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THE INFORMATION TECHNOLOGY REVOLUTION AND THE STOCK MARKET: EVIDENCE

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ABSTRACT

Since 1968, the ratio of stock market capitalization to GDP has varied by a factor of 5. In 1972, the ratio stood at above unity, but by 1974, it had fallen to 0.45 where it stayed for the next decade. It then began a steady climb, and today it stands above 2. We argue that the IT revolution was behind this and, moreover, that the capitalization/GDP ratio is likely to decline and then rise after any major technological shift. The three assumptions that deliver the result are:

1. The IT revolution was anticipated by early 1973,

2. IT was resisted by incumbents, which led their value to fall, and

3. Takeovers are an imperfect policing device that allowed many firms to remain inefficient until the mid-1980's.

We lay out some facts that the IT hypothesis explains, but that some alternative hypotheses -- oil-price shocks, increased market volatility, and bubbles -- do not.

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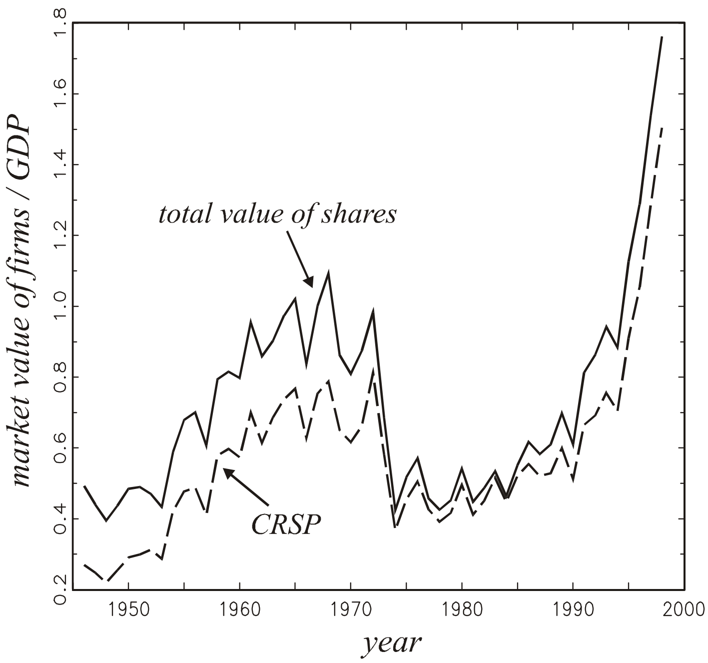

Figure 1: Stock market value relative to GDP

1 Introduction

In this paper, we shall study the post-war behavior of the U.S. stock market. We shall argue that a major technological innovation causes the stock market to be temporarily undervalued until the claims to future dividends enter the stock market via initial public offerings. In other words, that aggregate capitalization fell below the present value of dividends because a chunk of the dividend-yielding capital stock was missing from the stock market. Capital is likely to "disappear" during epochs of major technological change – especially at the beginning of such epochs, because this is when new capital forms in small, private companies. Only when a private company promises to be successful is it IPO'd, and only then does its capital stock become a part of stock-market capitalization. Greenwood and Jovanovic (1999) have used this logic to argue that the information technology (IT) revolution caused the post-1973 fall and the post-1985 rise in the ratio of market capitalization to GDP. Here, we shall present new evidence on this view, and on other proposed explanations of the '70's episode, explanations like oil-price shocks, increased market volatility, and nonfundamentals.

Figure 1 depicts a puzzling phenomenon. The solid line is the market value of U.S. equity relative to GDP since World War II, measured as the ratio of market capitalization to GDP as published by the Federal Reserve Board of Governors. After hovering around one all through the 1960's, market-cap/GDP plummeted to 0.4 in

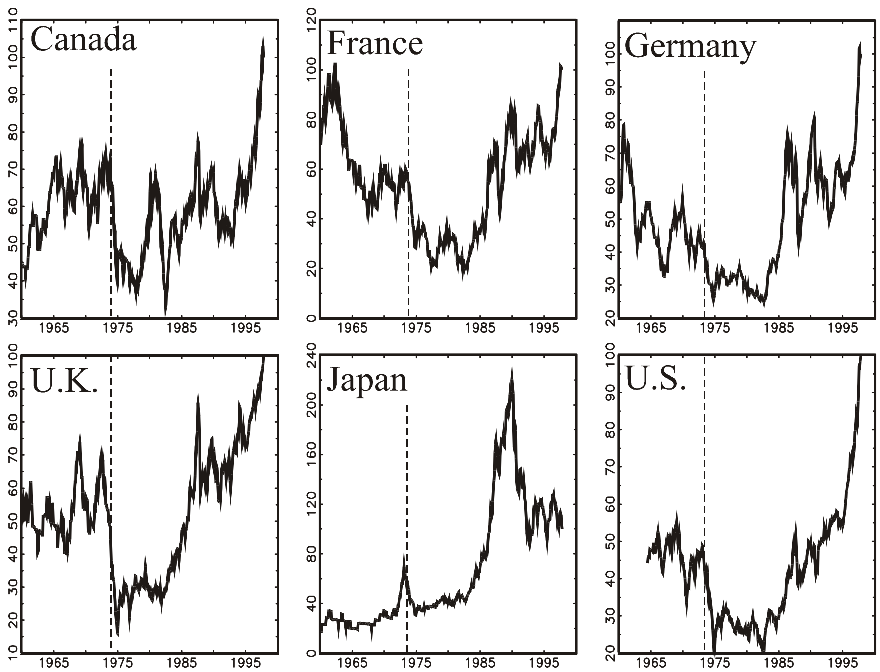

Figure 2: Real stock market indices in 6 OECD countries

1973, and did not recover until the mid-1980's, and then it rose sharply.

Figure 2 shows that except Japan, the leading OECD countries experienced similar movements in their stock markets. The figure plots the real stock market indices for Japan, Canada, 3 European countries, and the U.S. – because we do not have the market cap data for these countries, not quite the variable plotted as the solid line in Figure 1; instead of market cap, Figure 2 plots a stock market index, and the index is not divided by output. The data are from the macroeconomic indicators published by the OECD and cover 1960 -1998, except for the U.S. for which the share index was unavailable prior to 1964.

If one were to add up the market capitalizations of these 6 countries and divide them by their combined output, one would obtain a "world" series that would look much like the solid line in Figure 1. Japan is an outlier, but too small to overturn the broad pattern in the rest of the advanced world.

Mehra (1998) argues that the kind of volatility that Figures 1 and 2 portray is not consistent with the standard stochastic growth model, and Hall (1999) notes that the standard model implies a puzzling "meltdown" of capital in 1973-4. The puzzle, in terms of Figure 1, is the nearly threefold decline in market-cap/GDP in 1973-4, followed by its fivefold rise since 1985. The literature offers three solutions to the puzzle. First, that the first oil crisis, combined, perhaps, with a reaction in monetary policy, reduced expected future profits of firms and, as a result, led to a drop in stock prices. Second, that the decline of the 1970's reflected a response of

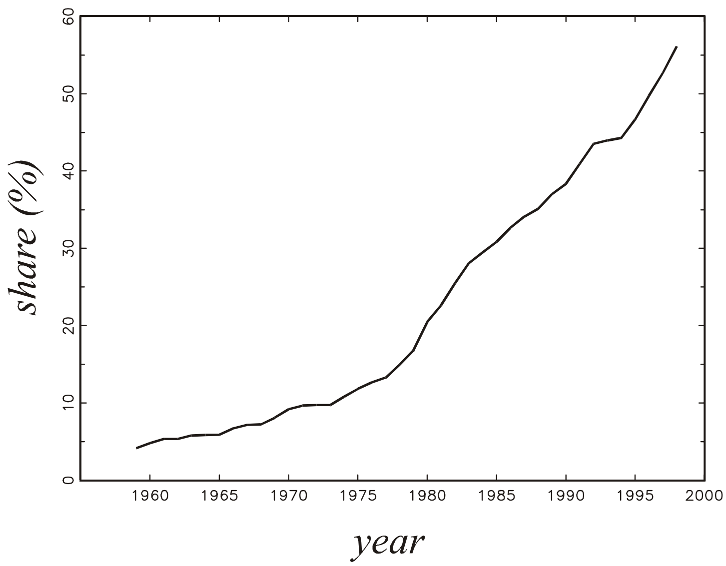

Figure 3: Share of computers and software in real equipment investment

risk-averse investors to a secular rise in the volatility of stock returns. And, third, that a positive bubble burst, or a negative one formed in 1973 and that today a positive bubble exists, especially in the internet stocks.

This paper takes on a different view. The view is that *good* news arrived in 1973, news that information technology was on the horizon. Figures 1, 2 show that stock prices fell just after Intel had developed the microprocessor in late 1971, and just as *IT* investment, plotted in Figure 3, was about to take off. In 1968, *IT* comprised only 7 percent of equipment investment, but it then started to rise, reaching 56 percent in 1998, and is rising still. It seems natural, therefore, to label early 1973 as the date in which "the news about *IT* arrived". Arrived, in the sense that this is when it started to matter, and when American business started incorporating it in a major way.

The paper proceeds as follows. Section 2 describes the main assumptions and, then, the model. Section 3 describes several tests of the *IT* hypothesis. Section 4 considers some other explanations. Section 5 outlines further tests include firms' debt, and Section 6 concludes the paper.

2 The *IT* hypothesis

Our argument rests on three assumptions. First, that the success of the *IT* revolution suddenly became evident in early 1973. Second, that the *IT* revolution favored new firms, that incumbents resisted it, and that this caused their values to fall. And, third, that as a policing device, mergers and takeovers worked imperfectly, thereby letting incumbents remain inefficient until the mid-1980's. We now explain why we find these assumptions reasonable.

Assumption 1: The *IT* revolution was heralded in 1973, or perhaps in stages during 1968-74

Before 1971, the computer was no friend of small business. A computer was expensive and users shared computer-time. Mainframe computers and minicomputers had been used at some large companies, at NASA, at the Defense Department, at the Bureau of the Census, and at other federal and local government bureaus. But it would take a technological leap before the computer could transform the way business was done, and before any firm, large or small, could afford to provide one to each of its administrative workers.

That technological leap was the invention of the microprocessor – the "4004 computer chip." This invention made the powerful "PC" of today possible. By late 1971 Intel was advertising the chip,[1] and commercial implementation followed almost at once: A French company produced the "MICRAL," a general purpose computer that embodied the new chip. "A base model cost under $2,000, and it found a market replacing minicomputers for simple control operations. Around two thousand were sold in the next two years...." (Ceruzzi, 1998, p. 222).[2] In the U.S., the early adopters of the new microprocessor – Intel's "4004" miniature computer – were outside the corporate sector, which surprised even Intel's sales staff.[3]. Intel had IPO'd in October of 1971 and, by August 1972, it had released its second microprocessor – the "8008".[4]

[1] "Robert Noyce [The 1968 co-founder of INTEL] negotiated a deal with Busicom [a Japanese calculator manufacturer] to manufacture for Intel chips [that Intel had designed] at a lower cost giving Intel, in return, the right to market the chips. From these unsophisticated negotiations with Busicom, in Noyce's words, came a pivotal moment in the history of computing.

"The result was a set of four chips, first advertised in a trade journal in late 1971, which included 'a microprogrammable computer on a chip!' That was the 4004, on which one found all the basic registers and control functions of a tiny, general-purpose stored-program computer. The other chips contained a read-only memory (ROM), random access memory (RAM), and a chip to handle output functions. The 4004 became the historical milestone, but the other chips were important as well, especially the ROM chip that supplied the code that turned a general-purpose processor into something that could meet a customer's needs." (Ceruzzi 1998, p. 220).

[2] Similarly, Campbell-Kelly and Aspray (1996, p. 237) write that it was "possible to produce an affordable personal computer (costing less than $2000, say) any time after...November 1971." Indeed, by March of 1974, Intel was offering the kit for the Scelbi-8H minicomputer for as low as $440 (Ceruzzi, 1998, p. 225).

[3] "Since it was a miniature general-purpose computer, [the 4004] could be used by industrial designers to do any number of different jobs. The customization would be in the software.... The target customers for this use of the 4004 chip were engineers in America's biggest industrial companies. But most of these engineers knew nothing about computer programming. Instead, it was smaller, hungrier companies without a strong, entrenched market position that saw the potential of the tiny chip first....The early adopters of the 4004 were much more obscure. Someone inside Intel's marketing department described the 4004 customer list as "not so much *Who's Who* as *Who's That*?" " (Jackson 1997, p. 75)

[4] Two buyers of the 8008 were none other than Bill Gates and Paul Allen who used it for a project that failed (Jackson 1997, p. 76).

To be sure, the early microprocessor was a highly primitive ancestor of today's PC – it had no keyboard, no screen, and a minute fraction of the power. But, by early 1973, it should have been clear that now one could expect rapid development of both hardware and software. By "Moore's Law," the power of computers would quickly become phenomenal, and, as soon as the software needed to turn the computer into a multi-purpose problem-solver became available – and this was just a matter of time – the computer would transform the face of American business.

It may well be that the world realized more gradually that computers would transform things in a big way. Our story works – and we do not resist this interpretation – if, instead one big news flash in late 1973, the news came in several stages, starting in 1968 or so, and ending in 1974. This was the period during which the P/Y ratio declined by a factor of three, with some bumps along the way. For simplicity, though, we shall model the episode by assuming that all the information arrived at once.

Assumption 2: The *IT* revolution favored new firms

An old firm has old physical capital on hand, and so it faces an additional economic cost to investing in frontier methods. It also has old human capital on hand; its manager may lack the awareness and its workers may lack the skill to implement the new technology (e.g., in 1972, large companies didn't have the programming expertise needed to use the microprocessor productively). In short, incumbents have a comparative disadvantage in adopting new technology. This is the "sunk cost" argument that we have seen in vintage capital growth models, in incumbent *vs.* potential-entrant models of R&D, and elsewhere. Other arguments that relate incumbency to technological change have recently surfaced: Holmes and Schmitz (1990) argue that some people are good at starting new firms, while others are good at running existing ones, and this distinction matters especially in times of major technological change; similarly, Ueda (1997) and Takii (1999) argue that the onset of technological uncertainty reallocates resources to those that are best able to cope with it – an argument that rests on Nelson-Phelps notions.

An even more telling reason why an incumbent firm will resist change is the entrenchment of its personnel. A large company is likely to be top-heavy, and its employees are more likely to be drawing salaries do not reflect their performance – a CEO with a handsome golden parachute has little reason to do *anything* for his firm, much less learn something new.

Based on this logic, our model will assume that when the news of the new technology arrives, the market correctly expects an incumbent to go on doing business as usual – indefinitely.

Assumption 3: Mergers and takeovers are an imperfect policing device

In theory, a stock market guides productive resources towards those hands that can generate most value from them. The mechanism that accomplishes this is the takeover. If the takeover market were frictionless, entrenchment and comparative disadvantage could not survive: An inefficient firm would quickly be acquired, its management replaced, and its inefficient work practices eliminated. Gort (1969) emphasizes that, by rearranging the pattern of comparative advantage, a new technology would usher in a merger-wave and that, instead of losing value, incumbents would simply face reorganization.

In practice, however, the takeover process faces some hurdles. Insiders – management and unionized workers especially – can protect themselves from hostile takeovers. Their firm may guarantee them a lot more than they are worth. To succeed, a raider would need to buy such people out, and the cost of doing so could exceed the efficiency gains that he could bring to the firm, in which case the takeover will not take place. Moreover, as Grossman and Hart (1981) argue, incumbent shareholders too can hold out and extract the efficiency gain from the acquiring firm.[5] These barriers have meant that a takeover has to raise value by about 40% before it goes through, and that, as a result, a firm can lose value and not be taken over.

If the takeover hurdle is too high, the inefficient firm may be driven out by more efficient entrants. This process is slower than the takeover, and this may be why the market took more than 10 years to recover. But, recover it did, and the painful adjustments are taking place[6]. Not surprisingly, the "excess fat" is mostly among managerial and nonproduction workers (Lichtenberg and Siegel 1991).[7] And since the adoption of IT is in many firms probably long overdue, some firms are seeing extremely high rates of return on their IT investments[8].

2.1 The model

The model is a version of the Lucas (1978) economy. A similar model in Greenwood and Jovanovic (1999) had some counterfactual implications for interest rates, and we shall depart from it in two ways. First, our economy will have two types of fruit and,

[5] Brearly and Myers's (1996, ch. 33) account of the RJR-Nabisco buyout indicates that the shareholder appropriated the entire gain from that deal.

[6] Farber and Hallock (1999) find that over the past thirty years, announcements about labor-force reductions are increasingly likely to lead to stock-price increases. The authors find this to be consistent with the view that such reductions are increasingly designed to improve efficiency, and are less likely than before to reflect reductions in product demand.

[7] This will seem odd to anyone who thinks of the unionized blue collar worker as the prime machine-resister. But the computer displaces mainly white-collar labor ("Behind each ATM flutter the ghosts of three bank-tellers," says a recent N.Y.Times article), and so this is where one would expect to be able to cut costs the most. In their study of the Indian iron and steel industry, Das and Sengupta (1999) find that in the typical (presumably sheltered) public sector firm, managerial workers are much more overemployed than the production workers.

[8] "Using eight years of data for over 1000 firms in the United States, we find that an increase of one dollar in the quantity of computer capital installed by a firm is associated with an increase of five to 20 dollars in the financial markets' valuation of the firm. Other forms of capital do not exhibit these high valuations." (Brynjolfsson and Yang 1998, p. 1). If these numbers are even close to being correct, IT must have met with some pretty stiff resistance.

second, fruit is an intermediate good that firms use to make a single final good – fruit juice. So, this is a production economy with a single final good, two intermediate goods, no storage, and no capital.

Let y_t denote gallons of juice produced and consumed at date t. Preferences are

$$\sum_{t=0}^{\infty} \beta^t U(y_t).$$

Competitive firms make juice using apples, x, z, and a third factor, n, as its inputs in the constant-returns-to-scale production function for final goods

$$y = \bar{F}(x, z, n),$$

taking the prices of fruit, p_x and p_z as given. The factor n is fixed; we shall normalize its supply to be equal to 1, and define

$$F(x, z) = \bar{F}(x, z, 1)$$

The numeraire is y_t. Optimal input choice means that prices of x and z must equal their marginal products:

$$p_{x,t} = \frac{\partial F}{\partial x}(x_t, z_t) \qquad \text{and} \qquad p_{z,t} = \frac{\partial F}{\partial z}(x_t, z_t).$$

Since returns are constant, factor payments equal output, and firms make zero profits.

The proceeds from the sales of apples and oranges are paid out as dividends. Claims to the apple-tree and orange-tree dividends trade freely at prices $P_{x,t}$ and $P_{z,t}$ respectively. If the stream of dividends that these trees will pay is $\{x_t\}$ and $\{z_t\}$, the date-τ price of the trees would be

$$P_{x,\tau} = \sum_{t=\tau}^{\infty} \beta^{t-\tau} \frac{U'(y_t)}{U'(y_\tau)} \frac{\partial F}{\partial x}(x_t, z_t) x_t, \qquad \text{and} \qquad P_{z,\tau} = \sum_{t=\tau}^{\infty} \beta^{t-\tau} \frac{U'(y_t)}{U'(y_\tau)} \frac{\partial F}{\partial z}(x_t, z_t) z_t.$$

2.1.1 Before the shock

Initially, there are no orange trees. The economy comprises a unit measure of apple trees, each yielding x apples. Output and consumption are

$$y = F(x, 0),$$

and expected to remain there indefinitely. Any change in this state of affairs is thought to be impossible, or at least, highly improbable. The aggregate stock market value or "market capitalization", is then,

$$M_\tau = \sum_{t=\tau}^{\infty} \beta^{t-\tau} \frac{U'(y)}{U'(y)} \frac{\partial F}{\partial x}(x, 0) x = \frac{(1-s) y}{1-\beta},$$

for all τ, because by Euler's Theorem $\frac{\partial F}{\partial x}(x, 0) x = (1-s) y$, where s is the cost-share of the factor n. The ratio market capitalization to GDP is just $(1-s)/(1-\beta)$.

2.1.2 News arrives at date zero

News arrives at $t = 0$ that a unit-measure of orange trees will spring forth at the beginning of date T, and that each tree will yield z oranges per period. At date T – and *not* at date zero – agents will also expect to receive an equal share of claims to the output of these orange trees. This assumed delay is supposed to reflect the reality that a new company takes years before reaching its initial public offering. The arrival of the orange trees permanently raises the output of juice to

$$y' = F(x, z).$$

Until date T, stockholders will only receive the dividends from the apple trees. All this becomes known at date zero, and no further shocks are expected.

The effect of the news on stock prices In what follows, we shall assume that s, the share of the third input, in constant. An example follows. Since $(1-s)\,y = F\,(x,0) = \frac{\partial F(x,0)}{\partial x}x$ the apple trees will command a price of

$$P_{x,t} = \begin{cases} \frac{1-\beta^{T-t}}{1-\beta}\,(1-s)\,y + \frac{\beta^{T-t}}{1-\beta}\left(\frac{U'(y')}{U'(y)}\right)\frac{\partial F(x,z)}{\partial x}x & \text{for } t \leq T-1 \\ \frac{1}{1-\beta}\frac{\partial F(x,z)}{\partial x}x & \text{for } t \geq T \end{cases},$$

and market capitalization now becomes.

$$M_t = \begin{cases} P_{x,t} & \text{for } t \leq T-1 \\ \frac{(1-s)y'}{1-\beta} & \text{for } t \geq T \end{cases}.$$

Note that we have *defined* $P_{z,t}$ to equal zero for $t \leq T-1$, even though, even before date T, the value of the sprouting orange trees would be positive if they were to trade on the stock market.

When the news arrives, $P_{x,t}$, and therefore M_t as well, falls for two reasons. First, the rate of interest between date $T-1$ and date T rises because that is when output rises permanently from y to y'. Before date T arrives, dividends beyond date $T-1$ are now discounted at a higher rate, i.e., they are multiplied by the factor $\left(\frac{U'(y')}{U'(y)}\right) < 1$. This effect cannot really explain the stock-market drop, however, because the real rate of interest simply did not rise by that much during the 1970's and 1980's. Moreover, in an open economy, if the price of juice at all dates was fixed and constant, the interest-rate impact does not exist, even in theory.

The second effect is a possible obsolescence of apples – oranges may displace apples as an input and, assuming that apples and oranges are substitutes in the production of juice this would show up as a lower price of x, in that $\frac{\partial F(x,z)}{\partial x} < \frac{\partial F(x,0)}{\partial x}$. The largest impact would occur if the arrival of oranges were to make apples *fully* obsolete so that $F_x\,(x,z) = 0$. This would happen, e.g., if people wanted at most one glass of

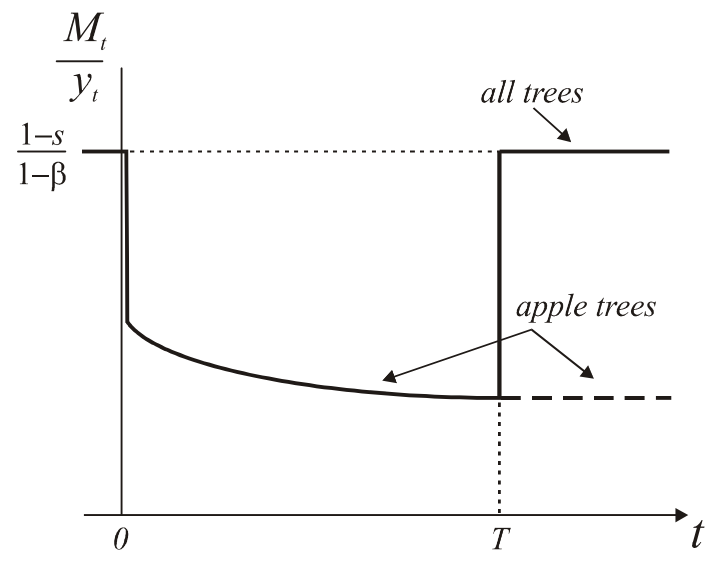

Figure 4: The predicted path of the market cap/GDP ratio

juice, and if they preferred that juice to be pure orange. The value of the apple trees relative to GDP would then be

$$\frac{P_{x,t}}{y_t} = \begin{cases} (1-s)\,\frac{1-\beta^{T-t}}{1-\beta} & \text{for } t \leq T-1 \\ 0 & \text{for } t \geq T. \end{cases}$$

Ignoring the constant of proportionality $(1-s)$, the impact effect of the news at date zero would be $\frac{1-\beta^T}{1-\beta}$, which, at $T = 12$ and $\beta = 0.96$ would represent a fall from $\frac{1}{1-(0.96)} = 25$ to $\frac{1-(0.96)^{12}}{1-(0.96)} = 9.7$, a 61 percent drop and the largest that this model can deliver. To get a drop of this size, however, requires that we assume the value of incumbents to be zero after date T, and this, as we shall see, does not fit the facts.

After the orange trees start to be traded, the ratio M_t/y_t reverts to its pre-news level of $(1-s)/(1-\beta)$. Figure 3 illustrates the predicted time path of M_t/y_t before and after the news arrives. Figure 4 is the theoretical counterpart of Figure 1. The two figures look similar if the date $t = 0$ is set to correspond to the year 1973, and if $T = 12$ years. This might seem like a long time, but the time-to-IPO should be longer when a technology is young and, hence, risky. Microsoft, for example, was formed in 1976 but only went public in 1986.

Example Here is an example of a production function $F(x, z, n)$ for which the share of the third factor, i.e. s, is constant, as we had assumed above. Let

$$F(x, z, n) = \max_{n \in [0,1]} \left\{ x^\alpha n^{1-\alpha} + z^\alpha (1-n)^{1-\alpha} \right\}.$$

The share of n is $(1-\alpha)$. The price of apples is $\alpha x^{\alpha-1}$ and the apple dividend is αx^{α}. The new price is price of apples is $\alpha x^{\alpha-1} n^{1-\alpha}$and the apple dividend in units of the final good is $\alpha x^{\alpha} n^{1-\alpha}$. Therefore the percentage drop in dividend value is $1-n^{1-\alpha}$and it depends on how many resources n are left. This depends, in turn on how much z "arrives". Suppose $z = \gamma x$. Then the FOC says that $n^{-\alpha} = \gamma^{\alpha} (1-n)^{-\alpha}$, so that $n = \frac{1}{1+\gamma}$. The price of apples falls from $\alpha x^{\alpha-1}$ to $\alpha x^{\alpha-1} \left(\frac{1}{1+\gamma}\right)^{1-\alpha}$, and the new value of the apple-tree dividend is $\alpha x^{\alpha} \left(\frac{1}{1+\gamma}\right)^{1-\alpha}$. So, dividends of apple trees fall permanently by a factor of $\left(\frac{1}{1+\gamma}\right)^{1-\alpha}$ at date T.

3 Tests of the *IT* hypothesis

The model suggests that the drop and subsequent rise in market-cap/GDP should have been accompanied by the following five observations:

1. Most of the post-1985 rise in market capitalization should be due to the post-1972 entry of new firms and not to an increase in the value of the 1972 stock market incumbents.

2. The model should work best for the *IT*-intensive sectors of the economy. The largest 1973-4 price declines should have occurred in sectors that had the largest post-1973 investments in *IT* – sectors like Finance, Insurance and Real Estate (FIRE), and the service sector generally.

3. If *IT* revolution really did change the pattern of comparative managing advantage in 1973, then we should see a rise in mergers, takeovers, and exits before or around the same time the new firms arrive in the market.

4. If the *IT* revolution favored new firms, then new (and, perhaps young and, hence, small) firms should have grown faster than big firms after 1973.

5. The model predicts an increase of the real interest rate, or in an open economy, an increase in consumption at the time that the news about the *IT* revolution arrives.

This section takes up each of these implications in turn.

3.1 The fate of the 1972 incumbents

Figure 4 states that incumbents do not take part in the date-T recovery of the stock market. To test this proposition, we need to know who the 1972 incumbents were. Most are covered by the Center for Research in Security Prices (CRSP) data. The dashed line in Figure 1 is the ratio of market capitalization to GDP for the dataset

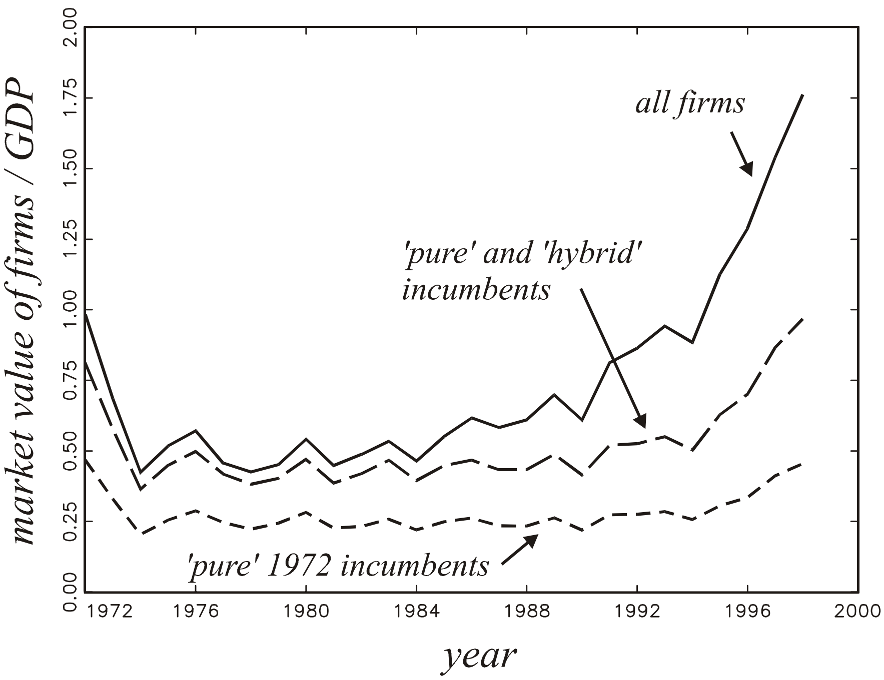

Figure 5: The fate of the 72 incumbents

published by the CRSP that contains the stocks traded on the NYSE, AMEX, and NASDAQ. The difference between the two are mainly stocks traded over the counter.

Because of mergers that took place after 1972, the "fate" of the 1972 incumbents is a little ambiguous. Some incumbents merged with firms that entered after 1972. If so, does the new value belong to the old vintage or to the new? We call this ambiguous class of firms *hybrids*. We shall distinguish these hybrid incumbents from *pure* 1972 incumbents that did not merged with any post-1972-vintage firms. An incumbent is either hybrid or pure.[9]

Figure 5 shows that relative to GDP, the 1972 CRSP incumbents' value fell by more than 50 percent over a few years, and never fully recovered. Yet, since 1985 the value of the market relative to GDP has tripled! *The source of this new value must, therefore, be firms that entered after* 1972, roughly as Figure 4 asserts.

The 1972 incumbents thus fared badly, and entrants did spectacularly well, some 15-20 years later. But, is this at all unusual? After all, we know that even after one controls for survivorship bias, small firms grow faster than large ones, and we believe that all firms must die sooner or later and make way for new firms. The question, then, shouldn't be whether the 1972 incumbents did badly relative to subsequent entrants, but rather, whether the 1972 incumbents did badly when compared with incumbents of *other* vintages. What became of incumbents that, at a corresponding

[9] A complete description of the data construction is given in Appendix A.

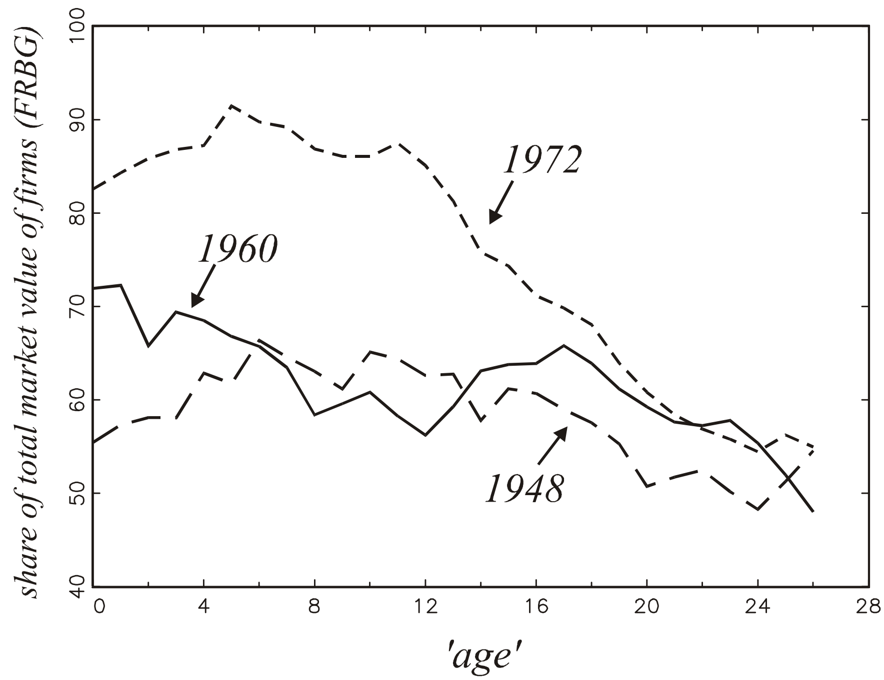

Figure 6: Shares of three vintages of incumbents

stage in their existence, did *not* have to cope with technological change as major as *IT*?

Figure 6 plots the market shares of three incumbent-vintages against their "age" (defined as calendar time minus their vintage). If no security traded over the counter, all three curves would begin at 100 percent. Instead, the intercepts of the curves rise with vintage, implying that over-the-counter trading has declined in importance relative to market trading. The capitalization of stocks that traded over the counter declined from 45 percent of total capitalization in 1948, to 28 percent in 1960, and finally to 17.5 percent in 1972. This decline probably took place because stock market trading has become much easier over time, a trend that is itself due in part to the computer.

Figure 6 also shows that the 1972 incumbents lost market share much faster than the other two generations. At age 26, the share of all three generations is around 50 percent, even though the 1972 incumbents start off with an eleven percent higher market share. Thus, the 1972 incumbents did worse than the other generations.

3.2 *IT*-intensive sectors lost more value in 1973

The service sector has invested much more heavily in *IT* than has the manufacturing sector, and, within the service sector, the FIRE segment of services being the first to

Table 1: Summary statistics

sector	**exposure to *IT***		**'72-'74**	**'98 Incumbent**
	inv. share	**cap. share**	**Drop**	**share**
Manuf.	33.9	17.9	44.7	80.2
TCPU	33.8	38.5	45.8	59.9
FIRE	30.0	41.5	49.5	58.7
Services	31.2	42.4	71.8	22.0

do so. Figure 7 reports the fate of the 1972 incumbents by major sector: Manufacturing, FIRE, services, and Transportation, Communication and Public Utilities.

Two things emerge from Figure 7. First, the biggest 1973 value drops occurred where subsequent *IT* investment was the highest. The smallest 1972-1974 decline is in manufacturing, where values fell by a factor of 45 percent. A larger decline (50 percent) occurred in FIRE , and a larger one still (72 percent) in other services. And, second, where incumbents' values fell the most in 1973, the subsequent recovery was the weakest. The point is, not being as much "at risk" from *IT*, manufacturing firms were not hit as hard by it as other sectors were.

This is all summarized in Table 1. The table reports two different measures of exposure to *IT*. The first, a flow concept, is the average real investment share of *IT* equipment in equipment investment for 1974-1996. The second, stock concept, is the share of real *IT* equipment in the real total stock of equipment. All data are from the BEA's tangible wealth table. The first measures more closely the costs of *adopting IT*, the second measures the *use* of *IT* in production. The two measures differ when industries' rates of investment are not constant. The stock measure conforms much better to the theory – a clear positive relation exists between the second and third columns.[10]

We also regressed the 1973-4 percentage drop of sector i, denoted by D_i, on the log of the capital share of IT in the '96 equipment capital stock (measured in 1992 prices, taken from the BEA tangible wealth table), denoted by $CapS_i$, and on the log of the share of the '72 incumbents in the sector's '98 market value, denoted by $IncS_i$. The regression results for the 52 sectors for which we have data are

$$D_i = \underset{(3.38)}{64.06} + \underset{(2.66)}{7.82}\ CapS_i - \underset{(-2.22)}{9.52}\ IncS_i \quad n = 52 \quad R^2 = .205$$

Hence, the more *IT* intensive a sector turned out to be the higher its drop in 1973, the more threatened incumbents were by entry in the 1974-1996 period the higher the drop again. This evidence is consistent with our hypothesis.

[10] We thank Hyunbae Chun of NYU for providing us with the the sectoral-IT investment data.

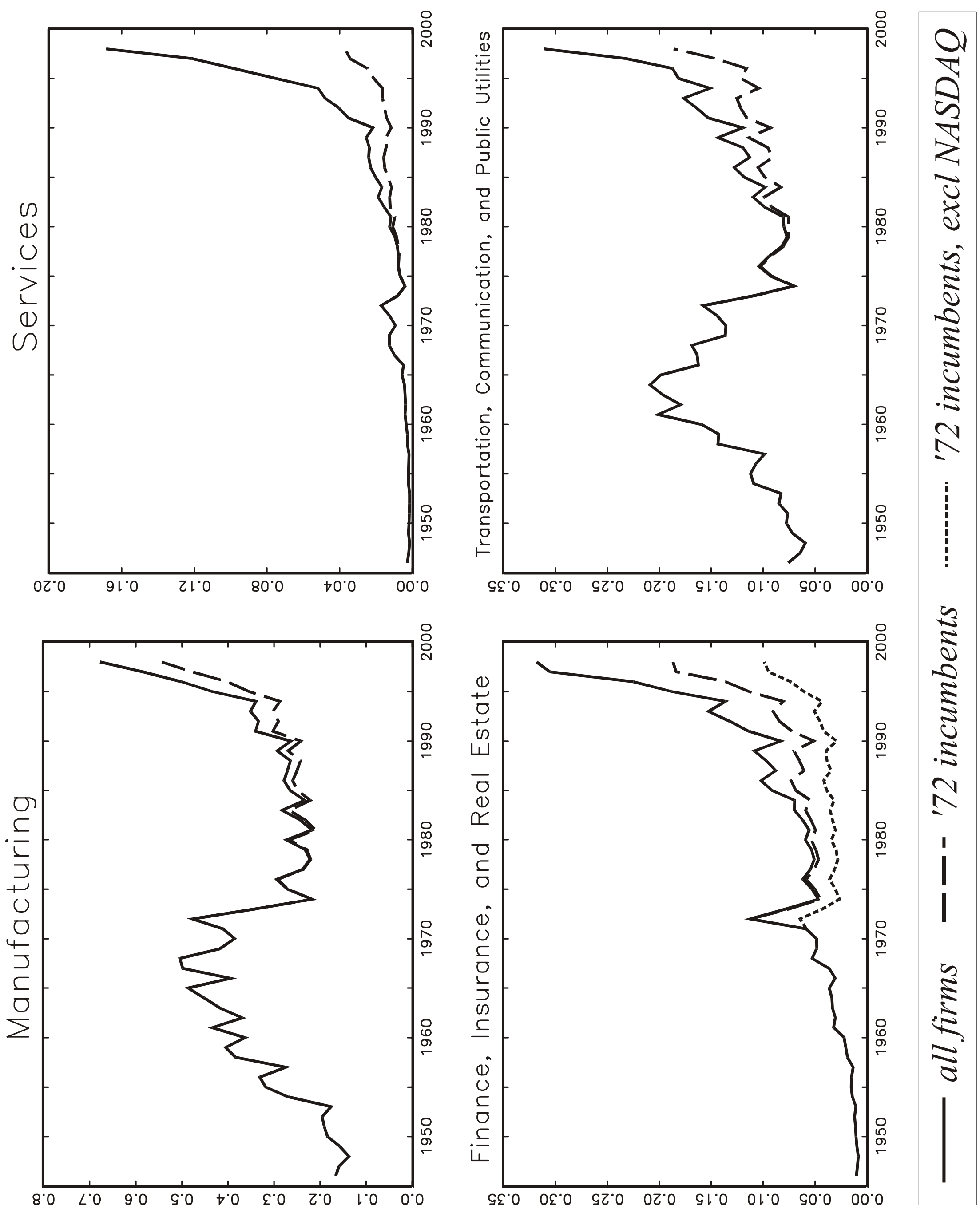

Figure 7: The fate of the 1972 incumbents by major sector

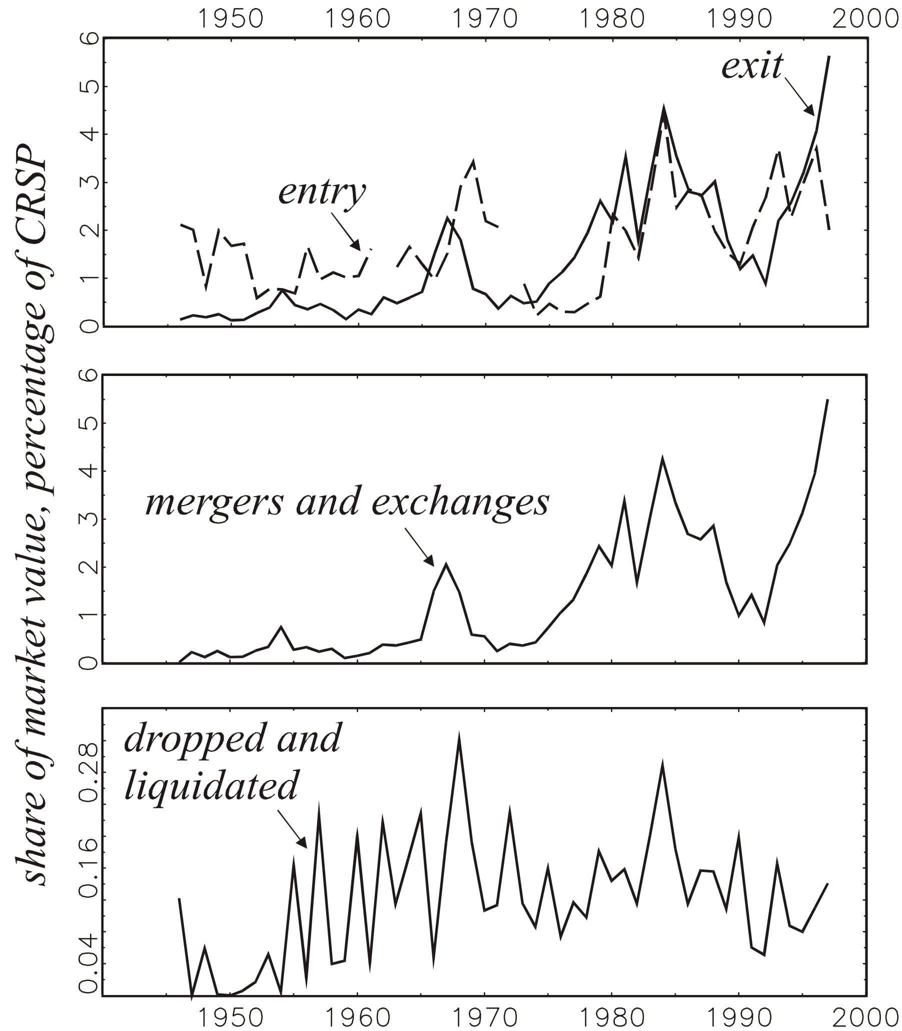

Figure 8: Entry, exit, and reasons for exit from stock market

3.3 The rise of entry, exit, takeovers, and mergers

The introduction of information technology coincided with a period in which entry, exit, takeover, and merger activity in the stock market, all increased. We argued in section 2 that these events were to be expected given that the advent of *IT*, a major new technology, rearranged the pattern of comparative advantage among managers. Ueda (1997) finds, for instance, merger waves focus on sectors that subsequently show high productivity growth. It seems, then, that when technology shifts, it prompts a re-shuffle.

The plot in the top panel of Figure 8 shows a pronounced rise in both entry and exit in the CRSP[11], denoted in terms of their share of the total market capitalization.

[11] For the entry series, two observations are left out on purpose – 1961 and 1972 – the years that

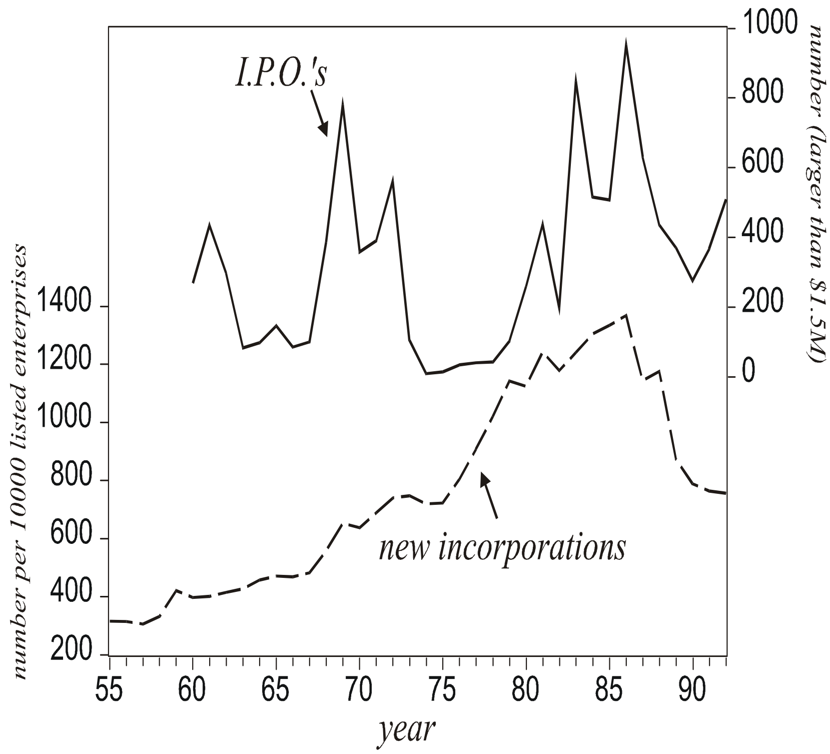

Figure 9: The rate of business incorporations and the number of IPO's

As suggested by the model, entry and exit activity both increased significantly after 1973. This remains true when one looks outside the CRSP. As Figure 10 shows, the rate of incorporations and real exits has risen substantially in the 1980's and remains high[12]. Together with the entry rate, we also plot the number of IPO's at least $1.5 million in size.[13] Since the 1980's IPO's are much higher than they were in the 1970's, although not much higher than they were during the 1960's. But new incorporations, a better measure of the "start-up" peaked in the 1980's, as were exits, plotted in the bottom panel of Figure 10.

In the manufacturing sector, the rate of gross job flows shows a slight, but relatively unbroken downward trend. This does not support our argument, but, as we shall shortly document, the manufacturing sector has invested the least in *IT*, and is the least likely to offer empirical support for our argument. Moreover, Haltiwanger and Schuh (1999, Figure 6) find that there has been a rise in the permanent (i.e., exceeding two years) component of job-destruction. That is, a job is now less likely

AMEX and NASDAQ enter the CRSP.

[12]The entry and exit data plotted in Figure 10 are rates per 10,000 registered enterprises. The data were provided us by Valerie Ramey; she had presented them in a discussion at the NBER Fluctuations meeting, July 17, 1999.

[13]More details on these data are in Ibbotson *et al* (1994).

Figure 10: The rate of failure of businesses

to be destroyed, but when it is gone, it is gone for good. This also explains why unemployment duration has risen in the 1990's, a time when the unemployment rate is generally falling.[14]

Gross job-flows may have slightly declined, but, on the other hand, gross flows of capital have risen. Ramey and Shapiro (1998) compiled a gross-capital-flow series, reproduced in Figure 11, that shows a definite rise since the 1980's, especially in capital destruction.

The gross flows of firms and of capital seem, therefore, to have picked up since the 1980's. Next, we return to the CRSP which decomposes the exits (but not entries) into several categories. Our next task is to quantify the individual exit flows.

The bottom two panels of figure 8 depict the reasons for exit. The peak in exit in the 1980's is due mainly to mergers and exchanges, consistent with the evidence in Golbe and White (1993). The share of firms liquidated also peaked in the early 80's. The fraction of value dropped from the market, mainly because the firm decides to stop to be traded on the market, is fairly constant for the post war period.

One important *caveat* here. We have interpreted the rise in stock-market entry as a symptom of greater frequency of "policing activity" the origin of which is the established firms' resistance to *IT*. But the increased entry may have a different explanation: Computerized trading and the NASDAQ made it relatively cheaper for firms to be traded on the stock market. Such a decrease in transaction costs would induce more firms to go public, but it should have *raised* market-cap/GDP.

[14] We thank Scott Schuh for this fact, documented in the Dallas Fed. Review (1994-5).

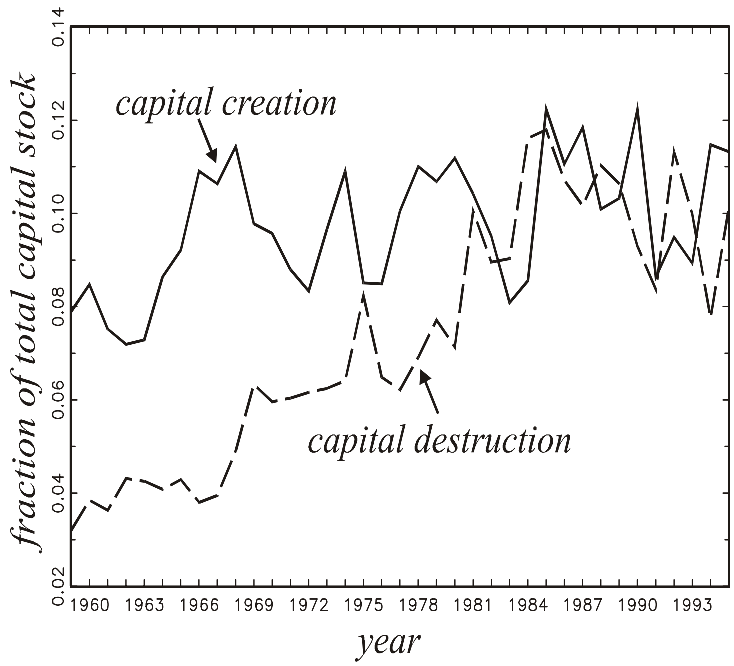

Figure 11: Entry and exit of physical capital

3.4 The post-1973 boom of entrants and small firms

Did entrants and small firms do better than large firms? This section asks whether entrants and small incumbents did especially well after *IT*-revolution. We look first at the performance of entrants, and then that of the small incumbents – i.e., the small-cap stocks.

3.4.1 Entrants

The results in Table 2 report on the fate of entrants ten years after their CRSP entry. Each row reports the percentage of entrants exiting by a decade's end. The first row gives the percentage of entrants that merged or 'exchanged' at some point during the decade. Mergers and exchanges have risen sharply over time: In '85-'95, exits for these two reasons were 2.5 times higher than they had been in '45-'55 and even 2 times higher than during the 60's merger wave. Some old firms are entering the *IT* era by acquiring the small innovators.

The last two rows of Table 2 present figures on genuine exits from the CRSP. A "drop" arises when a firm stops being traded, usually because its value has fallen below a critical level. Combined with "liquidations", such exits have risen dramatically – by a factor of 13.

Table 2: Achievements of entrants per decade

decade	**45-55**	**55-65**	**65-75**	**75-85**	**85-95**
Percentage merged or exchanged	5.61	8.84	7.27	10.78	15.37
Percentage liquidated	1.40	1.70	0.63	0.77	0.24
Percentage "dropped"	0.35	5.17	10.12	21.74	18.51
Total	7.37	15.71	18.02	33.28	34.12

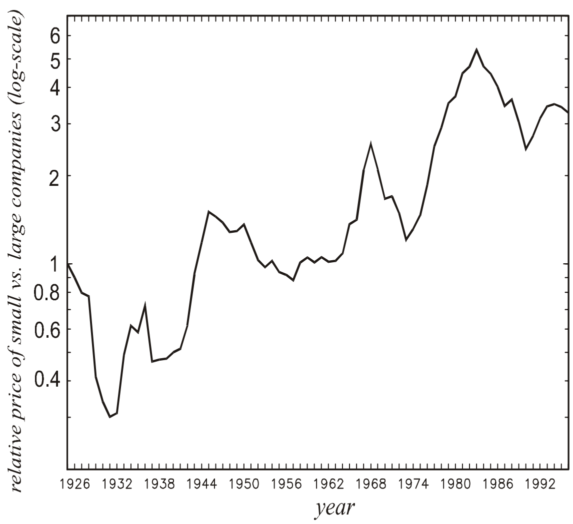

Figure 12: Performance of small companies vs. large companies

3.4.2 Small incumbents – the performance of small-cap stocks

Aside from entrants, the arrival of a new technology should have favored younger, and generally smaller, firms that tend to have a nonhierarchical structure, fewer unionized or tenured workers, and fewer outdated management practices.

Figure 12 plots the ratio of the Ibbotson small cap index to the S&P 500 index. During the period 1974 - 1982, small cap stocks outperformed the S&P 500 by a factor of nearly 4. Since then, the S&P 500 has done better than the small caps, probably because, by the early 1980's and the advent of the junk-bond, inefficient large firms began to feel stronger hostile-takeover pressures, and responded by becoming more efficient. The strong performance of the small caps in the 1974-82 period mirrors the small product-market performance of small relative to large firms that was summarized in Figure 8 of Greenwood and Jovanovic (1999). A summary of some information in Figure 12 is in Table 3 with the changes in the small/large-cap ratio for various time periods.

Table 3: Small cap performance for various historical periods

period	**years**	**change**
IT revolution	74-82	increased by factor of 3.7
Sixties boom	56-65	increased by factor of 1.5
WWII	41-45	increased by factor of 2.9
Depression	28-31	decreased by factor of 2.6

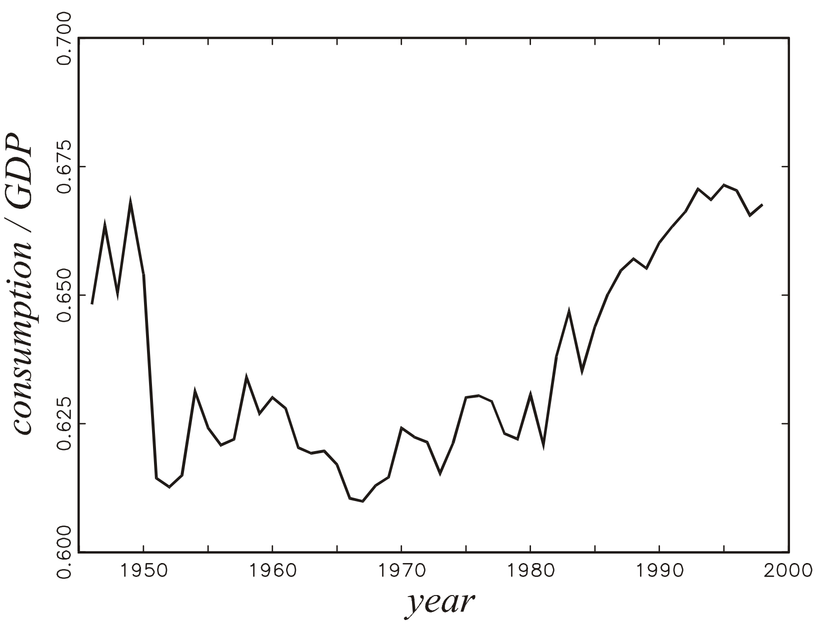

Figure 13: Consumption increase

3.5 Effect of the news on consumption

Since the real interest rate did not change much during the seventies, the IT hypothesis implies that consumption should have risen when the good news arrived. In the model consumption cannot rise until date T because the model includes neither capital nor imports, but in fact consumption could and, indeed, did rise in the 1970's. The U.S. personal savings rate was at a 30-year high in 1973, and has since become negative. U.S. personal consumption was at 61.5 percent of GDP in 1973, it rose to 63 percent in 1974, and it has been rising more or less steadily ever since. Moreover, Parker (1999) shows that consumption has been rising the most among the youngest cohorts, and this is what should have happened if the good news included a forecast of higher wages for them in the 1990's.

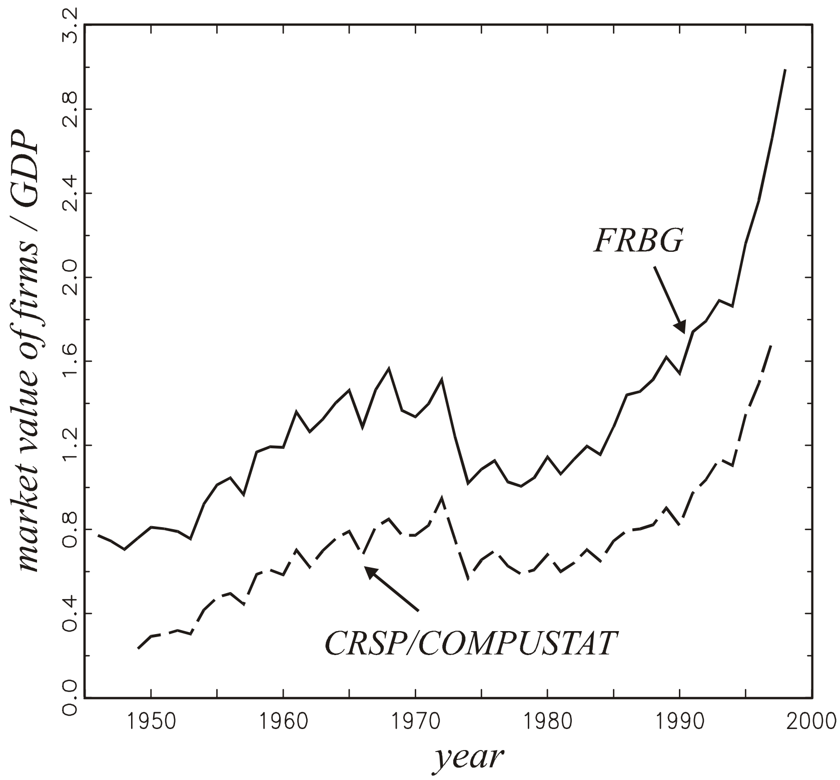

Figure 14: Market value of firms relative to GDP

4 Inclusion of debt

As a test of the *IT* hypothesis, it is better to compute the value of a firm by adding its debt to the value of its shares, because this is the total value of the claims on a firm's profit. This can readily be done in the aggregate, and Hall (1999) has done so. Using data from the Federal Reserve Board's Flow of Funds Accounts on equity and debt he has shown that these data also show a drop in 1973 that we have focussed on in this paper, and we, too, shall use these data below.

For individual firms, however, debt data as detailed as the CRSP stocks-data are hard to find. Nevertheless, we have merged the equity data from the CRSP with the debt data from Compustat. The extended data set generally confirm the results presented so far. For example, the equivalent of Figure 1 is Figure 14. This figure plots the ratio of market value of firms to GDP for both the aggregate data taken from the FRBG and the merged sample of Compustat and CRSP. Appendix A contains a detailed description of the construction of the data. Both Figures 1 and 14 show a drop in value in 1973. The one in Figure 14 is less percentage wise because of the fact that the book-market value of debt in 1973 did not fall as much as the value of equity.

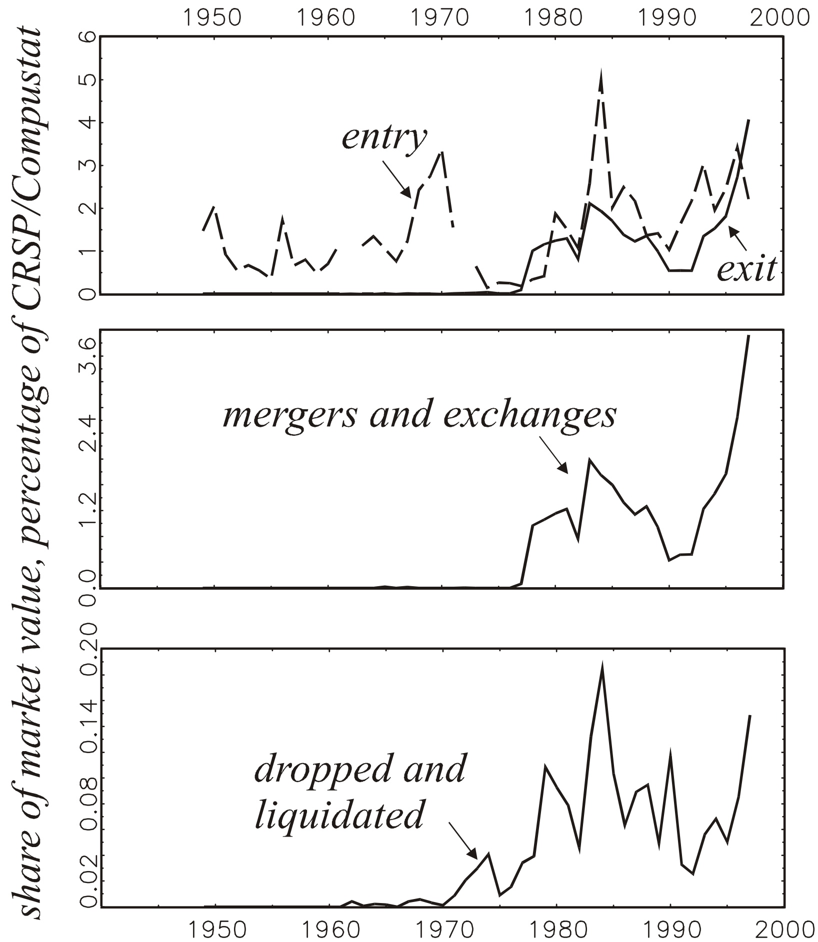

Figure 15: Selection bias in Compustat sample

The limiting feature of the historical Compustat data is their severe selection bias. To be in the Compustat sample, a firms had to be in the sample in the 1980's. The data therefore miss any firm that exited during the merger wave in the 60's or during the 70's. Using the Compustat thus severely limits the data availability for the sample of incumbents. This selection bias is most evident from the equivalent of Figure 8. That is, Figure 15 shows how little exit the Compustat sample exhibits before 1975.In spite of this selection bias we have redone our empirical evidence for the extended data and present the complete results in Appendix B. Though the results presented above and the ones in Appendix B differ quantitatively, they do not differ much qualitatively.

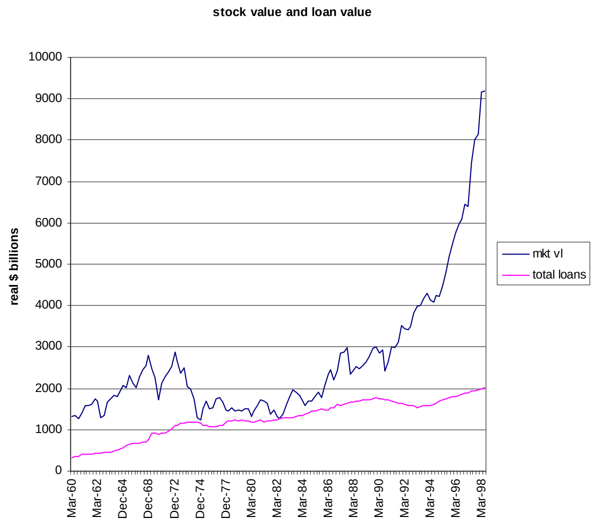

Figure 16: Total loans and the total value of stocks 1960 - 1998.

4.0.1 What did banks do when stocks fell in 73-4?

The *IT* hypothesis states that during the 1970's and early 1980's a large investment went undetected by the stock-market data, only to surface in the form of IPO's afterwards. Some of that investment probably entailed unmeasured time inputs – e.g., building a prototype in a garage – as well as foregone consumption. But some of that investment should also have shown in the form of increased bank loans. Total loans are much smoother than the value of stocks, as Figure 16, based on data analyzed by Craig and Haubrich (1999), shows. It also shows a definite rise in loans in 1973, and the correlation coefficient between the detrended series is -0.29.

5 Other explanations

The *IT* hypothesis manages to explain and link the following four facts:

1. The decline and subsequent rise of market-cap/GDP,
2. The dominant role of entrants in the post '85 market boom.
3. The merger wave of the eighties, and
4. The consumption boom that started in the 1970's.

What about the other possible explanations?

5.1 Oil shocks?

The oil-price increases of October-December of 1973 – the "first oil shock" – usually get blamed for some part of the productivity slowdown of the 1970's. One argument says that this shock, reinforced perhaps by a reaction by the Fed in setting its monetary policy, lowered expected profits for U.S. firms and, as such, depressed the stock market. The attractive thing about this explanation is that oil prices behaved the same way everywhere, and therefore their behavior may, perhaps, explain the universally bad performance of stock markets in the 1970's and early 1980's. But, monetary policies differed by country, and so this "reinforcement", which may have harmed stock prices in the U.S., did not exist elsewhere. Therefore, if we are to explain the collapse in the world's stock markets, we are left with the oil-shock by itself.

Three problems plague the oil-shock explanation. First, the large 1979 shock had no impact at all on the variables plotted in the first two figures. Second, oil was too small a fraction of costs to have much effect on dividends. Which firms lost the most value in 1973-4? Were these firms "at risk" of being affected by IT, in which case we should find them in sectors that later would invest a lot in IT? Or were they firms that used production processes that relied heavily on oil, and that would therefore be hit hardest by the oil price-rises of 1973-4? We run a statistical horse race in which IT wins hands down.

The dependent variable in the regressions in Table 4 is the percentage drop in the market capitalization of sector i in the 1972-1974 period, and it comes from the CRSP. Thus a positive value is a drop, a negative value a rise. The regressors should measure the relevance of IT and the relevance of oil prices. The first regressor is the logarithm of the share of computer and related equipment in the 1996 real equipment capital stock of sector i, in 1992 dollars, and it comes from the BEA's tangible wealth table. It measures how important IT was in the subsequent investment in sector i, and our model says that its coefficient should be positive, because sectors with a lot of investment-exposure to IT should have been the hardest hit by the new technology. The second regressor is essentially the 25-year survival rate of the 1972 incumbents' capital and arguably proxies for resistance to change in that sector; this variable is the logarithm of the 1996 share of the 1972 incumbents in the market capitalization of sector i, and it, too, comes from the CRSP. Our model says that its coefficient should be negative: Sectors in which value falls most should be ones in which, entrants add the most value later on. The fourth regressor is the log of the 1972 share of oil in the production costs of sector i – dollars spent (directly and indirectly, i.e., through inputs from other sectors) on crude petroleum and natural gas per 100 dollars of the output produced. These data come from the 1972 input-output tables. Our sectors do not completely correspond to the ones in the input output table, so we have matched them as well as we could. Finally, if by some chance the IT-intensive sectors were hit harder than others by the recession of '73-'74, the outcome could

Table 4: Regression results

dependent variable: *'72-'74 percentage drop in market capitalization* ($n = 52$)	I	II	III	IV	V
intercept	26.63 (2.94)	64.06 (3.37)	71.48 (3.79)	77.64 (4.13)	78.67 (4.15)
logarithm of '96 IT equipment capital share	8.12 (2.67)	7.82 (2.66)	9.00 (3.08)	7.68 (2.59)	7.80 (2.61)
logarithm of '98 share of '72 incumbents		−9.52 (2.22)	−13.42 (−2.89)	−13.96 (−3.06)	−14.58 (−3.12)
'73-'74 growth rate of output			−0.83 (−1.92)	−1.19 (−2.53)	−1.10 (−2.24)
logarithm of 1972 oil share				−6.66 (−1.75)	−5.86 (−1.47)
durables dummy					5.73 (0.68)
R^2	.124	.205	.262	.307	.314

Table 5: Correlation matrix

		1	2	3	4	5
1	*'72-'74 percentage drop in market cap.*	1.000	0.353	-0.299	-0.015	-0.234
2	*logarithm of '96 IT equipment capital share*	0.353	1.000	-0.046	0.209	-0.322
3	*logarithm of '98 share of '72 incumbents*	-0.299	-0.046	1.000	-0.437	0.150
4	*'73-'74 growth rate of output*	-0.015	0.209	-0.437	1.000	-0.483
5	*logarithm of 1972 oil share*	-0.234	-0.322	0.150	-0.483	1.000

be due to the recession and not to *IT*. To handle this possibility we include as a regressor the '73-'74 the growth rate of real output of the sector. Moreover, durable goods are more cyclical than others, and so to control for this concern, we include the dummy variable which is one for durable goods producing sectors (Construction, Furniture, Industrial machinery, Electronic and electric equipment, Motor vehicles, Transportation equipment, Instruments).

The regressions in Table 4 show that oil did not cause the stock market drop in 1973-1974, and they favor the *IT*-interpretation – both of the *IT* variables are of the correct sign and they differ significantly from zero. The coefficient associated with oil is not significant and, in fact, has the opposite sign from what one would have expected. That is, the sectors that were the *least* energy intensive dropped the most in value. The inclusion of the durable goods dummy doesn't change the conclusion.

Table 5 lists the cross correlations between the regressand and regressors that we considered. Our model would predict a higher correlation between the ex post *IT* intensity of the industries and their incumbent shares. The data, however, suggest that this correlation is close to zero, -0.046 to be precise. This is probably due to the fact that the incumbent variable does not only proxy for the degree of resistance

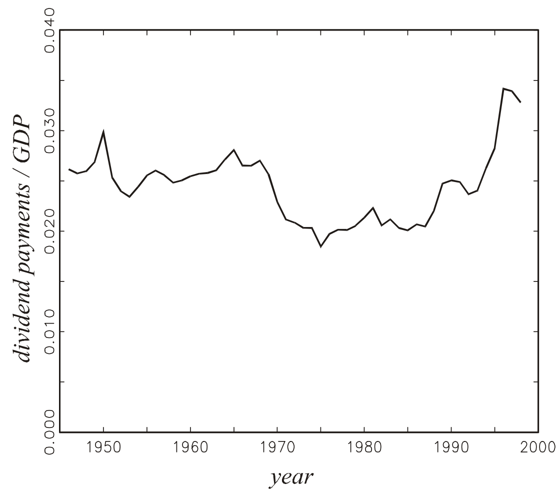

Figure 17: Dividends as a fraction of GDP

but also for the degree of deregulation in the various sectors. That is, sectors that are deregulated generally see a lot of entry of new firms. The most notable example of this is Sprint and MCI's threat to AT&T's telecommunications monopoly.

The third reason why oil prices cannot explain the time path of the stock market is that a rise in oil prices should have lowered current profits more than future profits, because of the greater ease of finding substitutes for oil on the long run, perhaps current output more than future output and, therefore, should have produced a *rise* in the ratio of market capitalization to GDP, not a fall. Moreover, this scenario does not suggest any entry in the stock market, and so, it implies that the share of the incumbent firms is constant at 1. Hence it also cannot explain the entry-driven increase in market value relative to GDP that we have observed in the late 80's and 90's.

Does this conclusion hinge on our assumption that dividends are a constant fraction of output? This is a potential concern because, as figure 17 shows, the first oil shock was followed by a drop in dividends relative to output.

But this drop was around 20 percent only, not large enough to produce the required rise in market-cap/dividends. In Figure 18 we plot this ratio, and it, too falls in 1973 instead of rising as one would have expected. Finally, the oil shock story also cannot explain why entrants were so important in the subsequent market rise. We conclude that, whatever role the oil shock may have played in generating the productivity slowdown of the '70's, it does not help explain the behavior of the stock market.

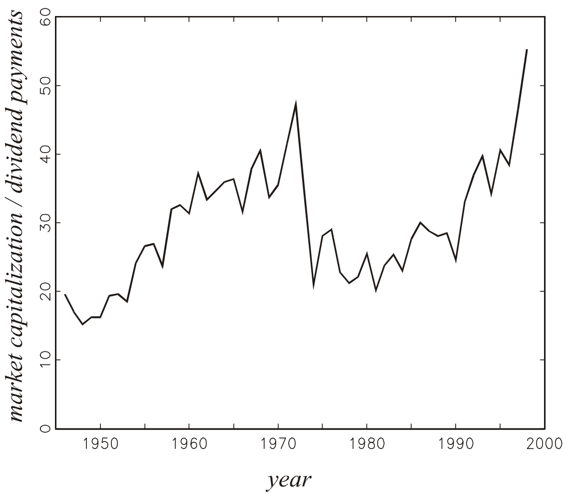

Figure 18: Market capitalization over dividend payments

5.2 Exhaustion of Old Technologies?

A similar argument is that, in 1973, news arrived that was *bad* for existing technologies, i.e., that the old technologies had played themselves out. Zeira (1999) offers a model in which such news arrives suddenly: Old technologies have a maximum potential, but we don't know what the maximum is; once we hit this ceiling, however, we suddenly realize that no further growth is possible, and this causes the technology's present value to crash. In other words, in Zeira's model, a crash occurs when output and dividends stop increasing. In particular, stock prices fall relative to output, just as Figure 1 says they did. Similarly, Jovanovic and Rob (1990) argue that the economy does well when the technologies in current use are working out well and that we direct our efforts towards developing new technologies only when we get bad news about the incumbent ones.

This line of argument faces two problems, both quantitative in nature. First, the sheer number and variety of technologies in use make it quite unlikely that they would all expire at the same time. And, second, as any technology gets older, we get to know it better. The more we use it and refine it, the smaller is the potential surprise.[15] It is new, untried technologies that hold the big surprises.

[15] In Zeira's model, the growth-epoch is exponentially distributed, and the probability distribution of the residual lifetime of growth stays constant as the technology ages. Because of this, news of the demise of growth is always a nasty surprise, no matter how old the technology that generates the growth. In Jovanovic and Rob's model, residual uncertainty shrinks as the technology ages, but , then, so does the potential surprise.

5.3 Increased volatility?

Pindyck (1984) considers Malkiel's suggestion that the decline of the 1970's reflected the response of risk-averse investors to a secular rise in the volatility of stock returns and in the uncertainty in the business environment. But after rising in the 1970's, the volatility of stock returns has not reverted to its pre-1970 level, yet stock prices bounced back after 1985. And judging, at least, by the higher turnover of values in the CRSP, the business environment is riskier than ever. Moreover, the very stocks that are now so highly valued are also extremely risky. This hypothesis does not, therefore, seem to be a serious contender for explaining the broader picture, unless one takes seriously the "Peso Problem" idea that investors considered an economic catastrophe (the likes of which are not included in the time series) more likely during the 1970's.[16]

5.4 Nonfundamentals?

Is the stock market bubble-prone? Did a positive bubble burst, or a negative one form sometime between 1968 and 1974? And today, do we see a positive bubble, especially in the internet stocks? One can, perhaps, dismiss explanations like "crazes", "manias", etc. that invoke investor irrationality, but this still leaves a class of models in which rational bubbles can form.

Theory says that to have sunspot equilibria in which the prices of assets fluctuate independently of fundamentals, we need finite horizons, or heterogeneous beliefs. These conditions seem reasonable enough, and one certainly could not, offhand, rule out the possibility that the story of the large post-war swings in the stock market is largely one of bubbles. To be at all convinced, however, we would also need to be told why the bubbles simultaneously burst and then, later, simultaneously formed in various stock markets around the world, but let's suppose that a respectable argument for this, too, can be found. What would this tell us about why the swings in the stock market took place? Exactly nothing, of course, since switches among equilibrium points *have* no economic explanation.[17]

6 Conclusion

We have argued that aggregate valuation can fall below the present value of dividends because capital may "disappear" right after a major technological shift because this

[16] Pindyck also discusses the Feldstein-Summers suggestion that the high inflation of the '70's reduced the value of firms because it reduced the real value of their depreciation write-offs, and Modigliani's suggestion that, in the '70's, inflationary expectations found their way into nominal interest rates but, somehow, not into future dividends.

[17] Some sunspot equilibria are not jumps among equilibrium points, but the jumps that they display still lie beyond the grasp of economic science.

is when new capital forms in small, private companies. Later, these companies are IPO'd, and their value then becomes a part of stock-market capitalization.

To put it another way, the vintage capital model teaches us that technological change destroys old capital. We go a step further and argue that major technological change – like the *IT* revolution – destroys old *firms*. It does so by making 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.

Arbitrage opportunities arise in the model only for an agent who has advance information. For instance, if an agent were to get the news about the *IT* shock before anyone else, he could make money by selling the incumbent firms short. Or, if he could identify the successful entrants at date T before anyone else did, he could acquire a stake in them, and make money at the IPO stage. In fact, many people must have made money in precisely this way. Moreover, through apparent good fortune, stockholders have done very well since the mid '80's – the growth of IPO values is only a part of the reason why the stock market has done so well in the last 15 years; after their IPO's these firms have done better than expected.

What of the excess volatility puzzle? The paper has used a compositional argument to explain some excess volatility in the aggregate – more specifically, occasional undervaluation of the aggregate dividend stream because of shifts in the composition of traded firms. On the other hand, *individual* stocks exhibit no aggregate volatility. A further test of our model, then, would be to see if excess volatility in the aggregate exceeds any excess volatility that may exist in a representative security.

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A Data Appendix

A.1 Data sources and construction

- Figure 1: Total value of shares taken from the Flow of Funds Accounts, published by the FRBG. "Issues at Market Value", table L.213.
- Figure 1: *CRSP,* Total market capitalization of all securities contained in the CRSP dataset. All market capitalization data are end of year, December 31, market capitalizations.
- Figure 3: Real investment in "Information Processing Equipment and Software" as a percentage of real investment in "Nonresidential Equipment and Software". Both are measured in 1992 dollars. Source: NIPA '99 revision.
- Figure 5: Year of entry of firms in CRSP is based on the first entry date of a security with the firms permanent company number (permco).
- Figure 5: The CRSP does not contain data on the merger partners of all firms that exit due to mergers from the dataset. To be specific, CRSP contains 3168 firms that exit due to exchanges or mergers, for which their merger partners are unaccounted for. For 1075 of these firms we have found their merger partner, which is part of the CRSP, in various editions of the Semi Annual Stock Reports. The other 2093 firms either merged with partners that were not in the CRSP or were not tractable.
- Figure 7: The SIC codes are still based on the old, pre '97, Standard Industry Classification.
- Figure 8: Firms that enter as the result of a merger between two other firms are not counted as entrants.
- Figure 12: The Ibbotson Small Company Stocks Index is based on fifth capitalization quintile of stocks on the NYSE for the period 1926-1981, and on the performance of the Dimensional Fund Advisors (DFA) Small Company Fund for 1982-present.
- Figure 14: The market value of firms is for the Flow of Funds Accounts is calculated as the sum of market value of all shares and the debt of the nonfinancial corporate sector, the financial sector, and the 'rest of the world'. The latter are U.S. subsidiaries of foreign owned firms. The merged sample of CRSP and Compustat contains 16174 firms. Their market value is calculated as the sum of their market capitalization, measured in the CRSP, and their long term debt, data item 9 in Compustat. Unfortunately, Compustat's historical data on preferred stocks were highly incomplete, because of which we decided to ignore them in our calculations.

- Figures 17 and 18: Total dividend payments are taken from the Flow of Funds accounts.

- Cross sectoral regressions: Based on two and some three digit SIC industries. Data on value drop and incumbent share constructed from the CRSP. Real output growth is obtained by combining nominal output data from the Gross Product Originating tables published by the BEA with output price indices published by the BLS.

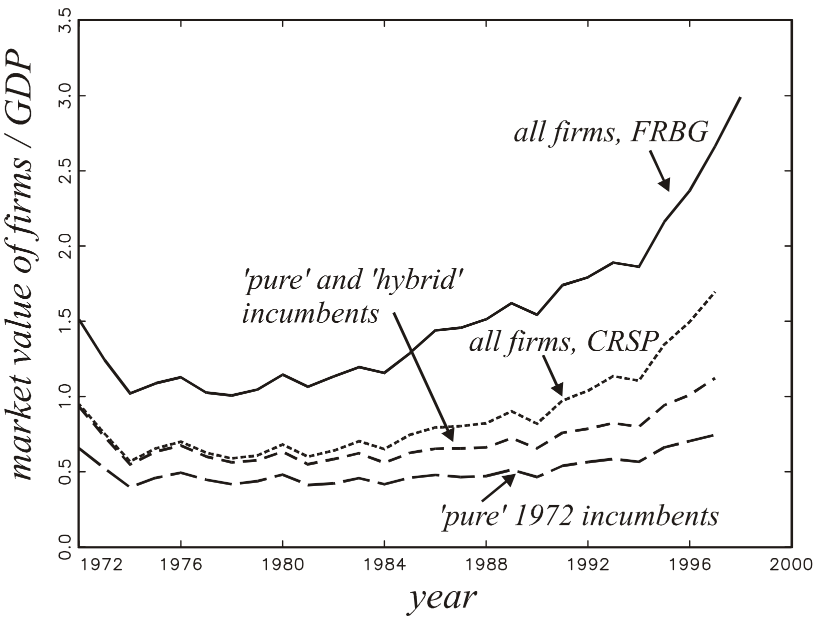

Figure 19: The fate of the 1972 incumbents revisited

B Results including debt

As mentioned in Section 4, we have also constructed our empirical evidence using both data on debt and equity by merging data from Compustat and CRSP. In this appendix we briefly list all these results. As explained in Section 4, the results obtained using firm level data should be interpreted with the necessary caution because the sample suffers from severe selection bias.

Figure 5: The equivalent of Figure 5 is Figure 19. Because there is a bigger difference between the Flow of Funds accounts data and the data constructed on the basis of CRSP and Compustat, we have plotted total market value for both data sources.

Figure 6: For the shares of the three vintages of incumbents we obtain Figure 20. The three vintages of incumbents here are 1950,1961, and 1972 because Compustat has no data available for 1948. Though the difference between the various vintages is less profound than in Figure 6, it is still obvious that incumbents lost market share in the second half of the 1970's and the 1980's more rapidly than in other time period. This can be seen from the series for the 1961 and 1972 vintages declining steeply for a decade from ages 15 and 4 onwards respectively.

Figure 7: Figure 21 is the equivalent of Figure 7, while table 6 lists the summary statistics.

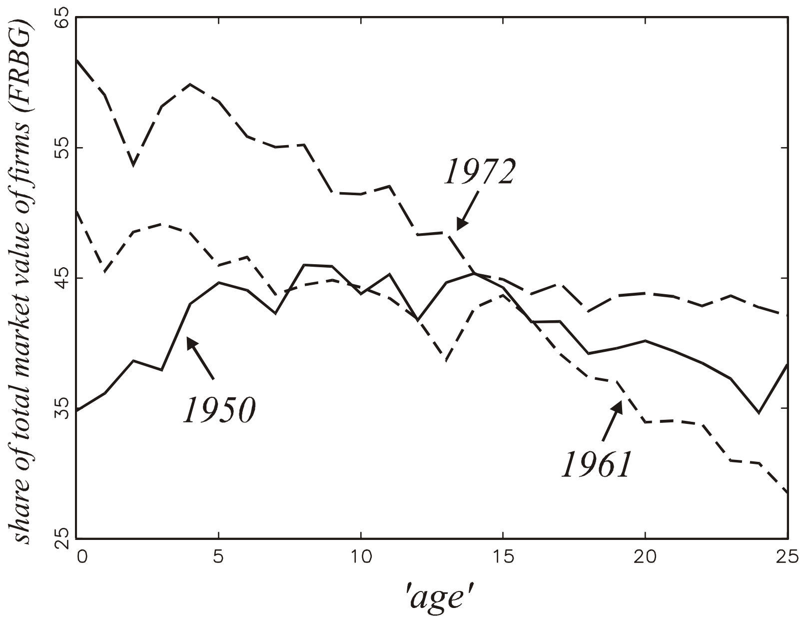

Figure 20: Shares of three vintages of incumbents revisited.

Table 6: Summary statistics (including debt)

sector	**exposure to *IT***		**'72-'74**	**'98 Incumbent**
	inv. share	**cap. share**	**Drop**	**share**
Manuf.	33.9	17.9	33.8	80.6
TCPU	33.9	38.5	18.5	62.9
FIRE	30.0	41.5	20.3	61.7
Services	31.2	42.4	43.2	27.0

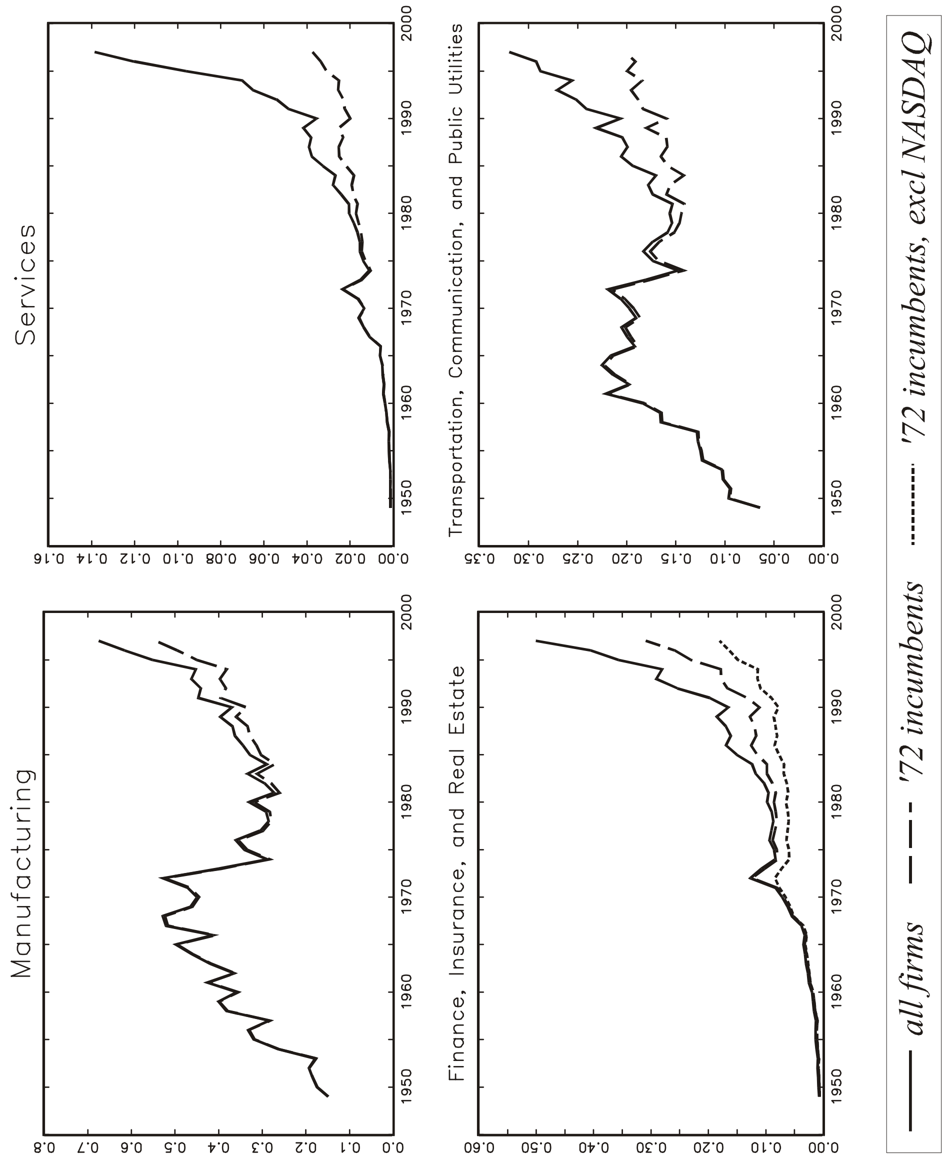

Figure 21: The fate of the 1972 by major sector revisited.

Table 7: Regression results (including debt)

dependent variable: *'72-'74 percentage drop in market capitalization* ($n = 52$)	I	II	III	IV	V
intercept	12.32 (1.40)	−10.93 (−0.55)	−3.82 (−0.19)	9.16 (0.50)	9.19 (0.49)
logarithm of '96 IT equipment capital share	5.58 (1.88)	5.72 (1.94)	6.84 (2.31)	4.49 (1.62)	4.50 (1.60)
logarithm of '97 share of '72 incumbents		5.88 (1.31)	2.24 (0.46)	0.75 (0.17)	0.73 (0.16)
'73-'74 growth rate of output			−0.76 (−1.76)	−1.42 (−3.22)	−1.42 (−3.06)
logarithm of 1972 oil share				−11.90 (−3.33)	−11.87 (−3.15)
durables dummy					0.20 (0.05)
R^2	.066	.097	.152	.314	.314

Table 8: Correlation matrix (including debt)

		1	2	3	4	5
1	*'72-'74 percentage drop in market cap.*	1.000	0.257	0.168	-0.227	-0.304
2	*logarithm of '96 IT equipment capital share*	0.257	1.000	-0.037	0.209	-0.322
3	*logarithm of '97 share of '72 incumbents*	0.168	-0.037	1.000	-0.423	0.115
4	*'73-'74 growth rate of output*	-0.227	0.209	-0.423	1.000	-0.483
5	*logarithm of 1972 oil share*	-0.304	-0.322	0.115	-0.483	1.000

Cross sectoral regressions: Tables 7 and 8 list the regression results for the CRSP/Compustat sample which are equivalent to the ones presented in Tables 4 and 5. As you can see, the coefficient for the log of the IT equipment capital share is still significant at a 10% level as long as the oil share is not included in the regression. However, when the log of the oilshare is included it turns out to be significant, but, just like in Table 4 with the counterintuitive sign. That is, the regression results seem to suggest that sectors using energy intensive technologies actually fared relatively well during the 1973 stock market decline.

Note that we had to use the '97 share of incumbents here, since year end data for 1998 were not yet available in Compustat.

Table 2: Table 2 is not replicated here for the merged CRSP/Compustat data since this dataset has no exits in the first two decades of the sample.