Figure 1 and presented below in Table 5. The counterfacual ratios (shown by

26 The counterfactual value is calculated as $\Sigma a_i \; b_j$ where a_i are the proportions of each sector in total output in the earlier year and b_j are the output/capital ratios in the later year. Since the proportions were weighted by share in output, the calculations weighted the C/Y (rather than Y/C) ratio and then converted to reciprocals.

directional arrows) indicate what the aggregate Y/C ratio would have been at the end of various periods if all industries had their actual Y/C ratios for the ending years but were weighted with their share of output at the beginning of the time period. For example, the solid line between 1950 and 1966 indicates that the aggregate Y/C ratio would have declined to .63 rather than rising to the actual .73 if industries had their 1966 output/capital ratios but their 1950 relative shares in output.

The counterfactual ratios of Figure 3 illustrate the importance of structural shifts in the composition of output to the Y/C ratio during the "new economy" period from 1982-2000. They also show how, in earlier periods, structural change reduces the fall in the output/capital (Y/C) ratio which occurs from capital deepening within industries. But after 1982, both structural change and endogenous growth within industries and sectors actually increase the Y/C ratio. Without structural change in the composition of output the ratio still would have risen from.51 to.57 as a result of endogenous growth offsetting the diminishing marginal productivity of capital . But because of the shift from more to less capital intensive industries, it actually rose to .71

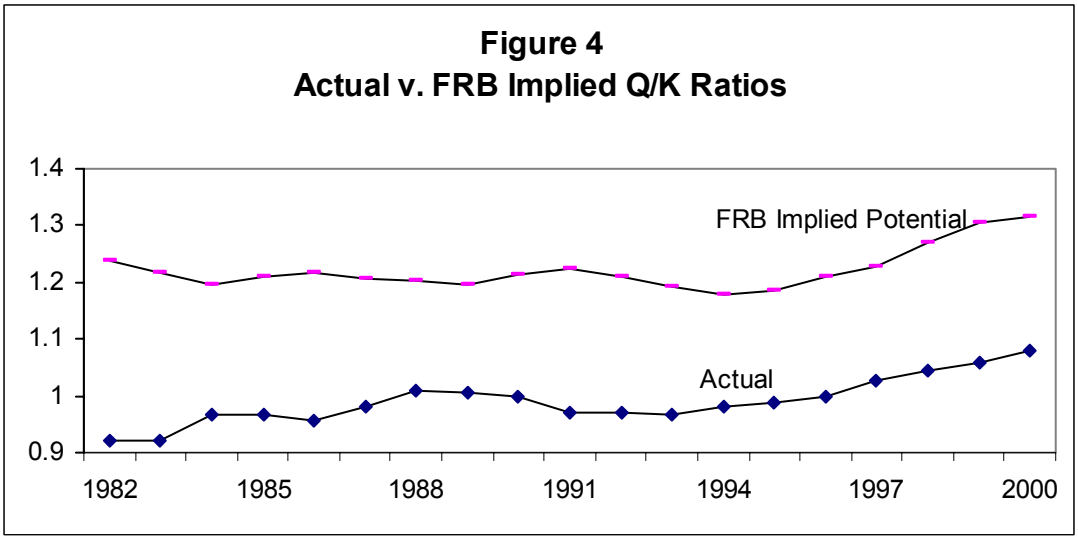
The disaggregated Y/C values and proportions of the Private Business Sector for SIC sectors and industries are presented in Text Table 5. Note that virtually every important sector and industry with an output/capital (Y/C) ratio less than one in 1950 declines in relative share of output in the Private Business Sector between 1950 and 2000.

Text Table 5
Output/Capital (Y/C) Ratios and Relative Shares of Private Business Sector

	1950	1966	1982	2000	1950	1966	1982	2000
	Y/C Ratios				Relatives PBS			
Private Busines Sector	**0.68**	**0.73**	**0.51**	**0.71**	**1.00**	**1.00**	**1.00**	**1.00**
Agriculture, forestry, and fishing.....	0.65	0.35	0.21	0.23	0.09	0.04	0.03	0.02
Farms.....	0.65	0.32	0.19	0.14	0.08	0.04	0.03	0.01
Agricultural services, forestry, and fishing...	0.71	0.82	0.44	0.62	0.00	0.00	0.00	0.01
Mining.....	0.37	0.19	0.19	0.11	0.04	0.02	0.04	0.01
Metal mining.....	0.50	0.26	0.07	0.04	0.00	0.00	0.00	0.00
Coal mining.....	1.20	0.53	0.42	0.14	0.01	0.00	0.01	0.00
Oil and gas extraction.....	0.25	0.14	0.18	0.11	0.02	0.01	0.03	0.01
Nonmetallic minerals, except fuels.....	0.55	0.53	0.22	0.07	0.00	0.00	0.00	0.00
Construction.	2.64	2.80	1.80	2.88	0.06	0.07	0.06	0.07
Manufacturing	1.21	1.19	0.63	0.70	0.36	0.38	0.28	0.20
Durable goods.....	1.55	1.42	0.70	0.78	0.21	0.24	0.16	0.12
Lumber and wood products.....	2.09	1.30	0.60	1.05	0.01	0.01	0.01	0.01
Furniture and fixtures.....	2.48	2.59	1.21	1.46	0.01	0.01	0.00	0.00
Stone, clay, and glass products.....	0.96	0.78	0.39	0.62	0.01	0.01	0.01	0.01
Primary metal industries.....	0.77	0.64	0.29	0.32	0.03	0.03	0.01	0.01
Fabricated metal products.....	2.21	1.78	0.81	0.97	0.03	0.03	0.02	0.02
Machinery, except electrical.....	1.84	1.88	0.90	0.91	0.03	0.04	0.04	0.02
Electronic equipment and instruments	2.29	2.42	0.96	0.78	0.03	0.05	0.04	0.03
Motor vehicles and equipment.....	2.48	1.42	0.53	0.67	0.03	0.03	0.01	0.01
Other transportation equipment.....	1.35	2.15	1.15	0.91	0.01	0.03	0.02	0.01
Miscellaneous Manfacturing	2.51	2.00	1.11	1.47	0.01	0.01	0.00	0.00
Nondurable goods.....	0.94	0.94	0.55	0.62	0.15	0.14	0.11	0.09
Food and kindred products.....	0.70	0.88	0.59	0.59	0.04	0.03	0.03	0.02
Tobacco products.....	1.40	1.56	0.92	0.53	0.00	0.00	0.00	0.00
Textile mill products.....	0.97	0.97	0.51	0.50	0.02	0.01	0.01	0.00
Apparel and other textile products.....	5.63	5.21	2.15	1.45	0.02	0.01	0.01	0.00
Paper and allied products.....	0.86	0.73	0.43	0.43	0.01	0.01	0.01	0.01
Printing and publishing.....	2.19	2.09	1.22	1.30	0.02	0.02	0.02	0.02
Chemicals and allied products.....	0.81	0.73	0.39	0.60	0.02	0.03	0.02	0.02
Petroleum and coal products.....	0.31	0.18	0.23	0.26	0.01	0.00	0.01	0.00
Rubber and miscellaneous plastics products...	1.47	1.33	0.75	0.71	0.01	0.01	0.01	0.01
Leather and leather products.....	2.69	3.38	1.76	1.18	0.01	0.00	0.00	0.00
Transportation.....	0.14	0.20	0.18	0.29	0.07	0.05	0.04	0.04
Railroad transportation.....	0.09	0.08	0.05	0.05	0.03	0.01	0.01	0.00
Local and interurban passenger transit.....	0.23	0.31	0.32	0.50	0.01	0.00	0.00	0.00
Trucking and warehousing.....	0.64	1.01	0.80	0.81	0.01	0.02	0.02	0.02
Water transportation.....	0.28	0.32	0.15	0.26	0.00	0.00	0.00	0.00
Transportation by air.....	0.59	0.50	0.25	0.36	0.00	0.01	0.01	0.01
Pipelines, except natural gas.....	0.05	0.06	0.13	0.07	0.00	0.00	0.00	0.00
Transportation services.....	0.22	0.30	0.36	0.55	0.00	0.00	0.00	0.00
Communications.....	0.26	0.27	0.22	0.23	0.02	0.03	0.03	0.03
Telephone and telegraph.....	0.25	0.25	0.21	0.21	0.01	0.02	0.03	0.02
Radio and television.....	0.49	0.52	0.32	0.31	0.00	0.00	0.00	0.01
Electric, gas, and sanitary services.....	0.11	0.12	0.11	0.13	0.02	0.03	0.03	0.02
Wholesale trade.....	3.31	2.28	1.13	0.90	0.08	0.08	0.09	0.08
Retail trade.....	1.52	1.50	1.00	0.95	0.13	0.12	0.11	0.11
Financial Services	3.11	2.61	1.07	1.37	0.06	0.07	0.08	0.14
Banks and Thrifts	0.86	0.85	0.41	0.54	0.02	0.02	0.03	0.05
Security and commodity brokers.....	2.21	4.98	2.53	1.18	0.00	0.00	0.01	0.02
Insurance carriers.....	3.59	2.75	0.84	0.73	0.01	0.01	0.01	0.02
Insurance agents, brokers, and service.....	2.86	3.79	2.78	2.88	0.00	0.01	0.01	0.01
Commercial and industrial real estate	0.18	0.12	0.08	0.11	0.03	0.02	0.02	0.03
Holding and other investment offices.....	0.45	0.25	0.48	0.00	0.00	0.00	0.00	0.00
Health services.....	4.42	2.83	3.13	2.62	0.02	0.04	0.07	0.08
Business services	1.49	1.64	1.31	1.93	0.01	0.04	0.06	0.13
Other Services	0.90	0.78	0.67	0.83	0.04	0.05	0.06	0.07
Hotels and other lodging places.....	0.33	0.29	0.30	0.36	0.01	0.01	0.01	0.01
Personal services.....	2.66	1.84	1.15	1.64	0.02	0.01	0.01	0.01
Auto repair, services, and parking.....	1.05	0.50	0.39	0.43	0.00	0.01	0.01	0.01
Miscellaneous repair services.....	2.60	1.93	1.27	1.40	0.00	0.00	0.00	0.00
Motion pictures.....	1.85	1.11	0.83	0.70	0.00	0.00	0.00	0.01
Amusement and recreation services.....	0.31	0.45	0.50	0.94	0.00	0.01	0.01	0.01
Legal services.....	2.46	3.12	3.50	4.88	0.01	0.01	0.02	0.02

Source: YKN2000:YK Ratios

3.Capacity Utilization. The upward shift in the Y/C ratio in the 1982-2000 period could be explained by fuller utilization of the existing stock of capital as well as technological and organizational change that increases the productivity of capital (Basu, 1996, Corrado, 1997). A major conceptual problem in estimating capital utilization is the absence of an economic definition or concept of the output capacity of capital goods. In its absence, one method of estimating the effect of business cycles on the Y/C ratio is using the Federal Reserve Board series on capacity utilization (FRB, 2002). The FRB implied Y/C ratio for the Manufacturing Sector is calculated as Actual (Q/K)/FRB Utilization Index ratio.



Sources: FRB,2001, U.S Dep't. of Commerce, 2001.

The estimated changes in the Y/C ratio resulting from cyclical changes in capacity utilization for the Private Business Sector calculated from the actual and FRB series are presented in Text Figure 4. For the entire period from 1982 to 2000 the growth in both the actual and potential Y/C ratios was a compound .8% per annum. For the period from 1982 to 1990, the actual Y/C rose by .9% - faster than the .3% for the potential Y/C as the economy increased utilization after the steep recession which bottomed in 1982. For the 1990s, however, the actual and potential Q/K ratios grew at virtually identical .8% per annum rates. Thus, I conclude (on the basis of an admittedly inadequate measure of capacity) that the upward shift in the real output/capital ratio resulted primarily from real changes in technology and organization, rather than just greater capacity utilization.

Text Table 6
Components of Change in Current $ Output/Capital Ratios: 1982-2000
Rates of Change in Capital Productivity and Relative Prices

		Components of Change in Y/C					
	Y/C	Yq	Kq	Capital Prdctvty	Yp	Kp	Relative Price
Private Busines Sector	**0.019**	**0.039**	**0.030**	**0.009**	**0.026**	**0.016**	**0.010**
Agriculture, forestry, and fishing...	**0.005**	0.030	-0.003	**0.033**	0.000	0.027	**-0.028**
Farms	**-0.016**	0.017	-0.010	**0.027**	-0.015	0.028	**-0.043**
Agricultural serv.forestry, & fishi	**0.019**	0.063	0.050	**0.013**	0.031	0.023	**0.008**
Mining	**-0.032**	-0.004	0.000	**-0.004**	-0.014	0.015	**-0.029**
Metal mining	**-0.034**	0.024	-0.011	**0.035**	-0.041	0.028	**-0.069**
Coal mining	**-0.059**	0.036	0.000	**0.037**	-0.072	0.026	**-0.097**
Oil and gas extraction	**-0.027**	-0.011	0.000	**-0.011**	-0.004	0.012	**-0.016**
Nonmetallic minerals, except fuels.	**-0.060**	-0.040	0.007	**-0.047**	0.010	0.026	**-0.015**
Construction.	**0.026**	0.036	0.022	**0.014**	0.037	0.024	**0.013**
Manufacturing	**0.006**	0.036	0.017	**0.019**	0.012	0.024	**-0.012**
Durable goods	**0.006**	0.051	0.017	**0.033**	-0.004	0.023	**-0.027**
Lumber and wood products	**0.032**	0.026	0.001	**0.025**	0.035	0.027	**0.008**
Furniture and fixtures	**0.010**	0.029	0.022	**0.007**	0.031	0.027	**0.004**
Stone, clay, and glass products	**0.026**	0.040	0.008	**0.032**	0.021	0.026	**-0.005**
Primary metal industries	**0.007**	0.017	-0.008	**0.025**	0.007	0.025	**-0.018**
Fabricated metal products	**0.010**	0.026	0.012	**0.014**	0.021	0.025	**-0.004**
Machinery, except electrical	**0.001**	0.095	0.021	**0.073**	-0.053	0.020	**-0.073**
Electronic equipment and instrume	**-0.011**	0.083	0.044	**0.039**	-0.031	0.020	**-0.051**
Motor vehicles and equipment	**0.013**	0.027	0.019	**0.007**	0.031	0.025	**0.006**
Other transportation equipment	**-0.013**	-0.007	0.019	**-0.026**	0.035	0.023	**0.012**
Miscellaneous Manfacturing	**0.016**	0.035	0.011	**0.025**	0.017	0.026	**-0.009**
Nondurable goods	**0.007**	0.017	0.017	**-0.001**	0.033	0.025	**0.008**
Food and kindred products	**0.000**	0.014	0.018	**-0.004**	0.031	0.027	**0.004**
Tobacco products	**-0.030**	-0.149	0.010	**-0.159**	0.154	0.026	**0.127**
Textile mill products	**-0.001**	0.015	-0.002	**0.017**	0.011	0.028	**-0.017**
Apparel and other textile product	**-0.022**	0.001	0.008	**-0.007**	0.010	0.026	**-0.015**
Paper and allied products	**0.000**	0.005	0.018	**-0.012**	0.037	0.025	**0.012**
Printing and publishing	**0.003**	0.001	0.034	**-0.033**	0.059	0.022	**0.037**
Chemicals and allied products	**0.024**	0.042	0.021	**0.021**	0.027	0.023	**0.004**
Petroleum and coal products	**0.007**	0.024	0.000	**0.024**	0.010	0.027	**-0.017**
Rubber and misc. plastics product	**-0.003**	0.062	0.037	**0.025**	-0.001	0.027	**-0.028**
Leather and leather products	**-0.022**	-0.027	-0.013	**-0.014**	0.019	0.028	**-0.008**
Transportation	**0.029**	0.045	0.008	**0.038**	0.014	0.022	**-0.008**
Railroad transportation	**0.001**	0.035	-0.009	**0.045**	-0.024	0.019	**-0.043**
Local & interurban passenger trar	**0.025**	0.013	0.018	**-0.005**	0.053	0.022	**0.031**
Trucking and warehousing	**0.001**	0.040	0.034	**0.007**	0.019	0.025	**-0.006**
Water transportation	**0.032**	0.012	-0.019	**0.032**	0.027	0.026	**0.000**
Transportation by air	**0.020**	0.076	0.043	**0.032**	0.017	0.027	**-0.010**
Pipelines, except natural gas	**-0.033**	-0.013	-0.006	**-0.008**	-0.003	0.023	**-0.026**
Transportation services	**0.024**	0.053	0.041	**0.012**	0.027	0.014	**0.014**
Communications	**0.001**	0.043	0.046	**-0.002**	0.015	0.011	**0.004**
Telephone and telegraph	**-0.002**	0.046	0.039	**0.007**	0.002	0.010	**-0.009**
Radio and television	**-0.001**	0.037	0.090	**-0.053**	0.068	0.016	**0.052**
Electric, gas, and sanitary services	**0.008**	0.023	0.017	**0.006**	0.025	0.023	**0.002**
Wholesale trade	**-0.013**	0.052	0.058	**-0.005**	0.008	0.016	**-0.008**
Retail trade	**-0.003**	0.045	0.039	**0.006**	0.018	0.027	**-0.009**
Financial Services	**0.014**	0.043	0.042	**0.001**	0.052	0.038	**0.014**
Banks and Thrifts	**0.015**	0.023	0.063	**-0.040**	0.073	0.017	**0.056**
Security and commodity brokers	**-0.042**	0.153	0.158	**-0.005**	-0.026	0.018	**-0.044**
Insurance carriers	**-0.008**	0.011	0.091	**-0.080**	0.091	0.021	**0.070**
Insurance agents, brokers, and serv	**0.002**	0.020	0.063	**-0.044**	0.065	0.019	**0.046**
Commercial and industrial real esta	**0.021**	0.065	0.033	**0.032**	0.022	0.031	**-0.009**
Holding and other investment office	**-0.244**	-0.241	0.088	**-0.328**	0.084	0.028	**0.056**
Health services	**-0.010**	0.018	0.074	**-0.056**	0.057	0.012	**0.045**
Business services	**0.022**	0.069	0.060	**0.009**	0.040	0.025	**0.015**
Other Services	**0.012**	0.027	0.050	**-0.024**	0.052	0.015	**0.037**
Hotels and other lodging places	**0.010**	0.021	0.031	**-0.009**	0.051	0.031	**0.020**
Personal services	**0.020**	0.021	0.032	**-0.011**	0.043	0.011	**0.032**
Auto repair, services, and parking.	**0.005**	0.033	0.052	**-0.018**	0.045	0.022	**0.024**
Miscellaneous repair services	**0.006**	-0.004	0.031	**-0.034**	0.061	0.021	**0.040**
Motion pictures	**-0.009**	0.051	0.083	**-0.032**	0.045	0.023	**0.022**
Amusement and recreation services	**0.035**	0.056	0.032	**0.024**	0.041	0.027	**0.014**
Legal services	**0.019**	0.019	0.044	**-0.025**	0.063	0.018	**0.045**

Source: YKN2000:ATIV

4 Nominal v. Real Sources of Shift in the Y/C Function. Aggregate evidence presented in Text Table 2 revealed that part of the increase in the Y/C ratio in the last two decades resulted from the prices of output rising more rapidly that the prices of capital goods. The disaggregated evidence on real growth in capital productivity and differential price changes in capital goods and final output is presented in Text Table 6.

The summary evidence for the sources of growth in the nominal (Y/C) ratio for the Private Business Sector for the period 1982-2000 (Row 1) shows that the rate of growth in the productivity of capital grew at a rate of .9% per year while output prices grew faster than capital prices by 1% per year during the period.

There were substantial differences in rates of change in capital productivity and rates of change in relative prices in the various sectors of the economy. In the quantitatively important Manufacturing Sector capital productivity rose at 1.9% but since the price index of output rose by 1.2% per annum more slowly than the price index of capital goods the nominal output/capital ratio rose only by the difference of .006 per annum. As noted earlier, within the Manufacturing Sector growth in capital productivity was particularly strong in the Durable Sector and also in capital-intensive chemicals, petroleum, and rubber products. As would be expected in competitive markets, the increased productivity of capital resulted in the prices of output falling relative to capital goods prices in these sectors and this reduced what would have been an ever greater rate of increase of the Y/C ratio. Similarly, in Agriculture the Y/C ratio was virtually stable because the increase in the productivity of capital was almost exactly offset by the slower increase in the relative price of final output; i.e., the farm gate price of food rose more slowly than the price of tractors because the increase in the productivity of tractors was less than the increase in the price of tractors. Throughout the economy the declining price of capital goods relative to their productivity, particularly computer equipment and software, increased the real productivity of capital.

In service sectors, because productivity growth was slower than in the capital goods-producing sectors, prices of final output rose more rapidly than the prices of the capital goods employed in service sectors. Thus, in the various service sectors of the economy, the increase in the Y/C ratio largely resulted from increases in the price of final output relative to capital prices; this was particularly true in Financial Services and Health Services and to a lesser extent in Business Services and Other Services. The Y/C ratio

declined in Wholesale and Retail Trade—largely because the price of capital goods rose more rapidly than margins in these two sectors.[27]

The aggregate Y/C ratio rose during the period both because of the increased productivity of capital in capital-intensive sectors and because of more rapid increases in the price of final output than capital in the less capital intensive service sectors. The economic importance of the rise in the nominal (Y/C) ratio due to the decline in the relative price of capital goods deserves emphasis. Households, businesses, and government all "save" on the basis of nominal incomes. If the price of capital goods declines relative to final output, the economy can increase its rate of capital formation for the same rate of saving or get the same rate of capital formation with a lower net saving rate. Productivity growth in the production of capital goods increases the potential rate of growth or sustainable level of consumption.[28]

Conclusion

Natura non facit saltum[29]

Is there a "new economy"? Yes. That economy started to emerge in the U.S. after the 1982 recession. The sources of growth within some sectors—particularly manufacturing—lends some support to economists' theorizing about endogenous growth. There is evidence to support the the widely held notion that computers and changes in information technology have brought increases in productivity within some other sectors and industries of the economy. However, in the Wholesale, Retail, and Financial Services sectors—where claims have been made for the importance of the computer and the internet—most of the increases in labor productivity appear to have come from traditional capital deepening rather than upward shifts in the production functions of particular industries. Workers increased their productivity by working with better computers and computer software.

However, the evidence also indicates that about half the upturn in growth in the Private Business Sector in the new economy resulted from the continuing shift in the structure of the U.S. economy away from more capital intensive to less capital intensive output industries and sectors rather than substantial shifts in the production functions for particular industries. Endogenous growth within the manufacturing

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27 It merits emphasis that the output of the Wholesale and Retail sectors is (primarily) the "gross margin" between the cost of goods and their selling price. Consolidation in these sectors led to a decrease in the markup of price over cost coupled with increases in volume of goods and services processed.
28 This point is elaborated in the Appendix.
29" Nature does not take leaps." (Alfred Marshall, Principles of Economics, 1896.)

sector and structural shifts in the composition of output were about equally important to the observed acceleration in growth resulting from the upward shift in the aggregate production function in the Private Business Sector.

Shifts in the composition of output are an integral part of the process of economic growth. Capital-intensive sectors decline in relative size because of changes in the composition of final demand that accompanies higher incomes created by economic growth and because differential productivity growth reduces the size and relative prices of goods produced by the more capital intensive sectors (Bjork, 1999).

Are there particular macroeconomic conditions which accelerated the shift after 1982? Here we are on more speculative ground. As an economist, I would expect that part of the upward shift in the macroeconomic production function from structural shifts and endogenous growth within sectors resulted from increased international specialization and the competitive effects of international competition on the internal allocation of labor and capital. Part of it may be due to the increase in competition for corporate control – corporate mergers, acquisitions, and leveraged buyouts that have forced management to use capital more effectively or lose control of it.

Competition in capital and labor and final output markets is important to productivity growth as well as "fairness" in income distribution. If a firm purchases its capital and labor inputs in competitive markets and sells its goods in competitive markets, very small changes in productivity from superior technology or management will allow it to increase its market share over time from only slightly less efficient competitive firms. When technology and markets are changing rapidly, this can happen very quickly. The importance of markets is not just static efficiency in the allocation of labor and capital; it is their dynamic effect on the invention and diffusion of more productive technology and organization.

Greater price stability and output stability in the period from 1982-2000 than in the period from 1966 to 1982 may also have improved the allocation of capital and reduced frictions in the management of the labor force. The Mexican, Asian and Russian financial crises of the 1990s prolonged the "boom" of the American economy. The inflow of foreign capital in response to financial instability abroad increased the exchange value of the dollar which, in turn, retarded the usual inflation and increases in interest rates that accompany cycles and eventually choke off the boom.

Given the coincidence of the 1966 and 1982 peak and trough in the output/capital ratio and the steady rise in the ratio from 1982 to 2000, it is tempting to link the downward and upward swings in the productivity of capital with the parallel movements in the P/E ratios in major stock indices and I expect that there is some relationship here. There is not a direct relationship, however, because increases in output per dollar of capital do not necessarily entail increases in profits per dollar of capital. With competitive product and factor markets, most of the increase in real income that results from productivity growth goes to workers and consumers through prices rising more slowly than wages.

Significance: What is the significance of the evidence presented in this paper? First, the importance of the acceleration of productivity growth in the Private Business Sector was not only its occurrence but the fact that it resulted from endogenous growth in productivity within industries that was large enough to offset conventional decreasing returns to capital deepening. This was a new development in the process of economic growth. However, it is also important to remember that the upward shift in the aggregate production function was equally attributable to the continuing shift in the ouput structure of the economy.

Implications: What are the implications of these findings? The most important is that the upward movement in productivity growth that began in the 1980s and accelerated in the 1990s moved the economy to a higher *level* of output and productivity—a new economy. However, this does not entail that the *growth* of productivity will continue at a higher rate—much less accelerate. An important implication of the importance of structural change to the long-run process of economic growth is that we should not expect the higher rates of growth in productivity to occur indefinitely. Without structural change in the composition of output, the growth rates would have been about half of what we observed. While endogenous growth can continue indefinitely and even accelerate, structural change from lower to higher productivity industries or from lower to higher productivity firms within an industry can only occur once![30] Further, the increase in the size of the service sectors increases their weight in the aggregate economy and in these sectors productivity growth is probably slower but certainly unmeasureable with current accounting conventions.

Another implication of this paper is that the measurement of national economic performance by gross output for the entire economy rather than net output for the sector of the economy where

30 After retailing has experienced productivity gains from moving sales from small merchants to Walmart, or from three pump "service" stations to 24-pump gas stations the shift cannot take place again and productivity gains from structural shift will decline.

measurement concepts and data are better can conceal changes in productivity growth that may have important consequences for national welfare. We can't tell from current NIA measurement concepts and data whether expenditure on health care and education are securing increases in human health or educational capital per real unit of labor and capital applied in those sectors.

One of the most important policy implications of the increase in the Y/C ratio is that net saving for increases in the capital stock may not need to be as large a proportion of national income if the output/capital ratio in the Private Business Sector is increasing. However, it is important to realize this accounts for only about a third of the fixed capital in the economy.[31] In 2000, the end year for my analysis, the United States had almost $30 trillion dollars in physical assets measured in terms of their replacement cost in current dollars – the GDP/Physical Assets ratio for the total economy was about 1/3. From the standpoint of macro policy, there needs to be further research on the need for gross and net investment in the total economy.

And , finally, the impact of human capital and knowledge capital on the endogenous shifts in production functions are not accounted for in this paper. They are the quantitatively "unknown" inputs in the aggregate production function. The level and rate of growth of human capital and knowledge capital depend upon the allocation of resources to their production—labor and capital can be used during the current time period to produce consumption goods or physical capital or government provision of internal security or external defense—or they can be used for the further education of the labor force and/or the increase in the stock of knowledge that determines the technology and organization that underlies individual and aggregate production functions.

APPENDIX

Economic theory has long used the concept of the production function to describe and explain the relationships between inputs and output in the production of goods and services. Productivity is the ratio of outputs to inputs. Economic growth is the increase in the ratio. The behavior of the production function over time is central to the empirical measurement and explanation of economic growth.

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31 Fixed assets in the Private Business Sector in 2000 comprised about 1/3 of the total fixed capital in the U.S. economy; the residential housing stock – both owner and tenant occupied – accounted for another third. Government fixed assets—schools, hospitals, streets and roads, water and sewer systems, and computer software accounted for another fifth of physical assets and the remainder was split between the Not-For-Profit Sector (churches, private schools, museums, labor unions, et al.) and consumer durables owned by households.

Increases in output per worker input are driven both by the increase in capital input per worker and by technological and organizational change that increases output per worker with the same amout of capital per worker. The rate of change of output per worker is the sum of the rates of change in the capital/labor and the output/capital ratios.

Notation:

Q≡ Real output, K ≡ Real Capital Stock input, and N ≡ Labor input:

$$Q/N \equiv K/N \times Q/K \qquad 1.0$$

$$\text{Differentiating: } \partial (Q/N) /\partial t \equiv \partial (K/N) \partial t + \partial(Q/K) \partial t + ((\partial(K/N)/\partial t) \times (\partial(Q/K)/\partial t)) \qquad 1.1$$

$$\text{Simplifying notation with lower case letter for derivatives: } q/n \equiv k/n + q/k + (k/n \times q/k) \qquad 1.11$$

What drives the rate of change in labor productivity – the rate of change in output per unit of labor input (q/n) - is the sum of the growth rates in the capital/labor ratio (k/n) and the output/capital ratio (q/k).[32] The conventional theory of the aggregate production function posits that k/n will be greater than q/n and q/k will be negative.[33]

The rate of growth of k/n is *assumed* to slow because of diminishing returns to capital. Conventional growth theory explains the slowdown in the rate of growth of output per worker as the combined effect of the slowdown in the rate of growth of capital per worker and the negative rate of change of the output/capital ratio.

Classical (e.g., J S Mill and Karl Marx), Neoclassical (e.g. ,Robert Solow,1956), and New Classical (e.g., Robert Barro,1995) growth models all *assume* diminishing returns for both labor and capital in the aggregate production function; this assumption is extrapolated from the Ricardian theory of variable proportion microeconomic production functions exhibiting diminishing returns.[34] The decreasing return to capital causes a decrease in the level of saving, net investment, and, hence, the slowdown of the rate of growth of capital per worker (k/n) in all theories.[35]

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32 Rates of change are computed as $X_{(t+n)} / X_t^{(1/n)} - 1$ where X is the variable and t is time and n is the interval.
33 If(k-n)>0 and (q-n)<(k-n), then (q-k)<0. If the capital labor ratio is increasing and accompanied by diminishing returns, then output is increasing more slowly than capital and the Q/K ratio will be falling.

34 One of the ironies of using the Ricardian production function is that Ricardo's purpose was to explain the effects of population growth on the distribution of income and the subsequent use by Neoclassical economists has been, primarily, to explain static equilibrium conditions in product and factor markets.
35 Classical and New Classical theories assume that diminishing returns lower the net return on capital while the supply of capital from saving is positively related to the real rate of interest. Net investment asymptotically approaches zero as the marginal efficiency of capital approaches the minimal rate of social time preference.

This assumption of diminishing returns has long existed alongside an emphasis, by other economists, on constant or even increasing returns from technological and organizational change increasing output per worker with the same or even less capital input. Modern endogenous growth theory (Romer, 1986) posits that the technologically generated shifts in production functions can be explained and produced by increases in human capital and by investment in research and development. However, the incorporation of emprical data on human and knowledge capital into macro models has been limited and disagreement between optimists and pessimists on the potential for long-term growth has continued.

The link between declining capital growth and the aggregate production function is inferred from the fall in the ouput/capital ratio. Robert Solow formalized the link between capital growth and the aggregate production function in Neoclassical growth models (Solow, 1956) but then, paradoxically, went on to supply some empirics on the relative importance of technological change rather than capital deepening in the process of economic growth (Solow, 1957).[36]

The Neoclassical growth model builds on the extrapolation of the conventional microeconomic production function. To simplify the presentation of the theory, it is assumed (1) that the aggregate production function behaves like the conventional microeconomic production function and exhibits continuously diminishing returns as the capital/labor ratio is increased, (2) that depreciation is a constant proportion of capital, (3) that saving is a constant proportion of income, (4) that labor force is constant, and (5) the production function does not shift as a result of technological or organizational change. With these

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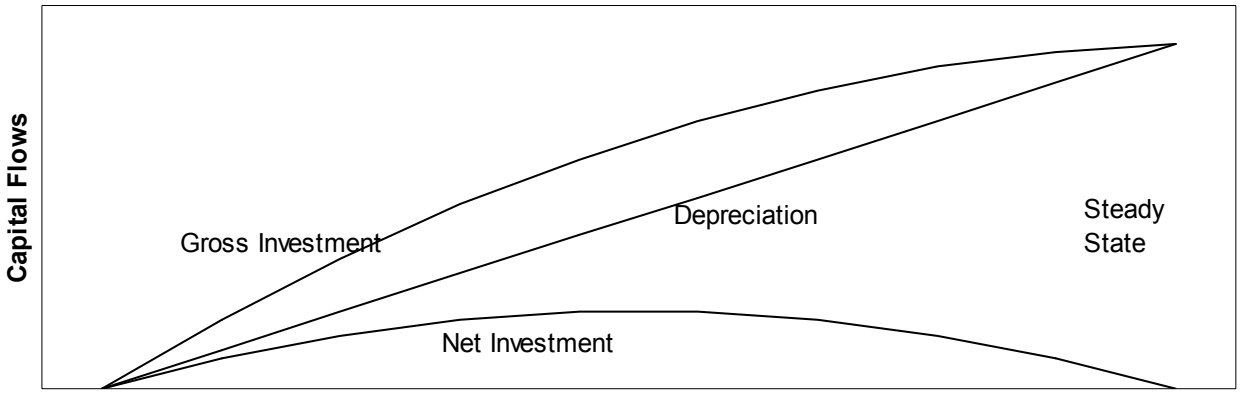
Abstracting from the effects of productivity change and labor force growth, capital and output per worker asymptotically approach a "steady state."

Neoclassical theorizing about the aggregate production function and economic growth began with extensions of the Keynesian analytic framework by Harrod and Domar. Keynesian macro theory followed classical theory in making the declining marginal effficiency of capital the determinant of the decrease in investment; however, the Keynesian saving rate becomes a function of income levels rather than interest rates. Consequently, in the Neoclassical growth model, the growth in the capital stock becomes a function of the saving ratio, depreciation rates and the (output/capital)Y/K ratio. The linking of Keynesian growth models to Neoclassical production functions entailed that increases in the capital/labor ratio which accompanied economic growth would lead to a decline in the output/capital ratio. In turn, that would slow the growth rate of income, saving, capital formation, and, hence, output growth.

36 Solow's empirical work indicated the relative importance of technological and organizational change—the "residual" rather than capital deepening in productivity growth. It paved the way for growth accounting by Denison (1962), Jorgenson (1967), Kendrick (1973), (Mankiew et al., 1992) and others that attempted to analyze growth by disaggregation of the inputs. In growth accounting models, labor and capital inputs are disaggregated in an attempt to reduce the unexplained "residual" to conform the standard production function to the evidence. For example, labor inputs are quantitatively increased by the incorporation of human capital through education and capital inputs are varied by utilization levels. However, these models do not test directly for upward shifts in the production function.

simplifying expository assumptions, the model posits that the rate of growth of capital per worker will inevitably slow *because of the fall in the output/capital ratio that accompanies the rise in the capital/labor ratio*.

Appendix Figure 1: The Neoclassical Growth Model



The Neoclassical Growth Model is shown in Appendix Figure 1. The Capital/Labor ratio is shown on the horizontal axis and the flows of capital from saving and depreciation are shown on the vertical axis. Depreciation is assumed to rise at a constant rate as the (K/N) ratio increases. Gross saving is assumed to be a constant proportion of income. Net investment is the difference between gross saving/investment and depreciation. The *level* of net capital investment per worker rises and then asymptotically approaches zero when the gross saving and depreciation functions cross at the "steady-state" level of capital/labor and capital/output. The *rate* of net capital formation increases and then slows as the level of net investment declines and the capital stock base increases. (Not included in Figure or model.)[37]

In the Solow Neoclassical growth model, the savings and depreciation rates determine the equilibrium *level* of the capital stock rather than the *rate* of growth of the capital stock. The *rate* of growth of capital slows as the economy asymptotically approaches the steady state because the level of the capital stock is increasing and net investment is decreasing. Increasing the saving rate or decreasing the depreciation rate may temporarily postpone the inevitablity of the slowdown in capital formation per worker within the model. Outside the model, the production function may be shifted by technological

37 Using standard notation: $k = s(Y/K) - dK$: $k \equiv$ rate of growth of the capital stock, $s \equiv$ gross saving and investment flows as a proportion of net output, $Y \equiv$ net output, $K \equiv$ current capital stock, $d \equiv$ depreciation rate of the capital stock.

change or increasing returns from investment in human capital and/or knowledge capital. But, within the model the growth rate of capital stock per worker—and by assumption, output per worker—inevitably slows and asymptotically approaches a steady state.The Neoclassical growth model is not really a theory of the growth of capital or income – it is a theory about the optimal level of the capital stock.

The appeal of the Neoclassical growth model is its elegance and expositional simplicity. The applicability of the model depends upon the reality of its three assumptions: (1) the Ricardian diminishing returns production function; (2) the constant depreciation rate; (3) the constant saving rate. The model must be supplemented with a labor force variable to take into account changes in the growth rate of the labor force due to demographic and participation rate changes because variations in labor force growth affect the level of net investment per worker and the rate of growth of the capital stock per worker.

There is a further complication in the Neoclassical model. The income outputs and capital inputs are in "real" (price-level adjusted) terms. However, if these series are deflated by different price indexes applicable to capital goods and final output goods and the price of final output increases relative to the price of capital goods, the growth in the real capital stock need not decline as rapidly as income with a constant saving rate. It can be argued that a fundamental characteristic of economic growth is a fall in the price of capital goods relative to their potential output capacity (Bjork,1999). The evidence in this paper indicates that the aggregate price level for the stocks of physical capital goods (buildings, machines, computer software) fell relative to final output prices in the 1980s and 1990s. This fall in the relative price of the capital stock entails that a given expenditure on capital stock yields more potential output per dollar of capital stock.

Thus, from a macroeconomic perspective, it is the nominal output/capital (Y/C) ratio that is important in assessing the change in the aggregate production function reflected in the nominal output/capital ratio.[38] A secular upward movement in the Y/C function due to either real or relative price change factors would constitute evidence for a "new economy" that avoids, even if temporarily, the steady decline in the growth in output per worker that results from the process of capital deepening. Both Classical and Neoclassical growth theories predict a decline in the ratio of saving and investment during the process of economic growth *because of the decline in the marginal productivity of capital that occurs with capital deepening*.. However, the return to capital would not fall if upward shifts in the production function raised

38 It is for this reason that both nominal (Y/C) and real (Q/K) ratios are analyzed in the paper.

the marginal efficiency of capital *or if prices of capital equipment rise more slowly than the price of final output because of higher productivity in the industries producing capital goods.*[39] As the nominal output/capital (Y/C) ratio rises for either relative price or real reasons, either the proportion of net output saved can be reduced—and the share of consumption can rise—or the growth rate of capital (and income) can increase.

For example, with a net saving/investment rate of 6%, labor force growth of 2%, and a Y/C ratio of .5 (approximate values for the new economy), capital per worker increases by 1% per year. If the Y/C ratio goes to .75, the growth rate of capital per worker rises to 2% per year—it doubles. And, assuming constant returns, the growth rate in output per worker would rise from 1% to 2% per annum. Or to consider it another way, with the same assumptions, the net saving rate could fall from 6% to 4% with no change in the rate of growth of capital per worker. Another way of thinking about the new economy is that the saving and net investment rate could decline without decreasing the rate of growth of capital per worker or output per worker.

Conventional growth models link the slowing of capital per worker to a declining macroeconomic saving rate and constant depreciation rate. However, an aggregate saving rate is not usable for analysis of capital formation within an individual sector of the economy and the depreciation rate has been increasing. Further, there are theoretical and empirical problems in identifying the flow of net investment because of the absence of a flow series on depreciation. Consequently, I use direct evidence on the rate of growth of the capital stock from annual estimates of the capital stock and restrict my analysis to a segment of the economy where measurement of inputs and outputs are available and more reliable—the Private Business Sector. The rate of growth of the aggregate capital stock per worker within this sector declines as predicted by conventional growth theory but not primarily because of the declining saving/investment inferrence from conventional theory.

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39 As a heuristic example, if nominal incomes rise faster than housing prices, the proportion of income saved and invested in housing can be reduced as a proportion of income.

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