The Alchemist Fallacy and the New Economy

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Abstract

Valuation of new economy firms during the late 1990s rested on the alchemist hypothesis that not only could computer code be spun into gold but also that producers could capture a significant fraction of the Schumpeterian profits. The present study of 33 U.S. industries over the period 1977-2000, and a separate study of 3 new economy industries, finds that the alchemist hypothesis is decisively wrong in this period for these industries. Only a miniscule fraction of the social profits from technological advances were captured by producers, indicating that the view that rapid technological advances could rationalize high stock prices was subject to the alchemist fallacy.

Alchemy was an ancient art devoted to discovering a miraculous substance that would transmute common metals into gold. Once upon a time, perhaps two years ago, some believed that such a substance had been found in the world of electrons, optical fibers, and C++. The "new economy" was indeed providing miraculous productivity growth along with a dazzling array of new goods and services. The phenomenal increases in computer power over the twentieth century, for example, were far larger than anything else in the historical record.[1] Communications speed and access and retrieval speeds for information were also growing at astounding rates.

Many have scoffed at the idea that base metals can be transmuted into precious ones. But that was not the alchemist fallacy. Many far more miraculous things have come to pass than such a simple physical transformation. Imagine that you could ask the most esteemed scientists of the 19th century which was more likely – transforming base metals into gold or producing new elements named after the remotest planets of the solar system from which a few kilograms could destroy entire cities. They would probably find today's reality stranger than alchemy.

Rather, the alchemist fallacy was to think that, once a process for producing gold was discovered, gold would retain its scarcity and the discoverers would be rich beyond belief. The laws of economics teach us that were anyone to find such a miraculous substance, its value would quickly fall as entry, imitation, and innovation rapidly eat away at the profits, and increased supply would lower the price of miracles.

Turning to the alchemists of the new economy, the rapid rate of innovation in the "new economy" since the mid-1990s along with the rise and fall of equity valuations in the dot-com bubble and burst after March 2000 were one the most intriguing and puzzling economic events of recent years. Many analysts apparently believed that a substantial part of the economic value of the innovations in new economy firms would be captured by the innovators, and this in part drove the stock market boom of the dot.com firms and the NASDAQ market sector.

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[1] See William Nordhaus, "The Progress of Computing," version 5.1, February 6, 2002.

The present study examines the relationship between innovation and profitability with an eye to determining whether the behavior of stock prices in the dot-com era was evidence of the alchemist fallacy.

I. Background

A. <u>The rise and fall of the new economy in financial markets</u>

The rise and fall of the stock values of new economy firms is well known. The largest new economy firms (those with market capitalizations of $1 billion or more) had a value of around $3 trillion in March 2000, but by summer 2002 the value of those firms had declined to about $900 billion (of which about $500 billion was the 5 largest new economy firms). This decline was very close to that of the NASDAQ computer subindex, which declined 75 percent.

The stock market valuations of new economy stocks are now routinely dismissed as "idiocy" and a "bubble." As Business Week put it, "Many pundits have left the New Economy for dead. Now they're talking about the 'Bubble Economy.' "[2] Possibilities that excited investors in early 2000 are now routinely dismissed as ridiculous, as for example, "[M]any people were willing to pay ridiculous prices for shares of stocks that in some cases were literally worthless."[3] Yet, people owned $3 trillion in market value of new economy stocks in early 2000 and (at least on the margin) held beliefs that these stocks were good investments. What were they thinking about?

B. <u>Rationales for high new economy stock values</u>

A small industry of scholars has been analyzing the behavior of new economy finance. Some of the discussions focus on technical issues, such as the high volume or high fraction of stocks that were locked up.[4] I will focus here on views based on economic fundamentals – ones that

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[2] Peter Coy, *Business Week*, August 27, 2002.

[3] Dean Baker and Mark Weisbrot, "Hold On While I Sell," *Miami Herald*, March 26, 2001

[4] See particularly John Cochrane, "Stocks as Money: Convenience Yield and the Tech-Stock Bubble," NBER Working Paper, NBER Working Paper No. w8987, June 2002.

entertain the possibility that a substantial part of the valuations were ex ante rational.

Schwartz and Moon describe the underlying rationale of high valuations as follows:

> [Enthusiasts] see the Internet as dramatically transforming the way in which businesses is transacted. These investors believe that some of the upstart Internet companies will rapidly grow to dominate and even make irrelevant their traditional "bricks-and-mortar" competitors.[5]

Erik Brynjolfsson, Lorin M. Hitt, and Shinkyu Yang put the case more affirmatively in terms of the value of information technology.

> Taken together, these results provide evidence that the combination of computers and organizational structures creates more value than the simple sum of these contributions separately…. Our interpretation has focused on the assumption that the stock market is approximately correct in the way it values information technology and other capital investments firms rather than new high-technology entrants; thus, our results are not likely to be sensitive to a "high tech stock bubble." Interestingly, productivity analysis by Brynjolfsson and Hitt (1997) found that the long-run productivity benefits are approximately five times the direct capital cost of computers, consistent with a valuation of IT on the order of five times higher than the valuation of ordinary capital.[6]

Robert Hall lays out a defense of pricing of new economy stocks as follows:

> Economists are as perplexed as anyone by the behavior of the stock market…. I entertain the hypothesis that these large movements are the result of rational (if not accurate) appraisal of the cash likely to be received by shareholders in the future.[7]

In one sense, Hall is postulating that the new economy stocks will have an average and marginal q on their investments that exceeds unity.

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[5] Eduardo S. Schwartz and Mark Moon, "Rational Pricing of Internet Companies," September 1999, Revised January 2000, UCLA Working Paper.

[6] Erik Brynjolfsson, Lorin M. Hitt, and Shinkyu Yang, "Intangible Assets: How the Interaction of Computers and Organizational Structure Affects Stock Market Valuations," Working Paper.

[7] Robert Hall, "Struggling to Understand the Stock Market," …. ???

The most explicit assumption of the relationship among technology, profitability, and the stock market is in Greenwood and Jovanovic.[8] They postulate a Lucas tree model in which some trees (the old economy) suddenly die to be replaced in the future by new and better trees (the new economy). These new trees will not trade on the market for T periods, at which point the total value of stocks (but not the total social value of assets) rises by the value of the new economy IPOs. Note that in this circumstance, the value of the new trees is exogenous rather than produced, and furthermore the value is completely captured by the new economy owners. The results are summarized as follows:

> The vintage capital model teaches us that technological change destroys old capital. We have gone further and argued that major technological change—like the IT revolution— destroys old firms. It does so by making machines, workers, and managers obsolete. Product-market entry of new firms and new capital takes time, and their stock-market entry takes even longer. In the meantime, the stock market declines. We have argued that aggregate valuation can fall below the present value of dividends because capital may "disappear" right after a major technological shift, as new capital forms in small, private companies. Later, these companies are IPO'd, and only then does their value become a part of stock-market capitalization.[9]

The central idea in their model is that owners of the new trees are enriched by an exogenous event that creates value in their trees and destroys value in other trees. The value represents Schumpeterian profits on a chance technological shock to the economy.

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[8] Jeremy Greenwood and Boyan Jovanovic, "The Information-Technology Revolution and the Stock Market," *American Economic Review*, May 2001.

[9] Bart Hobijn and Boyan Jovanovic, "The Information-Technology Revolution and the Stock Market: Evidence," *American Economic Review*, December 2001.

C. <u>The central issue of appropriability</u>

The central question these studies raise, and the major economic question raised by the high market valuations of new economy firms, is the economic nature of the new economy technological revolution. Were these astounding technological changes – first created by the computer and then followed by further revolutions in software, communications, and finally the Internet – appropriable by their innovators or close followers?

In this interpretation, it matters little whether the information revolution was a major technological revolution (which I believe) or just another of a continuous stream of innovations that capitalism generates all the time. Even if it was the biggest revolution since fire or lighting, it would not generate excess stock value for the firms in the industry (that is, stock values greater than the replacement cost of assets) unless the firms were able to appropriate a significant fraction of the social value of the technological change. Subject to the accusation of being mono-causal, I would argue that the major questions involved in assessing the new economy stock market bubble are:

> (1) whether and to what extent innovations and technological change are generally appropriated by their inventors and innovators, so that a significant part of the market value of firms is the capitalized value of Schumpeterian profits;
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> and
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> (2) whether the nature of the information revolution is such that it is likely to be more easily appropriated, or was in fact more appropriated, than is the norm for technological change in the rest of the economy.

These two questions will be addressed in the balance of this study.

II. A Model of Appropriability and Schumpeterian Profits

The underlying idea to be developed in this section is straightforward. Numerous individuals and firms in a modern economy are engaged in innovative activities designed to produce new and improved goods and services along with processes that reduce the cost of production. Some of these are formalized in legal ownership of intellectual property rights such as patents, copyrights, and trademarks, while others are no more than trade secrets or early-mover advantages. Some of the innovative activities produce extra-normal profits (called Schumpeterian profits), which are profits above those that would represent the normal return to investment and risk-taking.

Most of the innovations produce social value as well as private value. When copy machines replace scribes, or computers replace hand calculations, the social cost of producing a given amount of goods declines. It is well-established that innovators do not generally capture the entire social value of inventive and innovational activity.[10] To a first approximation, it is generally believed, most of the value of new

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[10] There is an vast literature discussing the relationship between social and private returns to innovation. See Zvi Griliches, "Research Expenditures and Growth Accounting," in M. Brown, ed., *Science and Technology in Economic Growth*, New York, Wiley, 1973; Zvi Griliches, "Productivity, R&D, and Basic Research at the Firm Level in the 1970s," *American Economic Review*, vol. 76, 1986, pp. 141-54; Bronwyn Hall, "The Private and Social Returns to Research and Development," in Bruce Smith and Claude Barfield, *Technology, R&D, and the Economy*, Brookings, 1995, pp. 140-183; Adam Jaffe, "Technological Opportunity and Spillover of R&D: Evidence from Firms' Patents, Profits, and Market Value," *American Economic Review*, vol. 76, 1986, pp. 984-1001; Adam Jaffe, Manuel Trajenberg, and Rebecca Henderson, "Geographical Localization of Knowledge Spillovers as evidence by Patent Citations," *Quarterly Journal of Economics*, 1993; Richard Levin, Alvin Klevorick, Richard Nelson, and Sidney Winter, "Appropriating the Returns from Industrial Research and Development," *Brookings Papers on Economic Activity*, no. 3, 1987, pp. 783- 820; Edwin Mansfield, "Social and Private Rates of Return from Industrial Innovations," *Quarterly Journal of Economics*, 1977, vol. 91, pp. 221-40, "Basic Research and Productivity Increase in Manufacturing," *American Economic Review*, vol. 70, 1980, pp. 863-873, "How Fast Does New Industrial Technology Leak Out?" *Journal of Industrial Economics*, vol. 34, 1985, pp. 217-223, "Macroeconomic Policy and Technological Change," in Jeffrey C. Fuhrer and Jane Sneddon Little, eds, *Technology and Growth*, Conference Proceedings, Federal Reserve Bank of Boston, 1996, pp. 183-200; Edwin Mansfield et al., *Social and Private Rates of Return from Industrial Innovations*, 1995, NTIS, Washington, D. C.; and Nathan Associates, *Net Rates of Return on Innovation*, Report to the National Science Foundation, 1978.

products and processes has been passed on to consumers in the form of lower prices of goods and services.

But not all. Often, inventors and innovators get at least a slice of the social returns to productivity growth. There is, however, very little evidence on the size of the slice that goes to the originators of technological change. But there is scattered evidence that the degree of appropriability varies greatly across industries. Some industries like pharmaceuticals have high rates of profit and appear to capture a substantial fraction of the value of new products during (and sometimes after) the patent lifetimes. Other industries, such as farming, are ones which have enjoyed very rapid productivity growth without a corresponding high profitability of farmers or farm-equipment manufacturers.

One of the central questions about the new economy that I will address below is the extent to which the innovating firms in the new economy have been able to capture the economic value of the rapid technological change in that sector. To the extent that the new economy had the prospect of the happy conjunction of rapid innovation and high appropriability, perhaps the elevated stock prices of new economy firms were rational, as some of the discussion above indicates.

We can formalize these issues as follows. The basic assumption is that there is a stream of innovations in an industry, which lead to a more or less continuous reduction in the cost of production, c_t, for firm or industry i (I suppress the notation that this refers to industry i where inessential). Some of the innovations are in the public domain, such as the availability of improved weather forecasts. These are inappropriable and are therefore passed on in lower prices of goods or services. Other cost reductions are at least partially appropriable by the producers in the industry and are only partially passed on in price reductions. For those innovations whose cost reductions are partially appropriated, the producers or innovators will have temporary increases in profits, which are labeled Schumpeterian profits.

The two-period version of this model will illustrate the basic points. Consider a perfectly competitive industry where the technology is constant returns to scale. The level of productivity is represented by A_t, and the cost of production is $C_t = kA_t$, where k is a constant. In period 0, the dominant technology is widely available and determines the market price. The dominant technology costs C_0 and the good has a market price of $P_0 = C_0$.

A new innovation arrives in period 1 and lowers production cost to $C_1 < C_0$. Assume that the inventor can appropriate the fraction a of the cost savings from the innovation; a is the fundamental *appropriability ratio,* which will be estimated below. Then for small innovations, the inventor maximizes profit by setting the price at $P_1 = C_1 + a\ (C_0 - C_1)$. Figure 1 shows the initial competitive price, new cost, and new price under these assumptions. The shaded profit region is Schumpeterian profits. As is shown in Figure 1, the second-period price (P_1) lies between competitive cost of the old technology (C_0) and the new lower cost of the innovation (C_1). The extent to which P_1 is above the C_1 depends upon the appropriability ratio.

The inventor's profits are equal to $(P_1 - C_1)X_1$, which can be approximated by $a\ (C_0 - C_1)X_0 = a\ [(C_0 - C_1)/C_0](P_0 X_0) = a\ (\Delta A_1/A_0)Q_0$, where $Q_t = P_t X_t$ is nominal output. In words, *the private value of the innovation to the innovator is approximately equal to the appropriability ratio times the rate of improvement in technology times the value of output.*

To put this theory in a dynamic framework, we need to take into account the erosion of Schumpeterian profits over time. These temporary profits decay because of such factors as the expiration or non-enforcement of patents, the ability of others to imitate or innovate around innovations, the introduction of superior goods and services, and the loss of first-mover advantages. I will model the erosion of Schumpeterian profits as an exponential-decay process with decay rate λ per year. This implies that if an innovation was introduced θ years ago, the appropriation rate would be $ae^{-\lambda\theta}$ at the end of θ years. Finally, to simplify the analysis, I assume for this exposition that prices and costs are normalized so that the cost of inputs is always 1. This implies that any reduction in costs is due only to productivity growth.

Using the framework just introduced, this implies that if there were only one innovation, which occurs in period $(t-\theta)$, current price would be:

$$(1)\qquad P_t = C_t - ae^{-\lambda\theta}\ (C_t - C_{t-\theta}).$$

If the stream of innovations is continuous, then current price would be determined by the past innovations and the extent to which Schumpeterian profits had eroded. Because an innovation θ periods ago yielded a cost improvement of $\dot{C}_{t-\theta}$, we can integrate all the cost improvements over time to obtain the complete version of (1):

$$(2) \quad P_t = C_t - \int_0^\infty ae^{-\lambda\theta} \dot{C}_{t-\theta} \, d\theta.$$

The integral on the right hand side of (2) is the accumulated Schumpeterian profits, which I define as S_t:

$$(3) \quad S_t = \int_0^\infty - ae^{-\lambda\theta} \dot{C}_{t-\theta} \, d\theta.$$

Note that since costs are falling over time, S_t is positive.

Finally, note that if the rate of productivity growth is constant at h^* per year, then (2) and (3) simplify to:

$$(4) \quad (P_t - C_t)/C_t = \int_0^\infty - ae^{-\lambda\theta} [\dot{C}_{t-\theta}/C_t] \, d\theta = a\, h^*/(\lambda - h^*) .$$

We define μ_t as the *Schumpeterian profit margin.* The equilibrium Schumpeterian profit margin is equal to the appropriability ratio times a dynamic factor that equals the ratio of the rate of productivity growth divided by the difference between the rate of decay of Schumpeterian profits and the rate of productivity growth. The upper limit on the rate of profit is the appropriability factor, but this upper limit gets diluted by the evaporation of Schumpeterian profits.

Define the profit margin as $\mu_t = (P_t - C_t)/C_t$. Then take the time derivative of the markup and use equations (2) and (3), which yields

$$\dot{\mu}_{t-\theta} C_t + \dot{C}_t \mu_t = d[\int_0^\infty - ae^{-\lambda\theta} \dot{C}_{t-\theta} d\theta]/dt = - \lambda S_t - a \dot{C}_t$$

Since $\dot{C}_{t-\theta}/C_t = - h_t,$ this reduces to

(5) $\dot{\mu}_{t-\theta} = (a + \mu_t) h_t - \lambda \mu_t$

In steady state, where μ_t and h_t are constant at μ^* and h^*, this reduces to

(6) $\mu^* = a h^*/(\lambda - h^*)$

which is identical to equation (4).

We can also derive equation (5) in difference form, which yields

(7) $\mu_t = (1 - \lambda)\mu_{t-1} + a h_t + \mu_{t-1} h_t$

The major coefficients of interest are λ, which is the rate of evaporation of Schumpeterian profits, and a, which is the *Schumpeterian appropriation ratio*.

Equations (6) and (7) are two alternative representations of the relationship between the Schumpeterian profit margin and the rate of technological progress. Equation (6) would be appropriate in circumstances where the industry was in "innovational steady state" – that is, where the rate of innovation was more or less constant. Equation (7) would be appropriate where the rate of technological change were changing, such as occurred in the new economy over the last decade.

III. The Data

A. <u>Economy-wide data</u>

Two potential approaches to estimating equations (6) and (7) are company data and national accounts data. In principle, it would be desirable to use narrowly targeted company data so that the large differences in profits and technological performance could be separately identified. However, firm data are generally useless because of the unavailability of reliable real output and productivity indexes by firm. Equally serious is that firm data are generally limited to large firms listed on stock exchanges, and these data suffer from potentially large selection bias.

The alternative, which is followed here, is to use national accounts data by industry, which allow estimates of cost, price, profits, capital stocks, margins, and productivity. For this purpose, BEA prepares output, price, labor inputs, capital stocks, and profits after taxes for 65 detailed industries. These data are available for the period 1977 – 2000 on a more-or-less comparable industrial definition. For each industry, we use gross output (gross value added) along with the associated double-deflated price and input data. Of the 65 industries, we select 33 that have reasonably good price deflators and therefore relatively reliable measures of real output and productivity. The complete list along with the included industries are shown in Appendix A. A more detailed description of the data is provided in Appendix B.

The major series used here are productivity growth *(h1* and *h2)* and profit margins *(m1, m2, m2a,* and *m3).* The measures of productivity are relatively conventional: *h1* is the growth in labor productivity measured as real output per hour worked, while *h2* is the growth in total factor productivity measured as the difference between the growth in real output and the grow of an index of labor and capital inputs.

The measures of profit margins are less obvious. According to the definitions above, the margins are define as $\mu_t = (P_t - C_t)/C_t$, where $(P_t - C_t)$ is the difference between revenues and costs. For this study, I have developed four alternative measures of cost and therefore of the profit margin.

The first and broadest one *(m1)* is where $(P_t - C_t)$ equals all property type income (profits, proprietors income, rents, interest, and capital consumption), which in turn is equal to value added less indirect business taxes less total compensation; property type income is useful because it includes profits of the non-corporate sector as well as corporate profits. (It should be recalled that proprietors income is approximately as large as pre-tax corporate profits). To the extent that technological change takes place in small non-corporate entities which are incorporated and go public when they prove profitable (as in the Greenwood and Jovanovic model discussed above), it would be important to include this broader concept of property income.

The second and narrower measure of profits *(m2* and *m2a)* is limited to corporate profits. This concept is the usual NIPA definition (value added less compensation, rents, interest, capital consumption, and taxes). The data for profits before taxes *(m2a)* come from the industry accounts, while the data for profits after taxes *(m2)* come from Table 6.17 in the NIPAs. They have slightly different conceptual bases because the NIPA concept measures profits on a company basis while the industry accounts measure profits on an establishment basis. The numbers are reasonably consistent, however. The *m2* and *m2a* measures are useful because they captures more accurately a measure of economic costs. On the other hand, they may provide a distorted measure to the extent that non-corporate property income is an important component of total capital income in a sector. Because of this omission, the estimates of the appropriability factor may be biased downward for *m2* and *m2a.*

The third and narrowest measure of profits *(m3)* uses a measure of pure profitability. This measure takes all property type income and subtracts capital consumption (from the industry accounts) and an estimate of the opportunity cost of capital. The opportunity cost of capital is equal to a real cost of capital (estimated to be 5 percent be year) times the current replacement cost of the net capital stock of each industry. This narrowest measure of profits is conceptually the most appropriate measure of pure economic profits and captures the differences in the trends in the capital output ratios of different industries and includes property type income for all capital, not just corporate capital. If we were confident that *m3* captures the cost of capital accurately, it would be the most appropriate definition of the Schumpeterian profit margin.

B. Definition and data for the "new economy"

What is meant by the new economy? For purpose of this study, I use the following formal definition of the new economy. The new economy involves acquisition, processing and transformation, and distribution of information. The three major components are the hardware (primarily computers) that processes the information, the communications systems that acquire and distribute the information, and the software which, with human help, manages the entire system.

For purposes of this study, we are hamstrung because comprehensive data are limited to major industries as shown in Appendix A. The candidates for the new economy are those major industries that contain the new-economy sectors: Industrial machinery and equipment (SIC 35), Electronic and other electric equipment (SIC 36), Telephone and telegraph (SIC 48), and Business services (SIC 73). BEA has developed detailed industrial data for each of these industries for the period 1977-2000.

This definition of the new economy is much broader than would be ideal for the present purposes. For example, SIC 35 contains computers and office equipment, but the computer sector comprises less than 25 percent of the total 1996 value added in that sector. Other parts of SIC 35 include ball bearings and heating and garden equipment, whose prices are probably not well measured and which are dubious candidates for the new economy. SIC 36 contains prominently semiconductors, which is central to the new economy, but semiconductors constitute only 8 percent of the 1996 value added. This sector includes communications equipment, one part of which has hedonic deflation. This sector also contains many old-economy industries, including incandescent bulbs, and a wide array of consumer electronics, whose prices are almost surely poorly measured.

Similarly, while telephone and telegraph is central to the communications components of the new economy, that sector includes some paleoindustries like telegraph, whose commercial applications date from 1844, and telephone, which premiered in 1878.

Business services (SIC 73) is included because it contains software (computer programming, data processing, and other computer related services). Software is genuinely a new economy industry. However, only the prepackaged component (slightly larger than one-third of the total software segment) uses hedonic deflation at present. The rest of business services is a hodge-podge of poorly measured services such as legal, engineering, accounting, management, advertising, and public relations. In 1998, software was a rapidly growing segment but comprised only 40 percent of receipts.

Because of the importance of the new economy in the present analysis, it is worth emphasizing that relatively few industries use hedonic price indexes that systematically attempt to capture new goods and components or quality change. The BEA reports that only four major industries (all in new economy sectors) use systematic hedonic prices: computers and peripheral equipment, semiconductors, prepackaged software, and digital switching equipment. In 1998, these sectors comprised about 2.2 percent of GDP, while the four industries included in the broad definition of the new economy in this study comprised 10.7 percent of GDP. This suggests that only a fifth of what we have labeled as the new economy has careful hedonic measurement of prices and output.

In the end, I decided to exclude business services from the new economy because of the dominance of poorly measured components. Therefore, the three industries are SIC 35, 36, and 48.

IV. A Macroeconomic Example

We can give an overview of the technique using data for all nonfinancial corporations and the most aggregate concept of the profit margin, *m1* or total property type income. Figure 2 shows the variables on the left and right hand side of equation (6) for the business sector. Using data from the BLS for the period 1948 to 2000, we can estimate equation (6) using OLS and an a priori coefficient of $\lambda = 0.2$, which yields an estimate of $a = 0.0593$ ($\pm$ 0.0138). Using equation (6), this yields an equilibrium value of the Schumpeterian profit margin (the *m1* variant), μ^*, of $0.0593 \times 0.0118/(.2-0.0118) = 0.00372$, where 0.0118 is the average rate of growth of total factor productivity. In other words, the estimate implies that equilibrium Schumpeterian profits are about 0.37 percent of costs or of total output.

Considering the year 2000, the total value added of the business sector was $7600 billion. Applying the estimated ratio of the Schumpeterian profit share to total output, we obtain an equilibrium Schumpeterian profits at 2000 income levels of $21 billion out of a total of $2239 of capital income. (For comparative purposes with the estimates below, the number for the 1960-2000 period is $15 billion, and for the 1977-2000 period is $10 billion.)

We can use data for the non-financial corporate sector to compare these results with the rate of profit. BEA has published data on profits (with CCA and IVA), profits taxes, and net produced assets. We can compare the net return after deducting an opportunity cost of produced assets for this sector. Using the 5 percent real opportunity cost of capital, the total margin (in the *m3* sense) was 1.8 percent for the period 1960-1999. Applying this to the 1999 level of output yields a total excess profit of $72 billion. The estimate above is that $15 billion of this $72 billion was Schumpeterian profits. For the sample period 1977-2000, which is used for the industry estimates below, estimated Schumpeterian profits were While both of these numbers is sensitive to the time period and other assumptions, the fact that the two calculations are of the same order of magnitude lends some plausibility to the technique proposed here.

This example gives an intuitive feel for the procedure to be followed. The macroeconomic estimates are, however, not robust to alternative specifications, and they probably contain econometric bias, so we proceed to use industry data to obtain more reliable estimates.

V. Statistical Estimates Using Industry Data

The fundamental relationship tested here is between the profit margin and the rate of technological change. The figures in Appendix C provide a sample of the relationship over the period 1977-2000, and it would be worth studying those briefly before moving on to the formal empirical analysis.

The estimates shown use panel estimators. More precisely, we estimate the coefficients using fixed industry effects and cross-section weights of the observations. The estimates were performed using EViews 4.0 but have not been checked using alternative software packages.

We now show the results of the estimation. For this purpose, we examine the long run estimates in equation (6) and the dynamic estimates in equation (7).

A. All sectors

1. Long-run estimates

Table 1 shows the results for all sectors. For these calculations, I have limited the estimates to the 33 industries for which the output measures use reasonably reliable price measures and therefore have relatively reliable measures of real output and productivity.

In addition, for these estimates I have used a linearized form of equation (6). This seems slightly better than using non-linear estimation because noise in the data could make the denominator of (6) very large and thereby distort the estimates. The depreciation parameter (λ) is set a priori at 0.2 per year, but the general results are not sensitive to this estimate within the range of 0.1 to 0.3 per year. To determine the appropriability parameter from equation (6), we take the derivative of μ with respect to h, which yields:

$$(8) \quad d\mu/dh = a\, h^*/(\lambda - h^*)^2$$

from which we derive

$$(9) \quad a = [d\mu/dh]\,(\lambda - h^*)^2/h^*$$

where $[d\mu/dh]$ is the regression coefficient, λ is set a priori at 0.2, and h^* is the mean of the sample for h.

In addition, we use four different definitions of the profit margin and two alternative definitions of productivity growth. The variable *m1* is the ratio of all property type income to cost; *m2* and *m2a* are the ratio of profits after or before taxes to cost; while *m3* is the ratio of pure economic profits to cost. The variable *h1* is the growth of labor productivity (real gross value added per hour), while *h2* to is the growth of total factor productivity (where the inputs are the weighted average growth of labor and capital inputs).

The equilibrium estimates are shown in Table 1 and Figures 3 and 5. There is a fair amount of inconsistency of the estimates across different margin and productivity definitions. Table 5 shows a "central" estimate, which weights the different estimates by the inverse of their standard errors. The central estimate of the appropriability ratio is slightly above 1 percent for the entire economy. The range is from –0.3 percent to 3.6 percent. The *m1* and *m3* specifications give slightly larger numbers, which is appropriate given that they contain only corporate profits.

The results are moderately sensitive to alternative specifications, with the range of the appropriability ratio being between –1 percent of 4 percent depending upon the specification. I will give some examples using the *h2* and *m3* specification. Estimating the non-linear form of equation (6) with a depreciation rate of 0.3 gives an appropriability coefficient of 0.0014 rather than 0.0084. Using random effects rather than fixed effects has little effect on the estimates. Estimating using instrumental variables with the change of relative prices serving as an instrument for the change in total factor productivity yielded a negative appropriability factor for this regression (although the program sometimes provided the incorrect estimate with TSLS and a weighted regression, so these estimates are suspect). Unweighted regressions provided estimates that were very close to the weighted regressions. Using all 65 industries gave estimates that were slightly smaller than the 33 industries, presumably because several industries had unreliable estimates of total factor productivity.

The wide variety of estimates should not cloud the fundamental result that the estimated Schumpeterian profit margin is extremely small. The central estimate of the Schumpeterian profit margin is 0.13 percent, with a range of estimates of from 0.02 to 0.25 percent. From an economic point of view, the margin is just barely positive.

2. Dynamic estimates

The dynamic estimates are more problematic because of the likelihood that extraneous factors will influence short-run movements in the markup in the specification of equation (7). Such factors as business cycle impacts, delayed pass through of costs, and measurement error raise the likelihood of biased estimates with a lagged dependent variable.

To reduce the likelihood of simultaneous-equation bias, I lagged both of the independent or predetermined variables in equation (7). This yields:

$$\mu_t = (1 - \lambda + h_{t-1})\mu_{t-2} + a\, h_{t-1}$$

and is estimated in the following form:

$$(10)\quad \mu_t - \mu_{t-2}\, h_{t-1} = a\, h_{t-1} + (1 - \lambda)\mu_{t-2}$$

Table 2 shows the results of the dynamic specification for the 33 major industry groups. The appropriability coefficients are generally larger than those for the long-run estimates, but the standard errors were relatively large. The central estimate of the appropriability factor is 3.4 percent, but the range is from –3.5 percent to 6.1 percent.

The dynamic estimates are less robust than the equilibrium estimates. Using alternative specifications, such as instrumental variables, correction for autocorrelation of errors, or alternative lag structures, gave a wide variety of estimates. The interpretation is that many different factors are affecting the short-run movements in the profit margins. My inclination is therefore to trust the long-run estimators more than the dynamic estimators.

B. New Economy sectors

1. Long-run estimates

A central question is whether the new economy has new rules with respect to appropriability. Tables 3 and 4 undertake the same analysis for the three new economy sectors as were shown in Tables 1 and 2.

Table 3 and Figure 4 show the equilibrium estimates. The results are consistent with the estimates in Table 1, although the equilibrium estimates are somewhat lower. The central estimate of the appropriability ratio for the new economy is 0.3 percent, and therefore somewhat smaller than that of the overall economy. The range of estimates of the appropriability ratio is from --0.1 percent to 2.1 percent.

2. Dynamic estimates

The dynamic estimates have the same potential pitfalls as those for the overall economy. The appropriability coefficients are highly inconsistent across the different specifications, ranging from 1.8 percent to 23.1 percent. Many of the coefficients are, however, insignificant. These estimates are again sensitive to the specification, so they are relatively unreliable.

C. Summary of results

Table 5 shows the best estimates for the appropriability factor for each of the four sets of estimates. For these, we designate as "central" estimates ones which are weighted averages of the estimated appropriability ratios in Tables 1 to 4, where the weights are proportional to the inverse of the standard errors of the coefficients. The central value of the appropriability ratio is slightly above 1 percent for the total economy and below one-half percent for the new economy. The range of central estimates is large across the different margin concepts and productivity measures, but in all cases the appropriability ratio for the equilibrium estimates is in the 0 to 2 percent range.

More important is the estimate of the Schumpeterian profit margin, also shown in Table 5 and Figure 5. The central estimate of the Schumpeterian profit margin is slightly above 0.1 percent of total output for both all sectors and the new economy.

On the basis of these findings, we show in Table 6 estimates of total Schumpeterian profits in U.S. economy over the period 1977-2000. Using the central estimators and income figures for 2000, the dollar value of total output that was captured as Schumpeterian profits is estimated to be $11 billion out of total property type income of $3313 billion and total private output of $8657 billion. Schumpeterian profits for the new economy were estimated to be about $0.6 billion out of a total property type income of $195 billion and total output of $558 billion in the major new economy sectors.

These numbers are subject to the caveat that the estimates of the appropriability ratio and of the Schumpeterian profit margin are not well determined. The eight different estimators for the 33 private industries have a range of estimates of the appropriability factor of between –0.0 percent and 4.2 percent. We can be reasonably confident that the appropriability factor is well below 10 percent, but within the range of 0 to 4 percent the exact number is subject to considerable uncertainty. The estimates of the Schumpeterian profit margin also have a wide range – from 0.03 percent to 0.25 percent of total output – but the absolute number is in any case extremely small.

Subject to the caveat that the exact numbers are hard to pin down, the results are decisive: Schumpeterian profits were a tiny fraction of output or profits when averaged over all industries. This holds equally well for the new economy industries. Whether the benefits are passed backward to labor or forward to consumers is unclear, but only a minimal fraction of the social gains from technological change is captured by producers in Schumpeterian profits.

V. The Alchemist Fallacy and the New Economy Bubble

At the most fundamental level, the new economy stock-market overvaluation bubbled up from the alchemist fallacy that bits could be wrought into lasting value the way alchemists' lead could be turned into gold. The new alchemists were probably not mistaken in their belief that there was tremendous economic value in the new economy; the economic value of the technological change brought about by the information revolution is clearly enormous. If that surplus could be captured by the new entrepreneurs who were dreaming up everything from Internet grocery shopping to electronic dating, then the market value of these firms would also be enormous.

But that is not how a market economy works. This study suggests that to a first approximation, innovators on average get back a normal return on their investments but little more. The total amount of gold in the form of Schumpeterian profits that can be squeezed out of a bright idea, a few hundred lines of C++, and long nights at the cathode ray tube is about what could be earned from putting the same resources into the average steel mill, grocery store, or trucking firm.

To put this quantitatively, suppose that the new economy amounts to 5 percent of nominal output, is growing rapidly, and has costless total factor productivity growth of 10 percent per year. The new economy would currently be adding about $50 billion per year per year in social surplus. If the new entrepreneurs could capture half of the new economy surplus in Schumpeterian profits, then with other plausible parameters, the value of new economy firms would be $2 trillion.[11]

The problem with this scenario, however, is that the likelihood of new economy entrepreneurs capturing half of the social surplus is vanishingly small. One reason for doubting a high appropriability is, as shown by the results in this study, that U.S. capitalism grinds Schumpeterian profits into such a fine powder that they can barely be detected in the macroeconomic or industrial data. If the new economy entrepreneurs could capture 1 percent of the social gains – which is a good guess based on our estimates – then the market value of the excess profits would be closer to $40 billion than to $2 trillion. This $40 billion would, of course, be in excess to the normal return to capital and intangible investments.

The second reason to be skeptical of high Schumpeterian profits in the new economy is because of the nature of the industry. With a few exceptions that I will discuss shortly, entry and exit is relatively easy; the rapidity of the entry and easy demise of new economy firms indicates not only that bright ideas could get easily funded but also, alas, that imitators are quick to follow. Amazon.com clearly had a brilliant commercial idea for selling books on line while Etoys.com sounded like a great idea for toys; but Barnes and Noble or Toys-R-Us had more savvy, books, and toys and could easily and quickly adopt the bright ideas of the first movers. The result to date is that all four of these firms are losing money. More generally, the profitability in the new economy industries has plummeted in the last few years. From a peak of $53 billion in 1995,

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[11] The assumptions behind this are the following: I assume that the new economy is 5 percent of a $10 trillion economy; that the new economy is growing at 5 percent per year (in nominal values deflated by the GDP price index) for the first 20 years, then at 3 percent after that; that entrepreneurs appropriate half of the social value of technological change; that the rate of costless technological change is 10 percent per year; and that the discount rate on earnings is 10 percent per year. Under these assumptions, the present value of new economy earnings is $2.1 trillion when discounting the profits for the first 50 years.

the new economy industries' profit after tax fell to $15 billion in 2000 during a time that aggregate profits in the U.S. economy rose by 25 percent.

A third reason to doubt the presence of large Schumpeterian profits is that the information revolution concerns information, which is generally hard to appropriate. The economic nature of information is that it is expensive to produce and inexpensive to reproduce. Indeed, with the Internet, it is often essentially free to reproduce and distribute vast amounts of information. The low costs of imitation, transmission, and distribution of information technologies are likely to erode the value of property rights in intellectual property and reduce the durability of Schumpeterian profits in the new economy. An illustrative case is the appropriability of the value of knowledge embedded in encyclopedias. To imitate the *Encyclopedia Britannica* two decades ago would have required a massive investment in recruiting of scholars and editors along with a major publishing effort. Today, an online or CD encyclopedia is extremely inexpensive to produce and distribute, and some are free to consumers, such as Microsoft's online *Encarta*.

The final reason to be skeptical about new economy alchemy lies in the dynamics of a gold rush. Day traders were not the only people to put their money on the line in the new economy boom. Firms and individual entrepreneurs in the late 1990s invested hundreds of billions of dollars in information processing, communications equipment, software, and time that later proved unprofitable. It may well turn out that the net Schumpeterian profits in the new economy are negative because of the gold rush mentality. This syndrome is the formal equivalent of a patent race that induces excessive investment. In other words, there was a real as well as a financial component to the new economy bubble. The real component led to massive investment by firms and individuals who ultimately went bankrupt, were acquired for a song, or went back to graduate school.

Of course, to say that there are little or no Schumpeterian profits on average does not deny that a few new economy firms have been able to carve out a profitable niche for themselves. Just because the average earnings of actors is about the minimum wage does not mean that there are no rich actors. Microsoft and Intel, for example, have proven extremely profitable. In the former case, what started as Schumpeterian profits from DOS and Windows have evolved into illegally maintained monopoly profits, and in this respect Microsoft may be an exception to the finding in this paper. Estimates of Microsoft's rate of return on invested assets are around 100 percent over the last five years.[12] Intel has also earned a very high rate of return, but that rate has been eroding under competition from AMD. But the high rates of return of these two firms have been more than offset by low profitability and losses in the rest of the new economy, and the overall rate of profit in these industries has been well below the rest of the private sector.

Alchemy was an ancient art devoted to discovering a miraculous substance that would transmute common metals into gold. Not long ago, some believed that such a virtual substance had been found in the electronic world. But the laws of economics teach us that were anyone to find such a miraculous substance, its value would quickly fall as gold became as common and cheap as sand, optical fiber, and silicon chips. As of summer 2002, the laws of economics look like a safer bet than the lure of alchemy.

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[12] See the amicus brief by Robert Litan et al. in *United States v. Microsoft,* April 2000.

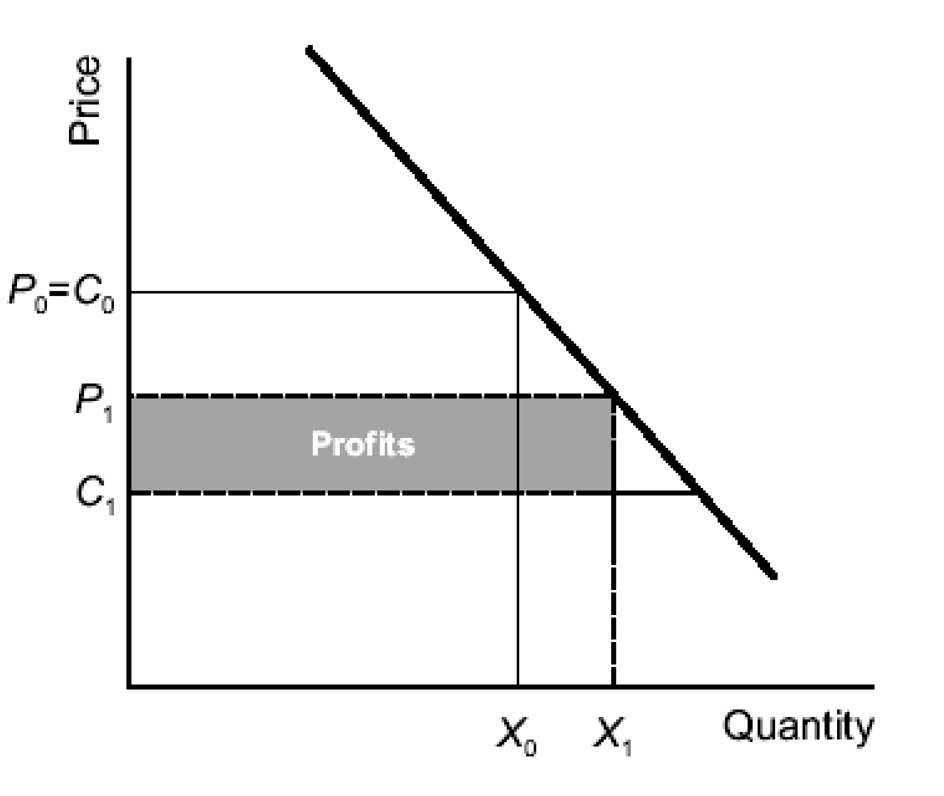


Figure 1. Technological Change and Schumpeterian Profits

The shaded region shows the Schumpeterian profits, while social surplus is that plus the quadrilateral between the shaded region and the $P_0 = C_0$ line. The ratio of Schumpeterian profits to social gains is determined by the appropriability ratio.

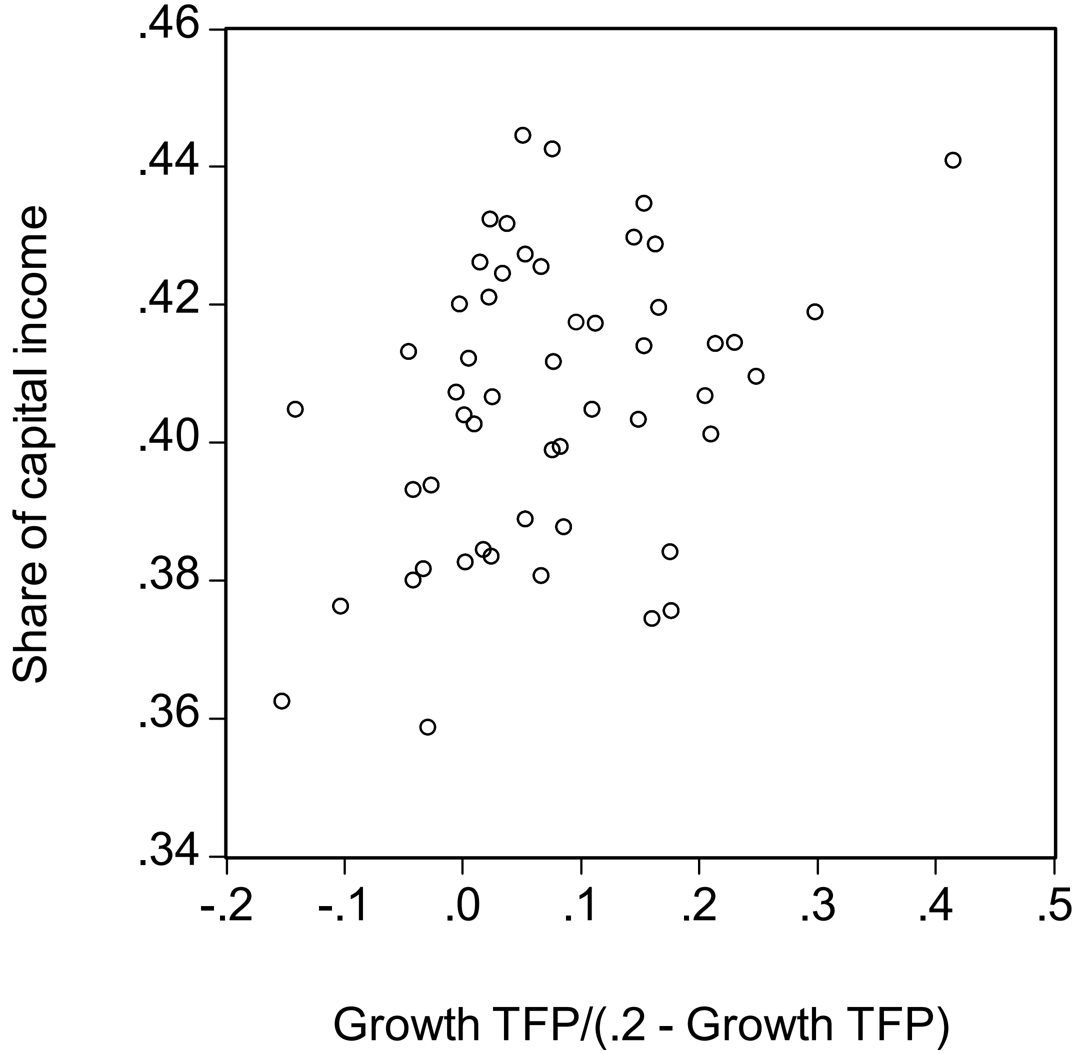


Figure 2. Plot of TFP function and capital's share

Horizontal axis is the right hand side of equation (6) for the business sector over the period 1949-2000 while the vertical axis is the *m1* Schumpeterian margin concept. The slope is estimated to be 0.059, which is the estimated appropriability ratio. Using these estimates, the share of Schumpeterian profits is estimated to be 0.037 percent of total output.

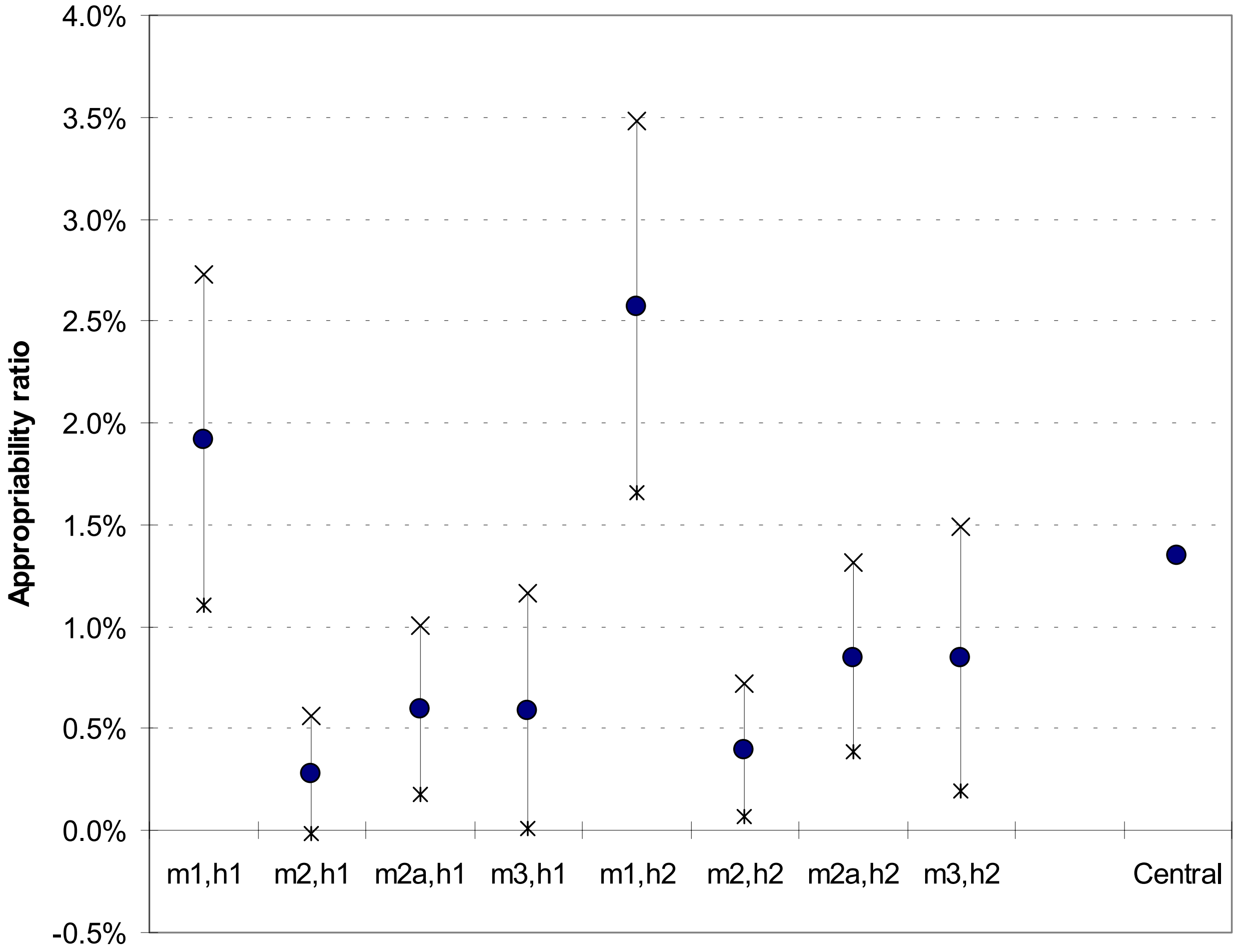


Figure 3. Estimates of Appropriability Ratio for Different Estimators for All Industries

Figure shows estimated plus error bounds for the Schumpeterian appropriability ratio for 23 sectors over the 1977-2000 period for estimates shown in Table 1. The labels on the horizontal axis designate the estimator combination of profit margin and productivity concept. The circle in the middle of the bar is the point estimate. The error bands calculate the standard error assuming that the other components in equation (6) are known without error. The "central" estimate is described in Table 5.

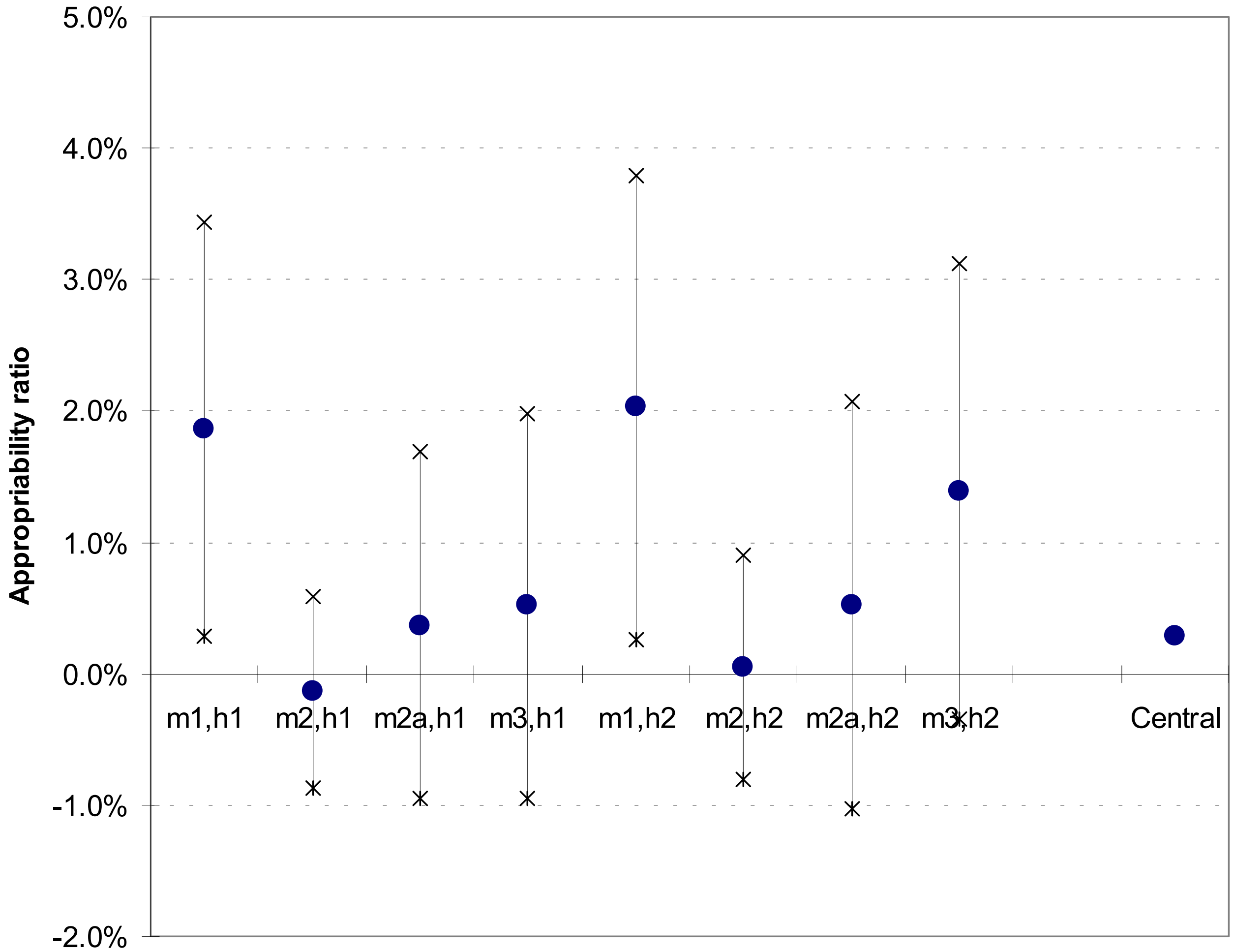


Figure 4. Estimates of Appropriability Ratio for Different Estimators for New Economy Industries

Figure shows estimated plus error bounds for the Schumpeterian appropriability ratio for 23 sectors over the 1977-2000 period for estimates shown in Table 3. The labels on the horizontal axis designate the estimator combination of profit margin and productivity concept. The circle in the middle of the bar is the point estimate. The error bands calculate the standard error assuming that the other components in equation (6) are known without error. The "central" estimate is described in Table 5.

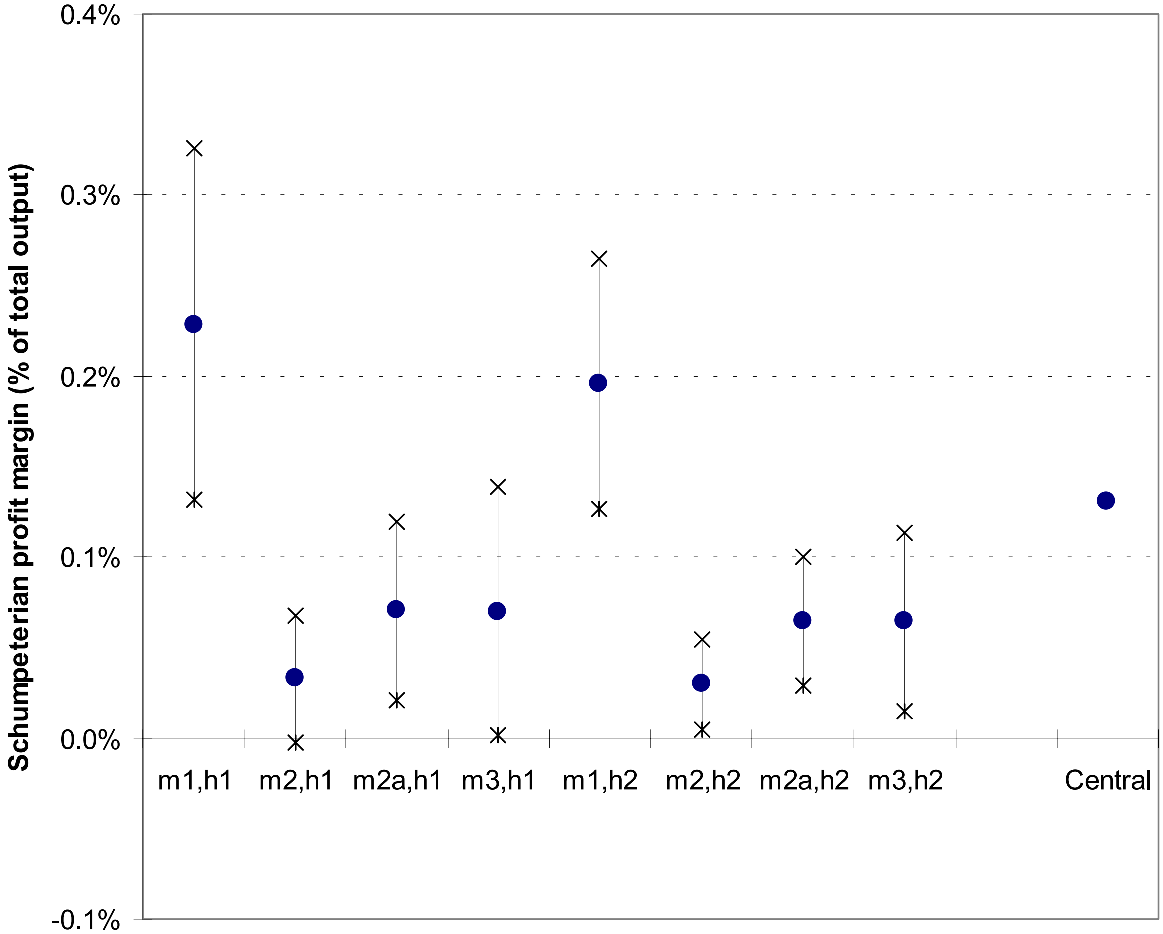


Figure 5. Estimates of Schumpeterian Profit Margin for Different Estimators for All Industries

Figure shows estimated Schumpeterian profit margin plus error bounds for 33 new economy sectors over the 1977-2000 period for estimates shown in Table 3. The labels on the horizontal axis designate the estimator combination of profit margin and productivity concept. The circle in the middle of the bar is the point estimate. The error bands calculate the standard error assuming that the other components in equation (6) are known without error. The "central" estimate is described in Table 5.

Long-run Specification

Dependent Variable	Independent Variable	Regression Coefficient	S.E.	t	Appropriability ratio (alpha)	Depreciation rate (lambda [a])
m1	h1	0.1201	0.0510	2.36	0.01917	0.20
m2	h1	0.0172	0.0182	0.94	0.00274	0.20
m2a	h1	0.0371	0.0258	1.44	0.00592	0.20
m3	h1	0.0367	0.0360	1.02	0.00587	0.20
m1	h2	0.1488	0.0526	2.83	0.02570	0.20
m2	h2	0.0228	0.0190	1.20	0.00393	0.20
m2a	h1	0.0492	0.0268	1.84	0.00849	0.20
m3	h2	0.0489	0.0376	1.30	0.00844	0.20

[a] Assumed coefficient.

Table 1. Estimates of parameters for long-run specification in Equation (6)

This equation takes the form of $\mu_{it} = \gamma h_{j,t-1}$, where $\gamma = ah^*/(\lambda - h^*)$ and the i and j indicate different margin and productivity concepts. The parameter α is calculated at the mean of the sample, where $a = da/dh = \gamma h^*/(\lambda - h^*)^2$, where the depreciation rate is assumed to be 0.2 per year, and where h* is the mean of the sample. The equations include fixed effects for each industry and use cross-section weighting of the regressions. The estimates were made using EViews 4.0.

The alternative specifications are:

m1 = total property income/total costs
m2 = profits after taxes/total costs
m2a = profits before taxes/total costs
m3 = net profits/total costs

h1 = growth of labor productivity
h2 = growth of total factor productivity

Included observations: 23
Number of cross-sections used: 33
Total panel (balanced) observations: 725

Dynamic Specification

Dependent Variable	Independent Variable	Appropriability ratio (alpha)		Depreciation rate (lambda)	
		Coeff	se	Coeff	t
m1	h14	-0.0351	0.0455	0.17	25.85
m2	h14	0.0228	0.0162	0.30	14.02
m2a	h14	0.0393	0.0222	0.31	14.77
m3	h14	0.0614	0.0332	0.28	17.14
m1	h24	0.0047	0.0465	0.16	26.24
m2	h24	0.0327	0.0169	0.29	14.35
m2a	h24	0.0523	0.0231	0.31	15.08
m3	h24	0.0938	0.0348	0.27	17.69

Table 2. Estimates of parameters for dynamic specification in Equation (7)

The actual estimation is described in text and takes the form μ_{it} - $\mu_{i,t-2}\, h_{j.t-1}$ $= a\, h_{j\,,t-1} + (1 - \lambda)\mu_{i,t-2}$,where the i and j indicate different margin and productivity concepts.

The alternative specifications are:

m1 = total property income/total costs
m2 = profits after taxes/total costs
m2a = profits before taxes/total costs
m3 = net profits/total costs

h1 = growth of labor productivity
h2 = growth of total factor productivity

Included observations: 19
Number of cross-sections used: 33
Total panel (balanced) observations: 627

Long-run Specification

Dependent Variable	Independent Variable	Regression			Appropriability ratio (alpha)	Depreciation rate (lambda [a])
		Coefficient	S.E.	t		
m1	h1	0.1977	0.1678	1.1787	0.01861	0.20
m2	h1	-0.0014	0.0775	-0.1877	-0.00137	0.20
m2a	h1	0.0037	0.1406	0.2790	0.00369	0.20
m3	h1	0.0052	0.1556	0.3554	0.00521	0.20
m1	h2	0.0203	0.1631	1.1503	0.02028	0.20
m2	h2	0.0005	0.0790	0.0607	0.00052	0.20
m2a	h1	0.0052	0.1433	0.3373	0.00522	0.20
m3	h2	0.0139	0.1600	0.8023	0.01388	0.20

[a] Assumed coefficient.

Table 3. Estimates of parameters for long-run specification in Equation (6) for new economy sectors

See Table 1 for the specification. The alternative definitions of the variables are:

m1 = total property income/total costs
m2 = profits after taxes/total costs
m2a = profits before taxes/total costs
m3 = net profits/total costs

h1 = growth of labor productivity
h2 = growth of total factor productivity

Included observations: 23
Number of cross-sections used: 3
Total panel (unbalanced) observations: 66

Dynamic Specification

Dependent Variable	Independent Variable	Appropriability ratio (alpha)		Depreciation rate (lambda)	
		Coeff	t	Coeff	t
m1	h14	0.0539	0.3062	0.21	8.42
m2	h14	0.0175	0.2226	0.40	2.93
m2a	h14	0.0498	0.3832	0.37	3.60
m3	h14	0.1358	0.9319	0.37	3.53
m1	h24	0.1124	0.6500	0.20	8.54
m2	h24	0.0618	0.7627	0.37	3.16
m2a	h24	0.1065	0.8056	0.36	3.80
m3	h24	0.2311	1.5556	0.35	3.84

Table 4. Estimates of parameters for dynamic specification in Equation (7) for new economy sectors

See Table 2 for the specification. The alternative definitions of the variables are:

m1 = total property income/total costs
m2 = profits after taxes/total costs
m2a = profits before taxes/total costs
m3 = net profits/total costs

h1 = growth of labor productivity
h2 = growth of total factor productivity

Included observations: 23
Number of cross-sections used: 3
Total panel (unbalanced) observations: 69

Sector and method	Appropriability Factor		Equilibrium Share of Schumpeterian Profits [Percent of total output, 2000]	
	Range	Central	Range	Central
Private industries				
Equilibrium	0.274% to 2.570%	**1.347%**	0.027% to 0.250%	**0.131%**
Dynamic	-3.512% to 9.385%	**3.445%**	-0.342% to 0.597%	**0.334%**
New economy				
Equilibrium	-0.137% to 2.028%	**0.279%**	-0.056% to 0.826%	**0.114%**
Dynamic	1.751% to 23.114%	**8.593%**	0.161% to 5.497%	**3.381%**

The best estimate takes the weighted average of the estimates in Tables 1 to 4, where the weights are the inverse of the absolute standard errors of the coefficients.

These calculations assume that the depreciation rate is 20 percent per year.

Table 5. Best estimates for Appropriability Ratio and Share of Profits

Table 5 derives the best estimate of appropriability factor and equilibrium share of Schumpeterian profits. Last four columns show the estimate of Schumpeterian profits in 2000 along with actual profits.

Sector and method	Equilibrium Value of Schumpeterian Profits [Billions of dollars, 2000] Range			Central	Corporate Profits, 2000 [billions of dollars]
Private industries					
Equilibrium	$2.31	to	$21.59	**$11.33**	$573.94
Dynamic	-$29.68	to	$51.41	**$28.92**	$573.94
New economy					
Equilibrium	-$0.31	to	$4.57	**$0.63**	$10.71
Dynamic	$0.90	to	$29.06	**$18.86**	$10.71

The best estimate takes the weighted average of the
estimates in Tables 1 to 4, where the weights are
the inverse of the absolute standard errors of the coefficients.

These calculations assume that the depreciation rate is 20 percent per year.

Table 6. Best estimates for Schumpeterian Profits

Table 6 derives the best estimate of Schumpeterian profits from estimates in Table 5. Last four columns show the estimate of Schumpeterian profits in 2000 along with actual profits.

Appendix A. Industries for which complete data are available.

Industries with asterisks are those included in the regression analyses. Industries labeled "NE" are included in new economy analysis. Data source: Bureau of Economic Analysis. Most data are available on the web site at www.bea.gov .

Gross Domestic Product (income side)
Private industries
  Agriculture, forestry, and fishing
    Farms
    Agricultural services, forestry, and fishing
  Mining
    Metal mining
    Coal mining*
    Oil and gas extraction
    Nonmetallic minerals, except fuels
  Construction
  Manufacturing
    Durable goods
      Lumber and wood products*
      Furniture and fixtures*
      Stone, clay, and glass products*
      Primary metal industries
      Fabricated metal products*
      Industrial machinery and equipment* (NE)
      Electronic and other electric equipment* (NE)
      Motor vehicles and equipment*
      Other transportation equipment
      Instruments and related products*
      Miscellaneous manufacturing industries*
    Nondurable goods
      Food and kindred products*
      Tobacco products
      Textile mill products*
      Apparel and other textile products*
      Paper and allied products*
      Printing and publishing*
      Chemicals and allied products*
      Petroleum and coal products
      Rubber and miscellaneous plastics products*
      Leather and leather products*
  Transportation and public utilities
    Transportation
      Railroad transportation*
      Local and interurban passenger transit

Trucking and warehousing*
Water transportation
Transportation by air*
Pipelines, except natural gas*
Transportation services*
Communications
Telephone and telegraph* (NE)
Radio and television*
Electric, gas, and sanitary services*
Wholesale trade*
Retail trade*
Finance, insurance, and real estate
Depository institutions
Nondepository institutions
Security and commodity brokers
Insurance carriers
Insurance agents, brokers, and service
Real estate
Nonfarm housing services
Other real estate
Holding and other investment offices
Services
Hotels and other lodging places*
Personal services
Business services
Software
Other
Auto repair, services, and parking*
Miscellaneous repair services
Motion pictures*
Amusement and recreation services*
Legal services
Educational services
Social services
Membership organizations
Other services
Private households
Statistical discrepancy
Government
Federal
General government
Government enterprises
State and local
General government
Government enterprises

Appendix B. Description of Variables

This study relies upon the industry data prepared by the Bureau of Economic Analysis. The major industries are shown in Appendix A. The data for each industry include nominal output, real output, prices, volumes and values of capital stocks, property type income, and profits before and after taxes. In all cases, real data are constructed as chain price and output indexes. For each industry, the BEA calculates gross output, value added (or gross product originating), and intermediate inputs (which equal gross output minus value added). In addition, the BEA prepared series on compensation, employment, and hours worked for each major industry. All data except hours are published on the BEA web page at www.bea.gov , and the hours data were obtained from BEA staff.

The data used for the series are defined as follows:

$h1_{it}$ = growth in labor productivity (logarithmic)
= $\ln(A_{it} / A_{i,t-1})$
A_{it} = labor productivity = X_{it}/H_{it}
X_{it} = gross output in industry i (measured as a Fisher quantity index)
H_{it} = hours worked in industry i

$h2_{it}$ = growth in total factor productivity (logarithmic)
= $\ln(TFP_{it} / TFP_{i,t-1})$
TFP_{it} = total factor productivity = X_{it}/Inp_{it}
Inp_{it} = index of H_{it} and K_{it}
K_{it} = quantity index of net capital stock in industry i

$m1_{it}$ = property income margin in industry i
= property type income/nominal gross output
= PTI_{it}/Q_{it}
PTI_{it} = property type income in industry i
= profits plus interest plus proprietors income plus net rents.
Q_{it} = nominal gross output (gross value added) in industry i

$m2_{it}$ = profits after taxes in industry i /nominal gross output in industry i
= PAT_{it}/Q_{it}

PAT_{it} = corporate profits after taxes in industry i (not including the inventory valuation adjustment and capital consumption adjustment), company basis

$m2a_{it}$ = profit margin in industry i
= profits before taxes/nominal gross output
= PBT_{it}/Q_{it}

PBT_{it} = corporate profits before taxes in industry i (not including the inventory valuation adjustment and capital consumption adjustment), establishment basis

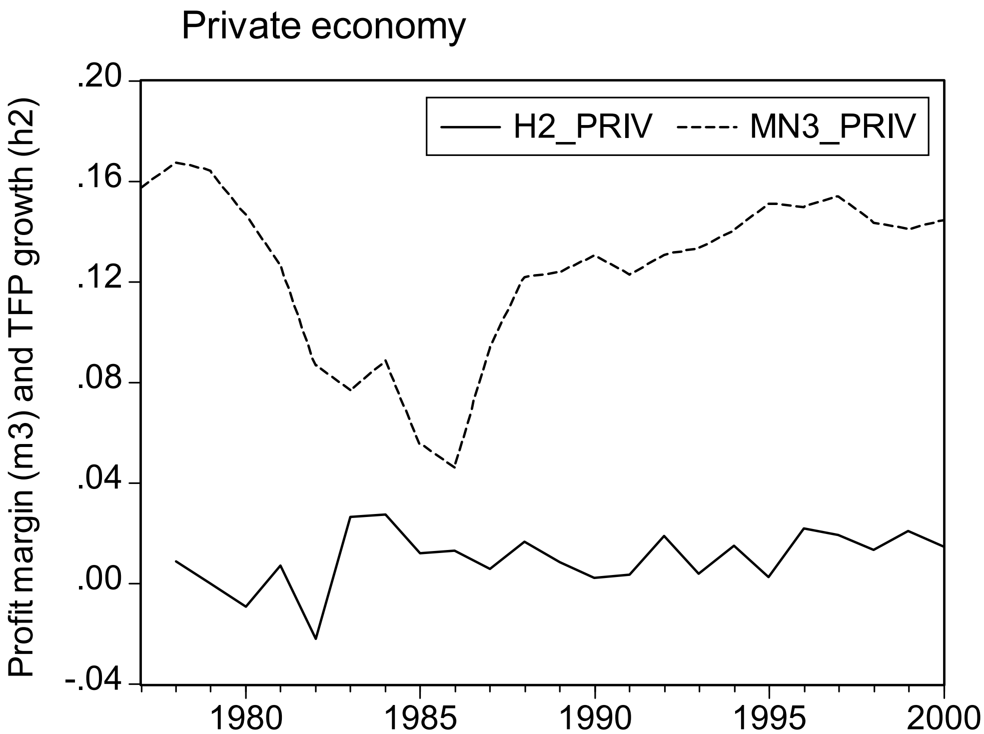
$m3_{it}$ = net economics profit margin in industry i
= net economic profits/nominal gross output
= $(NEP_{it})/Q_{it}$

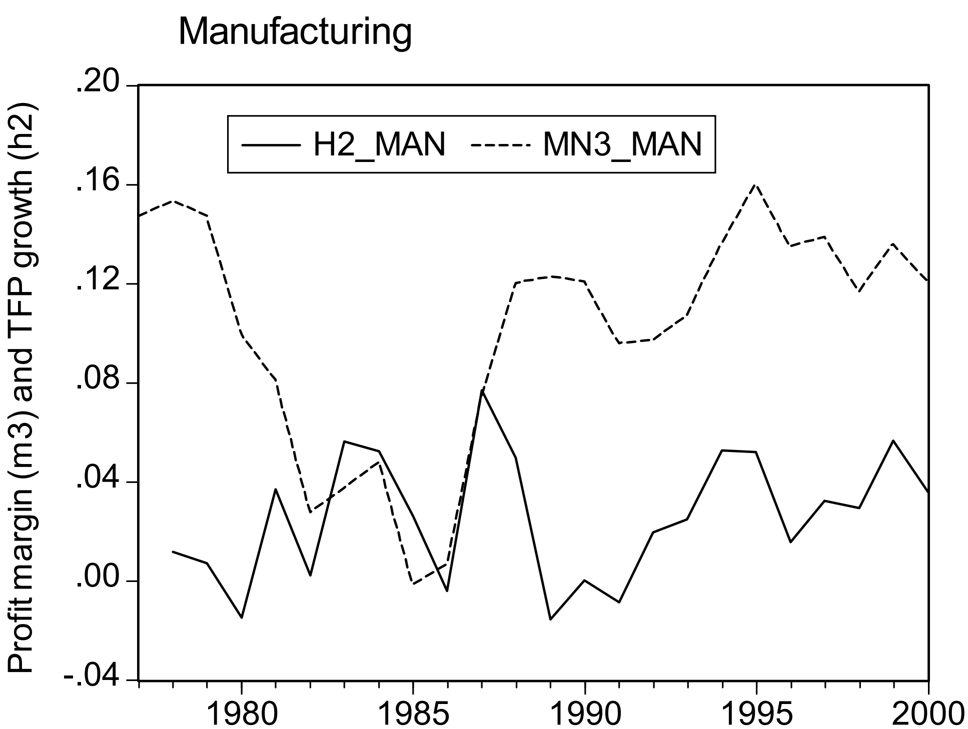
NEP_{it} = $(PTI_{it}- CCA_{it}- .05*CCK_{it})/Q_{it}$

CCK_{it} = current cost of net capital stock in industry i

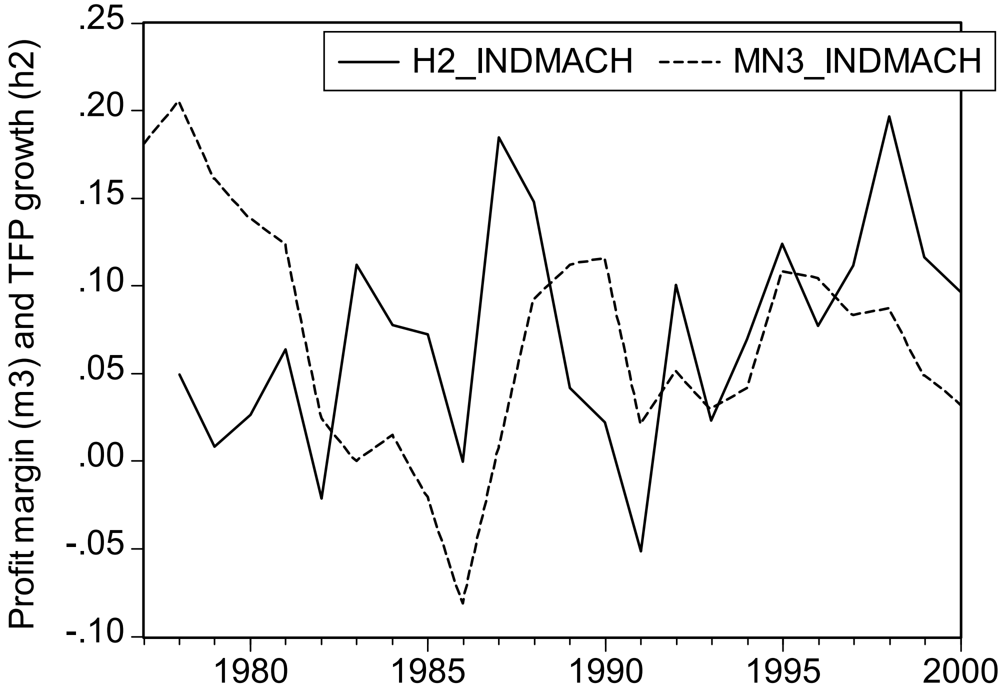
CCA_{it} = capital consumption allowances (deprecation) for industry i

Appendix C. Representative Graphs of Productivity Growth and Profit Margins

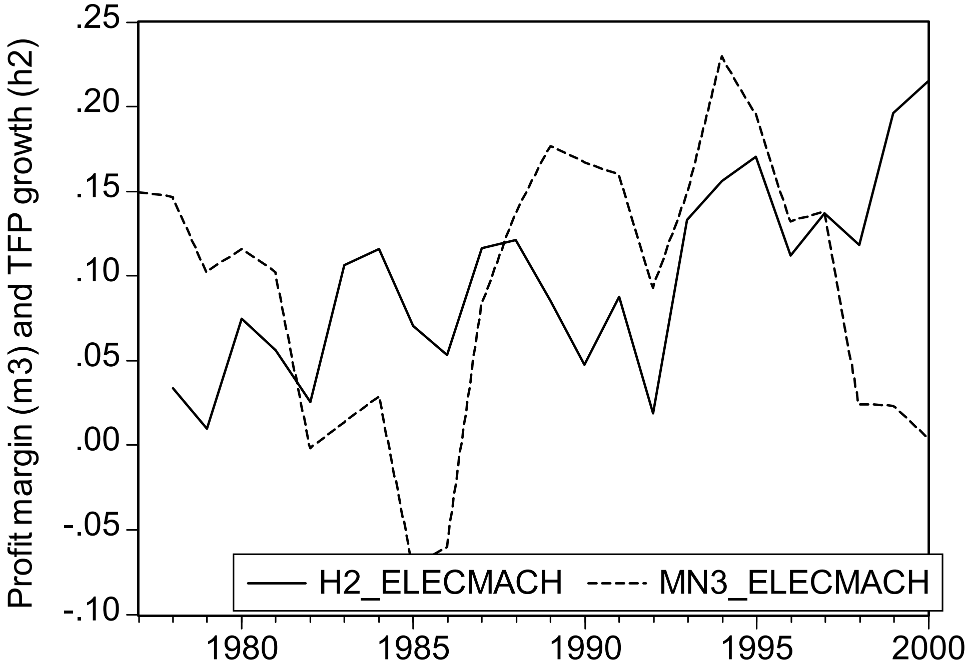




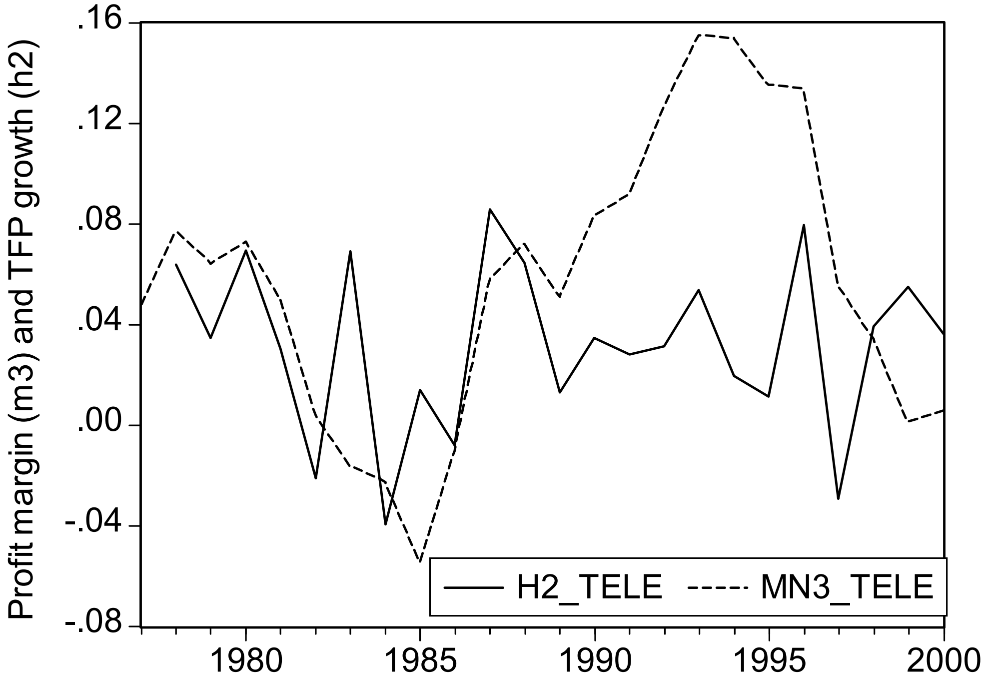
Industrial machinery (microprocessors)



Electrical Machinery



Telephone and telegraph



Business Services