Risk, Variety and Volatility in the PC Industry: *New* Economy or *Early* Life-Cycle?

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Abstract
The paper studies the co-evolution of industrial turbulence and financial volatility in the early phase of the US automobile industry (1900-1930) and the early phase of the US PC industry (1970-2000). In both industries, stock prices were the most volatile and idiosyncratic (compared to the general market) during the periods in which entry/exit rates, market share instability, and technological change were the strongest. Given the similarities between the early stages in the two industries, the patterns that have characterized the late evolution of automobiles provide some insights on the possible future of the PC industry.

Keywords: industry life-cycle, technological change, risk, stock price volatility
JEL Classification: L11 (Market Structure: Size Distributions of Firms), 030 (Technological Change), G12 (Asset Pricing)

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I. Introduction

While the concept of the “new economy” has inspired studies to compare the effect that new technologies have had on economy-wide productivity in previous eras with the effect that information technology (IT) has--or hasn’t yet--had in the current era (Gordon, 1999, Jorgenson and Stiroh 1999, David and Wright, 2000), there has been much less attention devoted to whether industry-level dynamics have really changed. That is, are the patterns that describe the evolution of new high-tech industries a result of something exciting behind the “new economy” or something more common behind the industry life-cycle? Or some of both?

To investigate this question, the paper compares the co-evolution of industrial and financial dynamics in the *early* phase of the industry life-cycle of the US automobile industry (1900-1930), a traditional industry that emerged with the second industrial revolution, with the *early* phase of the life-cycle of the US PC industry (1975-2000), a new “high-tech” industry that emerged with the third industrial revolution, often called the IT revolution or the “new” economy. The goal is to see whether patterns which are associated today with high-tech industries, such as the importance of small innovative firms, the increased role of expectations and volatility, and the low correlation between earnings and market values, were just as common in the early phase of an industry which is today considered mature. If so,

To the extent that similarities between the two industries’ early stages are found, the much longer time series available for automobiles allows us to draw insights on the patterns that might in the future characterize the mature phase of the PC industry. Furthermore, since the debate on economic growth in the new economy often centers around a comparison between the boom years of the 1920’s, which were based on the rise of the internal combustion engine, to the boom years of the 1990’s, which were based on the rise of information technology, a comparison of the industries which produce the technologies/products underlying these different eras will help shed light on which lessons from the 1920’s we can make use of today.

On the theoretical side, research into this question can benefit by linking two literatures that do not often talk to each other: the (dynamic) industrial organization literature that looks at factors that determine industrial *instability*, for example the rise and fall of firm numbers, the emergence of a skewed size distribution of firms, the random/persistent nature of firm growth rates, and market share instability (Hymer and Pashigian, 1962; Gort and Klepper, 1982; Dosi, 1988; Klepper, 1996; Sutton, 1997; Carroll and Hannan, 2000), and the finance literature that looks at the factors that determine stock price *volatility* (Shiller, 1989; Braun et al. 1995; Poterba, and Summers, 1988; Campbell et al. 2000; Vuolteennaho, 2000). The connection between the two literatures lies in how "risk" and uncertainty evolve over the industry life-cycle--i.e. the dynamics of a time-varying (industry) risk premium--and how this risk is both a cause and an effect of the mechanisms that create differences and inequality between firms. The presence of uncertainty is what generates opportunities for firms to differentiate themselves while the resulting inter-firm differences result in a riskier more uncertain environment (for the individual firm and for a potential investor). It is this non-linearity that led the pioneer of the economics of risk to state: "*Without uncertainty it is doubtful whether intelligence itself would exist*." (Knight, 1921, p. 268).

Section III (following a review of the data in Section II) uses the industry life-cycle framework to document the characteristics of instability and turbulence in the early evolution of the US automobile industry and the US PC industry. Both industries' early phase of development was characterized by: rapid market growth, a high rate of entry of new firms, a subsequent "shakeout" after about 15 years, high business failure rates relative to the economy average, quickly changing technology, random firm-level growth rates, rapidly declining prices, and high instability of market shares. Section IV asks to what degree these characteristics of industrial turbulence and uncertainty affect the dynamics of stock prices. In particular, how did the dynamics of high entry/exit rates and radical technological change affect: a) the volatility of stock prices over time, b) the relationship between stock prices and the underlying fundamentals, and c) the relationship between firm-level (and industry-level) stock returns and aggregate market-level returns (i.e. the degree of firm-specific and industry-specific risk).

The results indicate that industrial and financial turbulence co-evolve. Stock prices were most volatile during the periods in which market shares were the most unstable and technological change the most radical. Hence stock price volatility appears to be related to the mechanisms that create variety and inequality between firms. Furthermore, in the automobile industry, firm and industry-specific returns cointegrate with those of the general market (S&P500) only once industry growth slowed down. This suggests that idiosyncratic risk is higher in the early phase of the life-cycle and that recent patterns of stock price volatility experienced in IT based industries are at least partly due to the fact these industries are still in their early phase.

II. Data

The study focuses on the US market for automobiles and personal computers (including both domestic and foreign producers). The firm-level and industry-level data is annual. While this is not ideal for calculating stock price volatility, it is the only way that stock price volatility can be compared to the volatility of sales and market shares which are annual in the data sets used. Sales are measured in terms of annual units of automobiles (cars and trucks) and personal computers (all microcomputers, e.g. desktops and notebooks) produced. In both industries, units produced follow the same general qualitative dynamic as that of net sales in dollars but is preferred due to its greater precision (sales figures are affected by idiosyncratic accounting items).

Automobiles: Individual firm units and total industry units from 1900-1999 were collected from annual editions of *Wards Automotive Yearbooks* (first editions, reporting data starting in 1904, are published in 1924). Although firm-level units were collected for only 8 domestic firms and 5 foreign firms (the first foreign firms entered in 1965), the *total* industry sales include the units shipped by all existing firms (e.g. in 1909 that includes the output of 271 firms). Firm numbers and entry and exit figures (from 1895-1980) were generously provided by Klepper and Simons (1997) who made calculations using a list of producers found in Smith (1968)[i]. Data for calculating the frequency distribution of the length of life of the auto firms was taken from Epstein (1926). Hedonic prices and changes in quality were taken from the series used in Raff and

Trajtenberg (1997). Firm-specific and average industry innovation figures were taken from Abernathy et al. (1987). Innovations are weighted by the importance that the innovations had on the production process (a "transilience" scale). Firm-specific stock prices, dividends, and earnings/share figures were collected from annual editions of *Moody's Industrial Manual*. Industry-specific per share data were collected from the *Standard and Poor's Analyst Handbook*[ii]. However, since all financial data, except stock prices, only goes back to 1946 for the automobile industry, the data for the pre-war period was aggregated from the firm-specific data gathered from Moody's[iii].

PCs: Annual firm-level data on the total number of personal computers produced from 1973-2000 was obtained from the International Data Corporation (IDC), a market research firm in Framingham, Massachusetts. Although this database is very rich (including brand, form factor, processor speed, region and customer segment), for the purpose of this study firm-level units were aggregated across models and brands produced by the firm. From the firm-level units, the following were calculated: annual entry and exits, average life-span of firms, total number of firms, and total industry sales. Entry and exits were calculated using the methodology in Klepper and Simons (2000) explained below. Firm-level stock price, dividend, and earnings per share data were obtained from *Compustat.* Industry-level financial variables were obtained, as for the post-war auto industry, from the Standard and Poor's *Analyst's Handbook* (2000). The firms which define this index are all included in the firm-level analysis, except for Silicon Graphics and Sun Microsystems (the only two firms in the S&P computer index which don't produce personal computers)[iv]. Hedonic prices were obtained from the Bureau of Economic Analysis (BEA). An index measuring quality improvements was obtained from Filson (2000).

Market: General market data was collected from the following sources: GDP and CPI figures were obtained from the Bureau of Economic Analysis web page. S&P500 index stock prices, dividends and earnings/share (1900-2000) were obtained from Robert Shiller's web page. US business failure rates (used to compare with the industry-specific ones) were obtained from Dun and Bradstreet (via the BEA).

III. Industrial Instability

In this section we look at the evolution of the US automobile and PC industry side by side to highlight the similarities and differences in their early development. In Section IV we will ask to what degree the patterns observed here are related to the evolution of stock prices in these industries.

Why is uncertainty about future profits higher in certain types of industries, or during certain stages of an industry's evolution? Studies on the industry life-cycle have documented the following empirical regularities (Gort and Klepper, 1982; Klepper, 1997)[v]:

- *Introductory phase*. At the beginning of an industry's history there are many different types of firms, with different efficiency levels and historical backgrounds, that experiment with new product varieties. The technological opportunities in this phase cause the industry to be characterized by a lot of product innovation. The product undergoes many changes, for example in the auto industry from a go-cart type car, to a five wheel roofless car, and finally to a closed body car with four wheels. The high rate of entry in this phase and the lack of product standardization causes industry concentration to be relatively low and market share instability (changes in firm ranking) to be high. It is also a phase characterized by relatively low profits due to the lack of an established market and the lack of an efficient form of production centered around a particular product type. The high opportunities for innovation and resulting market share instability are both cause and effect of the uncertain environment.

- *Growth phase*. The growth phase begins once there is relative convergence of production around a particular product or standard (e.g. the closed body four wheel car). The market grows as consumers gain more knowledge about the product. Economies of scale in production allow both costs and prices to fall. The fall in prices allows a wider group of consumers (the mass market) to purchase the goods so that it is no longer just a hobby or luxury item. The increasing importance of economies of scale as well as the fall in price (which lowers profit margins) allow only the largest most efficient firms to be compete, and hence an industry "shakeout" to occur. The industry stabilizes and becomes concentrated around a few leading producers.

- *Mature phase*. The mature phase is one in which the opportunities for product innovation fall. Firm strategies are focussed on price competition, process innovation and advertising. Price competition often leads to lower profit margins and hence further exits. Demand is centered on direct/indirect replacement. Market shares tend to be much more stable and concentration high. Traditional product life-cycle theories suggest that industries become international in the later stage of evolution, but in recent years this has become less true as industries are born international (the PC industry is a good example)[vi].

The industry life-cycle can also move backwards: if the product undergoes changes, and if this occurs via new entry (e.g. the introduction of small cars by new foreign firms in the 1970's US automobile market), then evolution may go from the mature phase back to an earlier phase. The duration of each phase differs between industries. Although in recent years the life-cycle of specific products has become shorter (with many high-tech products becoming obsolete after a couple of years), this does not mean that industry life-cycles have. It simply means that technological change has become even more a necessity than before.

The introductory phase of the automobile industry lasted about 25 years from the 1890's until growth took off around 1913. During the first 10 years (1890-1900) production was carried out mainly by hobbyists than by commercial manufacturers. The number of producers rose drastically from only 4 in 1895 to 271 by 1910. The number then fell to 100 by 1923 and then to 12 by 1940! The beginning of the shakeout in the US auto industry is often attributed to the rise of mass production, after Ford introduced the assembly line technique to produce the Model T, which benefited large producers at the expense of small ones. US household penetration rate reached 50% in 1923 but the growth phase lasted to the end of the 1950's when industry sales slowed down considerably. In fact, it is important to distinguish the end of the 1920's, which is when entry rates dropped radically as did innovation, and the end of the 1950's which is when sales slowed down considerable[vii]. By 1960 the domestic producers included only (market shares in parentheses): General Motors (49% market share), Ford Motors (31%), Chrysler (12%), American Motors (6.5%) and Studebaker (1.5%). Although patterns of concentration and instability remained relatively stable from the post-war period to the current era, in the 1970'the industry received a jolt of juvenization when foreign firms entered by introducing smaller energy efficient cars.

As in the automobile industry, the first 5-8 years of the PC industry (1973-1981) were very experimental - run by hobbyist firms - and entry was determined primarily by technological innovation and by system-compatible software (Stavins, 1995). Before this period, all the players in the computer industry were large, established companies like IBM, RCA, AT&T, and Remington Rand. The PC industry stemmed from the existing market for *mainframes*, dominated by IBM since the 1960's, and later for the *minicomputer*, initiated by Digital Equipment Corporation's PDP-8. The first mass produced minicomputer was introduced in 1974: the MITS Altair 8800, produced by Micro Instrumentation and Telemetry Systems. The real commercial growth of the microcomputer industry occurred after IBM introduced the IBM "PC" in 1981, initiating the phase of IBM "compatibility" (both hardware and software) which allowed economies of scale in the industry. Three further developments markedly increased the growth of the PC industry: (1) Intel's introduction of the 32-bit 386 processors in 1985 which allowed graphical interface and hence a more user-friendly environment, (2) the introduction of Windows 3.0 in 1990, which standardized the PC on the Windows operating systems platform –allowing "cloning" of the IBM PC (based on its open-standards architecture), and (3) the rise of the world wide web in the 1990's. All three developments contributed to the rapid increase in sales and rapid fall in prices.

Even though by the end of the 1980's the PC industry began to experience a "shakeout", consolidating the industry around a set of leading firms (IBM, Apple, Dell, Compaq, Hewlett-Packard, Fujitsu-Siemens which together made up 50% of the industry by the early 1990's), innovation continued into the 1990's. Continuous product innovation and a vertically disintegrated industry have allowed growth to continue until the recent period. In 1999, when household penetration rate of personal computers reached 50% in the USA, growth began to slow down for the first time since the industry emerged[viii].

These patterns are looked at more systematically below by looking at the two industries side by side. In doing so, similarities and differences between the two industries become more apparent.

Number of firms, entry/exit

In both the automobile and the PC industry, the first 5-10 years witnessed a rapid rise in the number of firms and subsequently a rapid fall. Figure 1 illustrates the remarkable similarity in their first three decades of existence: in both cases the industry went from infancy to just below 300 firms in about 12 years (271 auto firms in 1909 and 286 PC firms in 1987) and the industry "shakeout" began to occur about 15 years after the initial growth spurt (around 1910 in the automobile industry and around 1989 in the PC industry). In automobiles, by 1940 there were only a dozen firms left, a phenomena that appears to be happening in the PC industry, where just 5 firms share 50% of the global market.

FIGURE 1

Number of firms in the US automobile industry (1899-1926) and the US PC industry (1973-1999)

However, whereas the maximum number of firms at any moment in time is strikingly similar in the two industries, the total number of firms that have ever existed is much larger in the PC industry. This is mostly due to the existence of "open standards" and due to the high level of vertical disintegration that has allowed computer firms to fill different niches (Bresnahan and Greenstein, 1997). It also has to do with the difficulty (related to the high vertical disintegration) of defining which firms to include in the PC industry. The IDC *PC Tracker Database* includes 668 firms between 1975-2000, but this includes firms that have just a dozen employees putting together parts bought in various places (e.g. Princeton Computer Products). In some cases, these are firms that may have sold 10 computers before going out of business. If one was to include all the equivalently defined automobile firms, then the numbers would be much higher as they are in Carroll and Hannan (2000) who include up to 2,197 automobile producers (and more than 5,000 if the ones that meant to produce but never succeeded are included!)[ix]. Since problems of industry definition arise in any industry, it may be sufficient to say that this problem is greater in the case of the PC industry (than the auto industry) due to the level of vertical disintegration. It does not affect any of the analysis in the paper which at the firm level deals only with the top 8-10 firms in each industry, and at the industry level deals mainly with aggregate units produced (and average stock price based on those top firms), hence if the firms are insignificant their output or stock price will not matter much.

Market growth

Figure 2 illustrates the growth of total units produced in automobiles from 1899-1998 (smooth line represents 15 year moving average). The familiar S shaped pattern of market growth indicates fast growth early on followed by stagnation around the beginning of the 1960's. Figure 3 compares the *early* years of market growth in the automobile industry with that of the PC industry and finds a strikingly similar picture both for market growth as well as for the time that it took to reach a 50% household penetration rate (vertical dotted line) -- in both industries about 23 years (1923 in automobiles and 1998 in PCs).

FIGURE 2
Total US automobile sales (units) (1899-1998), and 15 year moving average

FIGURE 3
Total US shipments in automobiles (1899-1926) and PCs (1973-2000), and 50% household penetration rate

The rise and fall of firm numbers is of course related to the dynamics of entry and exit. Figures 5-7 illustrate the figures for both industries. In both cases, entry and exit are often inversely correlated which suggests that firms choose good years to enter and bad years to exit (bad years discourage entry). However, while in the auto industry, entry began to fall already after the first decade of its existence, in the PC industry entry lasted a little longer.

FIGURE 4
Entry and exit in the US automobile industry (1899-1930)

FIGURE 5
Entry and exit in the US PC industry (1973-1995)

High exit rates mean that the risk of failure for an individual firm, or for an investor investing in that firm, is higher. This higher degree of risk in the early phase of industry evolution is illustrated in Table 1 which compares the business failure rate in the early phase of each industry to that in the economy in general. In both early phases, the industry-specific business failure rate is much larger than the economy-wide one. Evidence that this is particular to the early stage is seen by the fact that in automobiles the figure fell dramatically after the mid-1930's approaching much more that of the overall economy. This type of measure is similar to the measure of industry-specific risk studied in Section IV below which compares the variance in firm and industry returns with the general market returns.

TABLE 1

Aggregate business failure rate vs. failure rate in the auto and PC industry

Another way of depicting the risk faced by firms in industries characterized by high entry/exit rates is by looking at their average life-span. Epstein (1927) finds that the average length of life for the 180 companies that he includes in the period 1903-1924 was only 8 years[x]. Figure 6 uses figures from Epstein (1928) to calculate the frequency distribution of length of life of the 180 passenger car manufacturing firms from 1895-1924. We see there that 28% of the total number of firms lasted 3 years or less; 51% lasted 6 years or less; 34% lasted 10 years or more; and 20% lasted 16 years or more (Epstein, 1927, 1928). Using the IDC data, Figure 7, illustrates a similar dynamic for the US PC industry.

FIGURE 6

Frequency distribution of length of life of 180 automobile firms from 1895-1924.

FIGURE 7

Frequency distribution of length of life of 668 PC firms from 1969-2000.

In both industries as the length of (firm) life increases, the number of surviving firms decreased. The finding supports the regularity found by Evans (1987), that survival rates tend to increase with firm age. In the case of automobiles, by 1926 only 33% of the firms that began producing automobiles during the previous 22 years had survived. In the case of PCs, by 1999 only 20% of the firms that began producing PCs had survived.

Price changes

Many industry life-cycle models attribute the industry “shakeout” to the advent of a dominant design which by introducing the possibility of mass production and hence economies of scale, causes prices and price-cost margins to fall and hence firms with small scales to exit (Klepper, 1996; Utterback and Suarez, 1993). In fact, in automobiles, the greatest exits occurred around 1907-1912 which coincides with the advent of the Model T which introduced mass production techniques to the industry[xi]. Epstein (1926) claims that the extraordinarily high exit rate for 1910 was due to the fall in demand for high-priced cars that occurred in that year and the fact that those firms not able to adapt to the new cheaper cars (lighter-weight, four cylinder vehicles) were forced to exit[xii]. Ford’s Model T was the embodiment of the lighter car that could be sold for cheaper. The fall in exit rates after 1912 was due to the growth of the industry which facilitated the purchase and use of standardized parts[xiii].

Prices in the automobile industry fell most rapidly during periods of radical technological change. Between 1906 and 1940 the inflation adjusted prices of automobiles dropped almost 70% (Raff and Trajtenberg, 1997, p. 77). Using the hedonic price index that they created, Raff and Trajtenberg (1997) illustrate that most of the real change in automobile prices between 1906-1982 occurred between 1906-1940, and within that period most of the change occurred between 1906-1918. Between 1906-1940 hedonic prices fell at an average annual rate of 5%. The fall reflects the radical changes in technology, the diffusion of mass production, and the general expansion of the market.

Prices of personal computers were also greatly affected by technological advance. Yet Figure 8 indicates that whereas in the automobile industry the most radical drop in prices occurred during the first 15 years of its existence, the steady fall of prices in the PC industry has continued into the third decade of its existence. Prices began to drop significantly after Intel introduced the 32-bit 386 processors in 1985 and Microsoft introduced Windows 3.0 in 1990. The latter allowed the production of PCs to be standardized and “commoditized” (via cloning of the IBM PC). The rise of the internet also has increased sales and decreased prices. In recent years quality-adjusted prices have fallen at an average annual rate of 24% (BEA, Survey of Current Business, 2000). Berndt and Rappaport (2000) find that between 1983-89 PC prices fell by an average of 18%, between 1989-94 by 32%, and between 1994 and 99 by 40%. Recent reports suggest that the current price-war between PC manufactures, led by Dell's drastic price cuts, is causing profit margins to fall significantly, and hence the weaker firms to exit[xiv]

FIGURE 8

Hedonic prices in the US auto industry (1906-1926) and US PC industry (1980-2000)

Technological innovation

For the automobile industry, Epstein (1928) attributes the large change in firm numbers, entry/exit patterns and the fall in prices to technological change. In fact, his description of the dynamics of the auto industry sound remarkably similar to how one would describe a new high-tech industry today:

> "One would expect the hazards to be greater in a new industry, especially one making a complex fabricated product, subject to constant change and improvement in design and construction. This recurrent necessity of making innovations both in the character of the product and in methods of manufacture, if a firm's place in the industry is to be maintained, probably serves to explain in large measure the complete disappearance of many automotive names that were highly respected. Coupled with this imperative necessity of making alterations in the character of the product, has always existed the danger of making them too readily or too drastically. For if insufficient change of practice means stagnation, so also do frequent and complete shifts of production policy spell manufacturing and marketing confusion." (Epstein, 1927, p. 161).

He claims that most of the failures in automobiles occurred to the difficulty in finding a balance between increasing volume/sales (also lowering costs) and diversifying the product. Some firms like, Willys-Overland, Studebaker and Buick were "diversifiers" while others like Ford, Dodge, and Hudson, concentrated on a smaller line of products and focussed on volume. The same distinction can no doubt be found in the computer industry, with some firms like Apple choosing to produce high quality computers, even if that means lower compatibility and hence lower sales (due to network externalities), and others like Dell choosing to focus almost solely on volume and prices (instead of innovation).

Figures 9-11 illustrate the dynamics of innovation in both industries. Figure 9 illustrates the evolution of process and product innovations in the auto industry. The data was obtained from Abernathy et al. (1983) who compiled a chronological list of automobile innovations by firm from 1893 to 1981. They devised a weighting scheme to evaluate each innovation in terms of its overall impact on the production process. They chose a seven-point transilience scale, where 1's represent those innovations that had little or no impact on the production process and 7's those innovations that were very disruptive for the production process. Most of the activity appears to be concentrated between 1894-1935, i.e. during the early evolution of the industry.

FIGURE 9
Product and process innovations (transilience weighted) in the US auto industry

In his comparison of product and process innovations over the early histories of five different industries, including automobiles (1895-1929) and personal computers (1975-1999), Filson (2000) finds that whereas most quality improvements occurred in the early phase of the auto industry's life-cycle (with innovation dying down significantly towards the end of the growth phase), the same cannot be said of personal computers[xv]. Whereas in automobiles most of the percentage change in quality occurred between 1895-1908 (25% annual rate of change compared to 3.1% in the period 1909-1922 and 3.2% in the period 1923-1929), most of the percentage change quality in the personal computer industry occurred in the first and third stage: 34% between 1975-1986 (the years when the industry first emerged encompassing the introduction of Intel's 386 processor), and 38% in the period 1993-1999 (soon after Windows 3.0 was introduced), with only 17% in the middle stage.

FIGURE 10
Quality improvements in the US automobile industry

FIGURE 11
Quality improvements in the US PC industry

Bresnahan and Greenstein (1997) support the point that innovation in the PC industry was more disruptive in the 1990's than in the previous decades. Open standards and a high level of vertical disintegration allowed aggressive new entry via innovation. Whereas the innovations introduced in the 1970's and 1980's were controlled by IBM (since everything had to be IBM compatible), the quality changes in the 1990's disrupted the status quo, principally because power shifted from IBM to Microsoft and Intel. In the 1980's IBM was the force behind changes in platform technology due to its position as lead seller of microcomputer hardware, which allowed it strong negotiation power with its buyers and sellers. IBM focussed on incremental technical change with backward compatibility: all other firms' hardware and software products had to work with IBM equipment (Bresnahan and Greenstein, 1997: p. 28). This position of power first came under threat when the Intel 80386 chip was used by Compaq's new computer, so that the computer was marketed for the quality of the chip not the IBM compatibility. Once the "industry standard" label became more important than the "IBM compatible" label, IBM became much weaker. The next shakeup to the power structure came when IBM split with Microsoft over operating systems in 1990. OS/2 had begun as a joint product between the two companies but when the companies ended their collaboration, Microsoft developed *Windows* as a rival. The industry standard now changed to the "Wintel" standard, finishing off what remained of IBM's special status. Another reason why the 1990's presented such disruptive change was due to the development of the new "client/server" platform (networked platform with highly intelligent terminals). This new platform was based on a vertically disintegrated structure which devalued traditional management causing the strengths of the incumbents (mainly IBM and DEC) to become obsolete (Bresnahan and Greenstein, 1997). Furthermore, the tradition of backward compatibility made the incumbent platforms particularly hard to change in reaction to the users' new needs. All these reasons help explain why the last decade has witnessed not only the most quality change but also the most disruptive market structure.

Changes in industry structure: market share instability and concentration

The above story highlights the disruptive effect that technological change has on market structure, especially when the innovations are competence destroying ones, i.e. ones that destroy the incumbents' lead (Tushman and Anderson, 1986)[xvi]. Figures 12 and 13 illustrate that in both industries, periods in which there was the most innovation were also periods in which market shares were the most unstable. Market share instability is measured via an instability index defined as:

$$I = \sum_{i=1}^{n} [|\, s_{it} - s_{i,t-1} \,|]$$

where s_{it} = the market share of firm *i* at time *t* Hymer and Pashigian, 1962). The larger is the value of *I*, the more unstable are market shares in the industry and the riskier the environment for any given firm: current growth is not a guarantee of future growth. Industrial economists have argued that this index captures the force of competition much better than the classic concentration ratios since even if there are few firms the index may be high if they are competing fiercely (Hymer and Pashigian, 1962; Gort, 1963). Although the index might be affected by the number of firms, it is empirically not very sensitive to it because small firms do not contribute greatly to the value of the index since they account for such a small share of the industry and since they tend to grow no faster on average than large firms (Hymer and Pashigian,1962, p. 86). Nonetheless, in comparing the index between the automobile and PC industry, it is calculated based only on the market shares of the top 10 firms (since that is all we have for automobiles), so the number of firms is not an issue

To measure concentration, we use the Herfindahl index $H = \sum_{i=1}^{n} s_i^2$, which is a function of the number of firms and the variance between firm market shares.

In automobiles, instability was especially strong during the period 1910-1925 which witnessed not only high entry/exit rates but also some of the most radical innovations in the industry. Market share instability then decreased when innovation and new entry fell. The strong economies of scale that developed in the 1920's when most of the industry (not only Ford) began to use mass production techniques, along with the fall in price-cost margins, caused the industry to become increasingly concentrated. Concentration stopped increasing in the 1970's when the entry of foreign firms in the US market (through the introduction of smaller cars) stimulated more competition.

FIGURE 12

Market share instability and concentration in the US automobile industry

FIGURE 13

Market share instability and concentration in the US PC industry

In the PC industry, market share instability rose (and concentration fell) during the 1980's with the entry of new firms into the microcomputer market, but became especially volatile in the late 1980's and early 1990's with the introduction of new innovations in the industry (see above). The instability index was much higher in the 1990-2000 period than in the previous two decades: in 1970-80 it was 1.35, in 1980-90 it was 11.51, and in 1990-2000 it was 17.86. This appears to indicate that market share instability reacts more to changes in technology than to market growth per say (since market growth was actually highest in the earlier decades). In the last 2 years, slow industry growth has stimulated fierce price wars which have begun to increase concentration significantly. The focus on price and volume has turned attention away from innovation. If this continues, it is likely that the PC industry will soon look similar to the oligopolistic automobile industry:

> "*A price war is hitting PC makers hard. Many well-known names could disappear from the high street…But not all the problems are due to the downturn in the economy or the bursting of the internet bubble. Much of the suffering has been caused by Dell computer which started a price war to gain market share*." Trouble at the top for PC giants, The Guardian, September 13, 2001.

Industrial turbulence during the early stage: a summing up

The results suggest that although the rate of entry, the pace of technological change, the speed of price decline, and the level of market share instability were not any greater in the early stage of the PC industry than in the early stage of the automobile industry, the timing was different. This difference in timing will also emerge when we look at stock price volatility below. Both industries experienced a rapid rise then fall in the number of firms, but in the PC industry entry has taken longer to die down. This is because technological change in the PC industry has been strongest in the third decade of its existence rather than in the first decade as in automobiles (often stimulated, however, by improvements in other industries like software and internet services). The persistence of technological change has also allowed prices to drop for a longer period of time than they did in the automobile industry. Hence whereas in the automobile industry market share instability (caused by technological change) was highest during the first 10 years, in the

PC industry, it was highest in the 1990's (i.e. the third decade of the PC industry's existence).

IV. Stock Price Volatility

To what extent does the type of industry-level turbulence described above affect the dynamics market values? Are stock prices more volatile and idiosyncratic during the early phase of industry evolution? If so, perhaps some of the patterns of stock prices that have been in the recent years associated with the "new economy"(e.g. stock price volatility and lack of correlation with underlying fundamentals) are more a symptom of the fact that most IT based industries are still in their early stage.

Recent studies have used vector autoregressive (VAR) models to decompose the variance of volatility, highlighting the size of the idiosyncratic component and its possible sources (Campbell, 1991; Campbell et al. 2000, Vuolteennaho, 2001). Campbell et al. (2000) find that individual stock returns have become *more* volatile since the 1960's, i.e. that idiosyncratic risk has become stronger, and that this increase is not due to a decrease in aggregate stock market volatility (which has also increased). In their list of the possible causes of the increase in firm-specific risk, the authors claim that a possible source of this increase is the fact that companies have begun to issue stock earlier in their life-cycle when there is *more uncertainty about future profits*. This is similar to the finding in Morck et al. (1999) that volatility is higher in emerging markets due the effect of undeveloped institutional structures on the uncertainty about future profits.

In this section we ask a similar question, but instead of asking why stocks are more volatile per say, we ask why they are more volatile in young industries. That is, to what extent is the firm-specific and industry-specific nature of stock price volatility determined by the dynamics of an industry in its early phase, when it is experiencing changes in firm numbers, rapid technological change, market share instability, and changing industry concentration levels? The co-evolution of market share instability and stock price volatility is rooted in the mechanism by which market share instability affects "uncertainty" and how uncertainty affects stock prices. Since in periods of high market share instability, investors are less willing to use current market share as a signal of future performance, it is more likely that stock prices in this period will be less related to measures of current performance. Furthermore, there may be more volatility during this period due to the constant corrections that investors must make to their previous predictions.

Frank Knight (1921), the pioneer of the study of risk, made the connection between financial risk and the world of creative destruction many years ago when he distinguished risk from uncertainty: whereas risk describes controlled scenarios in which alternatives are clear and experiments can be repeated (like in gambling halls), uncertainty describes the world of "animal spirits" in which the situation is usually unique and unprecedented and alternatives are not known[xvii]. Although the terms uncertainty and risk are used here interchangeably, the uncertainty characteristic of early industry evolution no doubt pertains to the world of Knightian uncertainty: the (unpredictable) world of animal spirits and technological change.

In this section, we use different angles to look at how risk changed throughout the life-cycle of both industries. First, a constant discount rate version of the efficient market model (EMM) is used to gather insights on what a time-varying discount rate (or risk premium) *should* look like in order to allow the EMM to reproduce the volatility of *actual* stock prices. We look at how this emergent pattern of risk matches up to the pattern of risk and uncertainty developed in Section III. Second, the correlation between stock prices and underlying fundamentals is looked at more closely through the use of unit root tests and descriptive statistics to compare the volatility of stock prices, units and dividends. Third, cointegration tests (between firm/industry stock returns and market returns) are used to study whether firm-specific and industry-specific risk is higher in the early phase of the life-cycle or not. Lastly, panel data analysis is used to see whether stock prices are affected by fundamentals more in the early phase and to what degree the rate of change of stock prices in the different phases are correlated with changes in the number of firms, market share instability and changes in industry concentration.

a. Efficient market model

If markets are efficient then stock prices reflect all information that is known, so only random events can cause stock prices to change. Different studies have tested the theory by comparing the movements of stock prices with the movements of the underlying fundamentals which stock prices should reflect (Shiller, 1981, 1989; Blanchard and Watson, 1982; West, 1988). Shiller (1989) has criticized the EMM, arguing that variations in stock prices are much too volatile to be explained by variations in the underlying fundamentals (this is the definition of "excess volatility"). Critics of Shiller's early work have pointed to the problem of distinguishing the role of bubbles, fads and bandwagon effects from the role of unobservable market fundamentals and to the problematic assumption of a constant discount rate. More recent applications of the EMM have thus focussed on developing models of *time varying* discount rate or equity premium--for example through a consumption growth processes or through a model of habit formation (Campbell and Cochrane, 1999; Campbell, 1996). The goal of these models is to show that "excess volatility" disappears when the appropriate assumptions are made on how the discount rate, i.e. risk, changes over time. Other studies, more related to the method chosen in this paper, use unit root and cointegration tests on stocks and dividends to see whether explosive rational bubbles really exist (Diba and Grossman, 1984, 1988a, *for methods*: Dickey and Fuller, 1981; Engle and Granger, 1987; Bhargava, 1986).

Rather than modelling the time-varying risk premium, we purposely use the *constant* discount rate formula for the EMM to gather insight on how the time-varying risk premium *should* vary if it were to justify the prices that emerge from the EMM with actual prices. This emergent pattern of risk is then compared to the patterns of industrial turbulence and uncertainty (affecting risk) investigated in Section III: to what extent do they support each other?

The efficient market model (EMM) states that the real price is the expectation of discounted future dividends:

$$v_t = E_t v_t^* \qquad (1)$$

$$v_t^* = \sum_{k=0}^{\infty} D_{t+k} \prod_{j=0}^{k} g_{t+j} \qquad (2)$$

where v_t^* is the ex-post rational or perfect-foresight price, D_{t+k} is the dividend stream, g_{t+j} is a real discount factor equal to $1/(1+r_{t+j})$, and r_{t+j} is the short (one-period) rate of discount at time *t+j*. Shiller (1989) showed that if Eq (1) holds, and if we assume for simplicity a constant discount rate *r* then since $v_t^* = v_t + u_t$ (where u_t is the error term), then there is an *upper bound* to the variability of stock prices given by:

$$s\,(\Delta v_t^*) \le s\,(D_t)/\sqrt{2r} \qquad (3)$$

where σ denotes standard deviation (for formal proof see Shiller 1989, p.82). That is, the EMM predicts not only that changes in stock prices should reflect innovations in discounted dividends but also that the volatility of dividends (fundamentals) should be larger than the volatility of stock prices. Using S&P 500 data, Shiller (1989) has shown that it is exactly the opposite: stock prices are much more volatile than discounted dividends[xviii]. Mazzucato and Semmler (1999) illustrate this for the case of the automobile industry.

This approach is used here to study the difference in volatility of actual stock prices and the EMM prices in the two industries over time. The relevant stock price and dividend time series data are first divided by their S&P 500 equivalents, then detrended (using the hp filter) and differenced (if necessary) to make sure that the series are stationary and hence their variances comparable. To calculate the series (v_t) generated by the EMM the following equation is used recursively:

$$v_t = \frac{v_{t+1} + D_t}{(1+r)} \qquad (4)$$

where *r* is the constant discount rate and *D* the dividend per share[xix]. Given the lag in Eq. (4), it is not possible to calculate the EMM for the last period. If there are 100 periods, the value for the EMM at t = 99 is calculated by using the actual stock price at t=100 in place of v_{t+1} in Eq. (4). Then for each other value from t = 1 to t = 98, Eq. (4) is used.

In accordance with Equation (3), Figures 14 and 15 illustrate the standard deviation of the actual industry stock price and the standard deviation of the EMM price from Equation (4). In both industries we see that Shiller's prediction holds: the actual stock price is much more volatile than the EMM price. Yet since our point is not to judge the theory but to extract information from it, we concentrate here only on the degree to which the difference between the two prices changes over time.

Automobiles. Figure 14 illustrates that from 1918 to the early 1930's, actual stock prices were much more volatile than the EMM price but this difference began to get smaller in the end of the 1920's when the industry began to settle (especially in terms of innovation, price changes and market share instability). The difference in the volatility of the two would be much smaller if it were assumed that the discount rate in Equation (4) was not constant but varying and that it varied much more at the beginning of the industry's history. This would imply that risk was higher and more variable in that early period – exactly what the patterns of industrial turbulence suggest in Section III (e.g. more technological change, price changes and entry/exit).

Personal computers. Figure 15 compares the same series for the PC industry. Actual stock prices are no doubt more volatile than the EMM price, but the difference in volatility is more or less constant until 1990. After 1990, with the advent of Windows and the rise of the internet, the volatility of actual stock prices began to increase rapidly while that of the EMM remained constant. Hence it would appear that "excess" volatility increased in the period in which there were the greatest changes in quality and in price reductions. The only way to make excess volatility decrease would be to suppose that the risk premium was higher and more variable in the 1990's, an assumption that is supported in the analysis of industrial uncertainty in Section III. These patterns will be supported below when we see that firm-level stock prices were the most volatile in the 1990's

(Table 9) and the relative computer stock price (relative to the S&P500) began to rise in the beginning of the 1990's (Figure 17).

Interestingly, "excess volatility", measured in this simple (constant discount rate) way, is the highest precisely in the periods that we observed were the most uncertain in Section III, i.e. the periods in which technological change, price changes and market share instability were the greatest. Hence to justify the EMM with a time-varying discount rate, one would have to argue that the risk-premium was the highest and most volatile in exactly the periods we found to be most risky (for individual firms and investors).

b. Descriptive statistics and unit root tests

We next take a more direct look at stock price volatility by comparing it with the volatility of units produced and dividends. Unit root tests were used to determine the order of integration of the raw data series. The dimension of the tests was defined using the Schwartz Bayesian information criteria (SBC)[xx]. This information was used to decide whether de-trending and/or differencing was necessary when obtaining descriptive statistics on volatility[xxi].

Tables 2-13 contain the standard deviations, means and unit root tests on firm-level and industry-level units produced, market shares, stock prices and dividends (the descriptive statistics are on the growth rates of the variables while the unit root tests are on the levels). When unit root tests identified a trend, the statistics were also performed on the detrended data. But since no qualitative difference was found in the different periods between the detrended and the non-detrended series (after the logs and differences were taken), for purposes of consistency, statistics only for the non-detrended data is reported here.

Data is presented for the top 8 firms in the automobile industry: GM, Ford, Chrysler, American Motors, Studebaker, Packard, Hudson, and Nash (with unit root tests also presented for the foreign firms), and the top 10 firms in the PC industry: Apple, Compaq, Dell, Everex, Gateway, Hewlett-Packard, IBM, NEC, Toshiba, and Unisys. Results for the aggregate industry data are on total industry units produced and on the average industry stock price and dividend per share computed by the S*&P Analyst Handbook*. To control for movements in the general market, operations were also done on the units data divided by GDP and on the financial data divided by the S&P500 equivalent (e.g. GM stock price divided by the S&P500 stock price). The results for these relative values are found in italics. However, in both industries no qualitative differences were found between results for units that were not deflated and those that were.

The pre-war automobile data is divided into intervals which allow a comparison between units and stock prices[xxii]: 1918-1928 and 1918-1941 (omitting the 5 depression years 1929-1933), while the post-war automobile data is divided into the following six intervals: 1948-2000, 1948-70, 1970-2000, 1970-80, 1980-90, 1990-2000. The last four of these intervals are the ones used for the PC industry, allowing a direct comparison during those years (but not so informative given that in those intervals the auto industry is already mature while the PC industry is in its early-growth phase).

Automobiles. The results in Tables 3, 7, and 11 indicate that firm-level and industry-level units, stock prices, dividends and market shares were most volatile in the period 1918-1941, with most volatility of units, market shares and stock prices occurring between 1918-1928 and the most volatility of dividends in the period 1933-1941 (units were even more volatile in the period preceding 1918 but firms were not quoted on the stock market yet). This holds for all the firms, except for Studebaker which instead experienced more volatility of both units and stock prices in the post-war period (1948-1970) but more volatility of dividends in the pre-war period. Division by the S&P 500 indices does not alter any of the qualitative results between the two periods (i.e. the earlier period is still much more volatile), except again in the case of Studebaker, whose dividends were more volatile in the post-war period when divided by the S&P500 and vice versa when not divided. Table 2 indicates that firm-level units (and market shares) follow an I(1) process in the pre-war period and an I(0) process in the post-war period, confirming the results found for the Instability index in Section III (illustrating the much higher market share instability in the pre-war period). On the other hand, most of the stock prices and dividends follow an I(1) process in both periods (as does the S&P500 stock price index as well). The same results were found whether or not auto units were divided by GDP (although results are only shown for the raw data).

Table 7 indicates that the average relative automobile stock (i.e. the auto industry stock price divided by the S&P500 stock price) grew much less than the economy average in the post-war period. This can also be observed in Figure 16 which plots the relative (relative to the S&P500) average automobile stock: the auto stocks grew more than the market average until about 1962 and then began to fall. This is also the period when the average industry sales growth began to fall (the mean growth rate both at the firm and industry level is negative after 1970—also evident in Figure 2) and below we will see that it is also when the auto stock returns become cointegrated with the general market (S&P 500) stock returns.

As regards the last three decades, both units and stock prices are more volatile in the decade1970-1980 than the following two decades, most likely due to the effect of the oil crisis (which affected the auto industry more than the economy average) and the entry of foreign producers which shook up market shares. The most recent decade has witnessed the lowest average growth rate and also the lowest volatility.

Hence the results suggest that the 10-20 years of high entry/exit rates and rapid technological change caused both units and stock prices to be more volatile than they would be for the remaining 60 years.

Personal Computers. In the PC industry, the firm-level units data indicates that all firms experienced higher mean growth in the most recent decade (1990-2000) but more volatile growth (standard deviation) in either the first decade (1970-80) or the second decade (1980-90). Aggregate industry data instead suggests that units experienced both higher average growth and more volatile growth in the first decade 1970-80. However, although the figures for many other firms are not reported here (future work will look at all the firms), the different results for the firm-level and industry-level data highlight the problems with looking at aggregate data which in some years may dampen inter-firm heterogeneity and volatility while in other years it may enhance it, depending on how the different firm-level series interact. Nevertheless, it appears clear in both the firm-level and industry-level data that the last decade was the least volatile in terms of units.

In the case of stock prices, it is instead the last decade (especially in the *early* 1990's) that has witnessed the most volatility (for most firms and for the industry average). Given that we saw in Section III that most technological change, market share instability, and rate of price reductions occurred in the period 1990-2000, this points to the possibility that stock prices react more to technological change and market share dynamics than to growth of sales. However, since at the industry level dividends are also the most volatile in the last decade (not true for several firms), this does not mean that there is more "excess volatility" (also because, as we saw, this would depend on the discount rate used).

Figure 17 illustrates the evolution of the computer industry's relative stock price (relative to the S&P500). The figure indicates that to the beginning of the 1980's, the computer stock rose more than that of the general market. In the beginning of the 1980's, when the PC took off (with the advent of the IBM PC), the computer industry's relative price began to fall. Only in the beginning of the 1990's did it begin to rise again. This may be due to the fact, as hypothesized in Jovanovic and Greenwood (1999), that innovation by new entrants (who were not yet quoted) in the 1980's made the stock price of the incumbents, who were losing their leadership position, to fall. The new entrants that would provide the growth engine for the 1990's did not get included in the average index for the computer hardware industry until the following dates: Apple in 1984, Compaq in 1988, Dell in 1996, and Gateway in 1996. IBM has, instead, been included in the average computer industry index since 1918!! Some large firms like NCR were removed from the index before the relative rise: NCR was removed in 1991, Unisys in 1996, Xerox in 1987, and Wang in 1992. When compared to the results found in Filson (2000), it would appear that the index followed the trends of radical quality changes in the industry (see Figure 11): it rose in the first stage when the industry was just emerging, fell in the middle stagnant stage, and rose again in the phase when quality changes became the greatest.

Table14 summarizes for the two industries the volatility figures for the aggregate industry series. There it is clear that stock prices are the most volatile in the period when market share instability is highest, which is also the period in both industries characterized by the most radical change in quality (see Figures 9-11). The relationship between market share instability and stock price volatility invites the consideration of how variety (inequality), volatility and growth are related.

c. Cointegration and Error Correction Models

Given the results in (a) and (b) above, which both confirm that in the two industries periods of industrial instability were also ones of greater sock price volatility, we test here more formally whether firm and industry-specific risk were higher in these periods. In the capital asset pricing model (CAPM) model, firm-specific and industry-specific risk is measured through the covariance between movements in firm and industry stock returns and movements in the aggregate market return (e.g. S&P 500). The lower is this covariance the higher is the *unsystematic* or *idiosyncratic* level of risk. Hence firm-specific or industry-specific risk describes the degree to which an individual firm or industry's stock return varies differently from the general market's return. This unsystematic risk should be higher in periods when an industry is growing because in this phase idiosyncratic factors affecting both supply and demand are stronger: consumers' tastes for the (new) product are still adjusting and the product has yet to settle around a standardized version, often undergoing hundreds of model changes. However, it is also possible to think that in this period the industry is less settled hence more vulnerable to economy-wide shocks. In that case, one would expect higher covariance with the market return in the early phase.

To observe the changing level of firm and industry-specific risk in the two industries, we test for a cointegration relationship between firm-level (and average industry-level) stock returns and the general market return. The stock return is defined as:

$r_{i,t} = \frac{P_{i,t} + D_{i,t}}{P_{i,t-1} - 1}$ where P_{it} and D_{it} are the stock price and dividend (in logs) of firm i at time t (in the case of the average industry return, the subscript *i* is changed to *j*).

The two stage Engle and Granger (1997) test for cointegration is used, based on an augmented Dickey-Fuller test for cointegration (CRADF). The first step involves a regression in the levels of the variables: individual firm (and industry) stock returns are regressed on the S&P 500 stock return. Unit root tests are then run on the residuals from this regression to test for cointegration. If the two variables are I(1), then if a cointegrated relation exists the residual from the regression in levels are stationary and the relation can be assumed to be statistically stable in the long-run. In the tables, if the CRADF critical values from Mackinnon are larger than the 95% critical value, then the residual is I(0), i.e. stationary and the two variables are cointegrated. Furthermore, although with I(1) variables the standard error of the residuals (called *S.E. of R* in the tables) is not an exact measure, this standard error can be interpreted (lightly) as the firm-specific and industry-specific degree of risk: the larger it is the more unsystematic risk there is.

The second step involves the Granger Representation Theorem which states that a cointegrated relationship always admits a representation in terms of an Error Correction Model (ECM) with the variables in differences. The coefficient on the lagged residual (called *RES -1* in the tables) in this equation must be statistically meaningful and negative for the cointegration relationship to hold. The strength of the long run relation is captured by the dimension of this parameter. In fact, the lagged residual represents the distance from the *long-run* equilibrium relation in the previous period.

Automobiles. Cointegration between individual firm returns and the market return was tested only for those firms that were available for most of the sample: GM, Ford, Chrysler, Studebaker and American Motors. Although Table 15 displays the results only for the average industry return (which, as already mentioned, is computed by S&P using data on the top 15 firms—see endnote ii), the qualitative dynamics were the same for all the individual firms (except Studebaker). The first part of the table indicates that the average industry stock return became cointegrated with the market return only after 1956 (only in that period is the CRADF value in the table larger than the 95% critical value, and only in that period is the residual of the data generating process--Res. DGP--an

I(0) variable). Before the 1950's none of the firms' stock returns, nor the average industry stock return, cointegrated with that of the general market. This means that in this period, which coincides with the "early" life-cycle phase and the end of the end of the "growth" phase, firm-level and industry-level returns were determined by idiosyncratic factors, specific to the automobile industry (this is confirmed by the relatively high standard error of the residual in the pre-war period). Only in the mid-1950's did cointegration between the firm/industry-level returns and the S&P500 returns take place. This is true for all firms except for Studebaker, which never cointegrated with the market, probably because it was still in its own early phase when it exited the industry in 1964 (incorporated only in 1954).

The second part of Table 15 illustrates the results from the error correction representation of the cointegration regression in the aggregate industry case. Since the coefficient on the value of the lagged residual is significant and negative, this means that the long run cointegration relationship is strong. The recursive coefficients for the Error Correction Model solutions display the short-run solution of the long-run relations from the Engle and Granger two stage analysis. Figure 18, which displays the plot of the recursive coefficients, illustrates exactly when the individual stocks became cointegrated with the general market (i.e. when the change in regime occurred). In the case of the average auto index, the cointegration occurred around 1957; in the case of GM, Chrysler and Ford around 1960, and in the case of American Motors around 1970. A comparison with Figure 2 and Figure 16, illustrates that the basic range of this period (late 1960's early 1970's), is exactly when the growth of the auto industry began to slow down (i.e. the top part of the S shaped curve) and when the industry stock price began to fall in comparison to the S&P500. The negative coefficients on the trend variable also show that the industry return declined compared to the market average.

Personal Computers. Table 16 indicates that in the PC industry, no cointegration relationship was ever found between individual firm (and industry) stock returns and the market return (the CRADF value is lower than the 95% critical value). Hence, it would appear that returns in the PC industry are still characterized by the dynamics that characterized the pre-war automobile industry.

Although to discover any general patterns the same test must be run on the returns of many different industries, these results suggest that firm-specific patterns of returns become increasingly correlated with those of the general market only once an industry has entered its mature stage, i.e. when growth begins to stagnate. Prior to that, firm-specific and industry-specific patterns are more related to idiosyncratic factors like high rates of entry/exit, market share instability and radical technological change. The results confirm the findings in Section III regarding the greater instability in the early phase of the life-cycle of entry rates, prices, technological change and market share dynamics, as well as the findings in this section regarding the greater volatility of stock prices in the early phase. Given that various IT market research firms (e.g. IDC, Gartner group) confirm that the PC industry is entering a decline stage (e.g. "*Personal computer shipments suffer first fall in 15 years*," July 22, 2001, Financial Times), it is likely that in a few years the cointegration relationship found in the automobile industry will also show up in the PC industry.

The results highlight that firm and industry-specific risk should be looked at over the course of industry evolution, not in selected time frames which will coincide with the early stage of some industries and the mature stage of others. For example Campbell et al. (2000) find that since the 1960's idiosyncratic risk in many industries, including the automobile industry, has increased but they do not look at the pre-war period in automobiles when idiosyncratic risk was even higher due to the reasons outlined above.

d. Panel data analysis

Finally, to better understand the degree to which stock price dynamics follow the patterns of industrial instability described in Section III, panel data analysis is used to regress the rate of change of firm stock prices on fundamentals (firm and market dividends, earnings/share) and on life-cycle variables like changes in firm numbers, market share instability, market concentration. Given the results already obtained, the goal is to see whether during the early phase of industry evolution stock prices react more to variables defining industrial instability than they do in the mature phase, and whether in the mature phase they react more to changes in fundamentals than they do in the early phase.

Due to the long time period and the relatively small number of firms, Seemingly Unrelated Regression estimations (SURE) are used. This is a particularly suitable procedure for this paper since it allows us to gather insights on the role of inter-firm *heterogeneity* in different periods of industry evolution. Heterogeneity is tested for in terms of the differences between firms with respect to a single regressor (Wald test type 1) and the differences between firm-specific coefficients for all the single regressors (Wald test type 2). If the null hypothesis of homogeneity is rejected then the correct estimator is the Unrestricted SURE (which controls for the likelihood ratio test between the sum of the OLS equations). If instead the hypothesis of homogeneity cannot be rejected on the whole set of parameters (the Fixed Effect hypothesis) and we can also not reject the restrictions for homogeneity of the firm-specific coefficients for the single regressors, then this means that the correct estimator is the Restricted SURE.

Firm-level stock prices were run on firm-level dividends, market share, the S&P500 stock price, the S&P500 dividend, the number of firms in the industry and the level of concentration. Other variables were also included but since no convergence occurred to the Maximum Likelihood (ML) algorithm, they had to be omitted. Different specifications were tried for the PC industry, where each specification includes a different sub-set of firms. This is due to reasons of convergence, multicollinearity and parsimony. Due to space limitation, only the tables for the restricted case are included below, the unrestricted case which requires comparison with single equation OLS estimates are treated verbally.

Automobiles (1918-1941, 1948-2000). In Table 17, the results for the Wald tests indicate that in the pre-war period we can reject the joint restrictions for homogeneity (the Fixed Effect hypothesis) and also the restrictions of the firm-specific coefficients for the single regressors. In the post-war period we *cannot* reject this restriction on the whole set of parameters and we can also not reject the restrictions for homogeneity of the firm-specific coefficients for all the single regressors. This means that in the post-war period there is more homogeneity between firms in how stock prices are affected by the different variables. In the pre-war period, the rate of change of firm stock prices are significantly affected by changes in market shares, the number of firms and the herfindahl index. Neither the firm level, industry level not market level fundamentals seem to be significant in this period. In the post-war period there is increased significance of the fundamentals (both at the firm level and at the general market level) and no significance of the industrial dynamics variables (market shares, number of firms and herfindahl index).

Personal Computers (1975-1999). In each of the different specifications, the results were similar to those which emerged in the *pre-war* period for automobiles: rejection of the joint restrictions for homogeneity of the whole set of parameters (Fixed Effect panel hypothesis) and non-rejection of the restriction for homogeneity of the firm-specific coefficients for most of the single regressors. This means that the correct estimator is the *partially* restricted SURE estimator (only for homogeneity on those regressors for which restriction on homogeneity was rejected). As in the pre-war auto industry, the most significant variables are changes in market shares, the number of firms and the herfindahl index. The financial fundamentals both at the level of the firm and at the level of the general market were less significant.

Hence, in both industries stock price dynamics in the early phase of the industry life-cycle are affected significantly by the turbulence in market structure: changing number of firms, rising concentration and market share dynamics. On the other hand, firm level and market level fundamentals (dividends, earnings per share) have a greater effect on stock price dynamics in the mature phase than in the early phase. Furthermore, in the early phase of both industries it is easier to reject the joint restrictions for homogeneity of the whole set of parameters, indicating that in this phase, unlike in the mature phase (for automobiles at least), there is more heterogeneity between firms. The fact that there is more heterogeneity between firms in the early period and the fact that firm level stock prices react to changes in industrial turbulence supports the finding in the cointegration tests that there is a larger idiosyncratic nature to stock prices in the early life-cycle phase.

V. Conclusion

The results indicate that stock price volatility and the degree of firm-specific and industry-specific risk evolve with the dynamics of creative destruction. In both industries, those periods in which there was the most technological change, the fastest rate of price decline, the highest rates of entry/exit, and the most market share instability were also the periods in which there was the highest stock price volatility, the largest difference between the volatility of fundamentals and the volatility of stock prices, and the least correlation between individual returns and general market returns. These results suggest that the economic mechanisms causing *growth*, (inter-firm) *variety*, and *volatility* are related.

Given the similarity in early development of the two industries, it is likely that some of the patterns that have characterized the mature phase of the automobile industry will also characterize the future of the PC industry which is only now entering its mature phase (e.g. sales growth in 2001 slowed down for the first time since 1980). Using this logic we may expect the PC industry to be characterized by: higher levels of concentration (already happening with the recent merger between HP and Compaq and with the price-war led by Dell)[xxiii], more market share stability between the incumbents, more focus on process innovation (and advertising) than product innovation, decreasing volatility of stock prices and greater correlation between the firm (and industry) specific stock returns and those of the general market.

However, if instead future competition is carried out more via product innovation rather than through price-wars and economies of scale (as it is currently), and if this innovation is of the "competence-destroying" type, i.e. the type that allows firms with new competencies to enter, as opposed to the type that only strengthens the incumbents' existing competencies, then the characteristics of the early phase may re-appear and we may witness new entry, market share instability and stock price volatility. The future market structure of the PC industry will also depend on the nature of innovations and if the innovations allow the continuation of open standards and vertical disintegration, which in the past allowed new entry to occur and smaller firms to survive.

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Notes

[i] Entries were calculated as the number of firms that were recorded as producers in the year indicated, but that were not recorded as producers in the previous year. Exits were calculated as the number of firms that were not recorded as producers in the year indicated, but that were recorded as producers in the previous year.

[ii] The firms used to create the S&P index for automobiles are (dates in parentheses are the beginning and end dates): Chrysler (12-18-25), Ford Motor (8-29-56), General Motors (1-2-18), American Motors (5-5-54 to 8-5-87), Auburn Automobile (12-31-25 to 5-4-38), Chandler-Cleveland (1-2-18 to 12-28-25), Hudson Motor Car (12-31-25 to 4-28-54), Hupp Motor Car (1-2-18 to 1-17-40), Nash-Kelvinator Corp (12-31-25 to 4-28-54), Packard Motor Car (1-7-20 to 9-29-54), Pierce-Arrow (1-2-18 to 12-28-25), Reo Motor Car (12-31-25 to 1-17-40), Studebaker Corp. (10-6-54 to 4-22-64), White Motor (1-2-18 to 11-2-32), and Willy's Overland (1-2-18 to 3-29-33).

[iii] Since in the post-war period, the results were not sensitive to whether we used the aggregate industry data (provided by S&P) or the average of the firm-specific one, this suggests that the pre-war data is robust.

[iv] The computer industry was first labelled by S&P as *Computer Systems* and then in 1996 changed to *Computer Hardware*. Firms included in this index are:
Apple Computer (4-11-84), COMPAQ Computer (2-4-88), Dell Computer (9-5-96), Gateway, Inc. (4-24-98), Hewlett-Packard (6-4-95), IBM (1-12-19), Silicon Graphics (1-17-95), and Sun Microsystems (8-19-92).

[v] The life-cycle is what Marshall had in mind when he wrote "At any particular moment in any branch of manufacture, some businesses will be rising and others falling; some…doubting whether to start new factories, others whether to enlarge existing factories…while others, again, feeling themselves behind the age, finding by experience that the equipment and internal organization of their factories will hardly enable them to sell at current prices and make a profit, will be tending to diminish their average output, or perhaps breaking down altogether." (Marshall, 1890).

[vi] Although the global nature of the industry is not discussed here, the fact that most of the competitors are US firms and that the global sales dynamics seem to be very similar to the domestic dynamics (even market shares are similar), suggests that the fact that the US PC industry acquired a global character much sooner than the US auto industry did, did not greatly affect the dynamics discussed in the paper.

[vii] I believe the latter period is a better description of the beginning of the "mature" phase while others, like Filson (2000), have claimed that the end of the 1920's represents the beginning of the mature phase.
[viii] "Personal computer shipments suffer first fall in 15 years", *The Financial Times*, July 21/22, 2001.

[ix] Different sources contain different firm numbers for the automobile industry: Epstein (1928) claims that only 180 auto producers ever existed, while Carroll and Hannan (2000) include 3,845 "pre-producers" (firms that meant to produce but that did not succeed) and 2,197 producers. The main difference (especially with the latter source) concerns the definition of the industry and of what a "producer" means. The list used in Klepper and Simons (1997) was used here because it provides a reasonable "middle-ground" between the two extremes. For a more complete comparison between the different sources, see Klepper and Simons (1997).

[x] "…50 of the 180 companies have enjoyed a life of only 1,2, or at most 3 years. A life of 4-6 years is found for 42 other companies; while a 6-8 year duration characterizes 26 other firms…as the length of life increases, the number of companies enjoying it steadily shrinks. Only 5 companies have remained in business for 25-27 years, and only 2 have survived a 28-30 year period" (Epstein, 1927, p. 159).

[xi] Raff and Trajtenberg (1997) warn against this interpretation since mass production/assembly line techniques did not diffuse in the auto industry until the 1920's, a decade after the shakeout began (however, once it did diffuse, they admit that it contributed greatly to the advantages of large firms).

[xii] "Constant uncertainty as to what the progress of the industrial arts would next bring forth was coupled with doubt as to the extent of the market and the preference of the public for particular types of vehicles. Not only, during these years, did the demand for high-priced cars shrink relatively; it fell off absolutely as well". (Epstein, 1927: 167).

[xiii] "Instead of 800 different sizes of lock washer which the parts makers had been making, 16 standard sizes were adopted. In place of 1600 kinds of steel tubing , 210 types were specified. The number of alloy steels employed was reduced to less than fifty". (Epstein, 1927: 170).

[xiv] --"Dell computer is vowing to remain on the offensive in an ongoing PC price war, sacrificing profits in a bid to gain market shares—a strategy that the company's found admitted could ultimately kill off a competitor," *Dell predicts industry shakeout*, by Ken Popovich, *Eweek*, January 22, 2001.

[xv] For the automobile industry Filson (2000) used the quality series derived from the quality changes computed by Raff and Trajtenberg (1997). For the PC industry he computed quality ratios by dividing the actual price ratios by the constant-quality price ratios computed by the BEA.

[xvi] Tushman and Anderson (1986) argue that whereas competence-enhancing innovations (often but not always incremental changes) allow incumbents to build on existing knowledge and hence maintain their lead, competence-destroying innovations (often but not always radical changes) are usually introduced by outsiders since they build on totally new knowledge and thus erode the advantages built up by incumbents (who are burdened by tradition and inertia).

[xvii] Similarly, Keynes (1937) later claimed:"By "uncertain" knowledge, let me explain, I do not mean merely to distinguish what is known for certain from what is only probably. The game of roulette is not subject, in this sense, to uncertainty…The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper or the rate of interest twenty years hence…About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know." (J.M.Keynes, 1937)

[xviii] Even in the years around the Great Depression, dividends and earnings did not increase wildly when the stock market peaked around 1929, nor did they fall abruptly when the stock market fell.

[xix] Shiller's studies (1989) have shown the result of excess volatility to be insensitive to the particular discount rate chosen. He also experiments with time varying discount rates, where the variation is approximated by changes in real consumption data. He finds that such variation does not alter the results on excess volatility (Shiller ,1989:p. 115). The only way that the stock prices generated from the EMM can be made to be as volatile as real stock prices is to make the discount rate vary greatly at each point in time, a highly unrealistic assumption. To conclude, he states: "The movements in expected real interest rates that would justify the variability in stock prices are very large – much larger than the movements in nominal interest rates over the sample period." (Shiller, 1989: p. 124-125).

[xx] The choice of a parsimonious model selection criteria is motivated by the moderate number of observations available.

[xxi] Since unit root tests have been severely criticized for being biased against rejection of the null hypothesis that the series in question follows a unit root (Maddala and Kim, 1998), the cases when the unit root hypothesis is indeed rejected should be given particular attention.

[xxii] Automobile stock price data is available from 1918 onwards (no automobile stocks were listed before that date) but firm level units data is available from 1904 onwards. This unfortunately prevents us from looking at the relationship between sales and stock prices in the early period (1900-1918), which was found to be relatively important in Section III (i.e. the era of rapid technological change).

[xxiii] "Gartner Dataquest noted that the unit growth of different PC makers in the U.S. was wildly inconsistent compared with previous quarters. While Dell's fourth quarter 2000 growth rose 37.7% and HP's growth jumped 20.7%, for example, other vendors fared far worse. Compaq's growth, for instance, dropped 8.7% while Gateway fell 7.1% in the fourth quarter. This indicates that there is a lot of market share shift going on." (*PC sales growth hits 7-year low*, by Pui-Wing Tam, *WSJ Interactive Edition*, January 19, 2001.

FIGURE 1

Number of firms in the US automobile industry (1899-1926) and the US PC industry (1973-1999)
maximum # of firms= 271 auto firms (1909), 286 PC firms (1987)

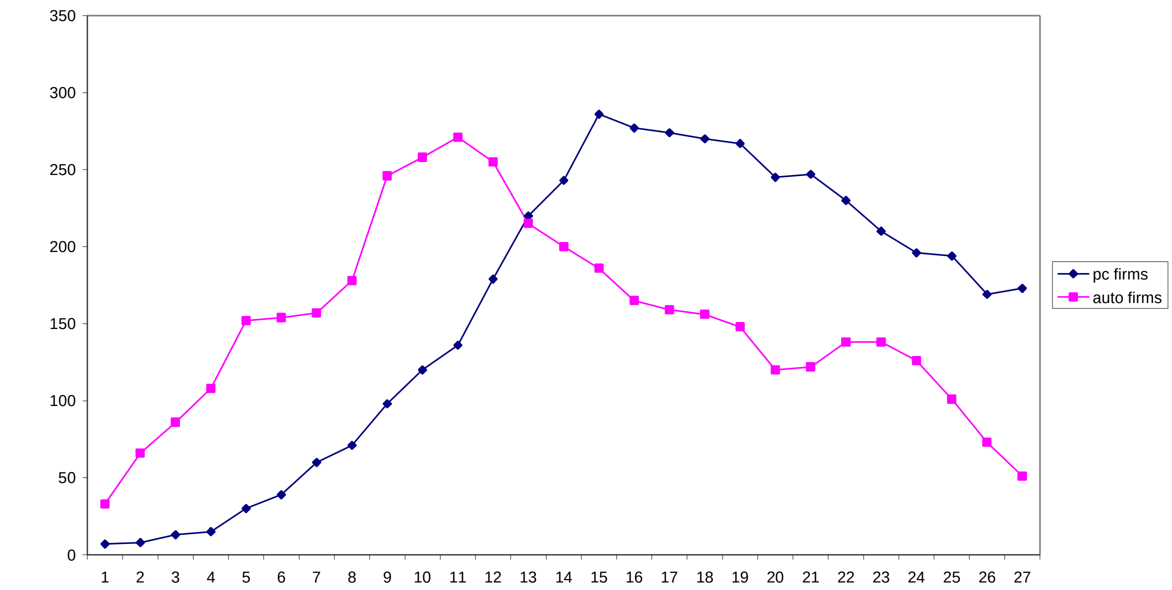

FIGURE 2

Total US automobile sales (1899-1998), total sales and 15 year moving avg.

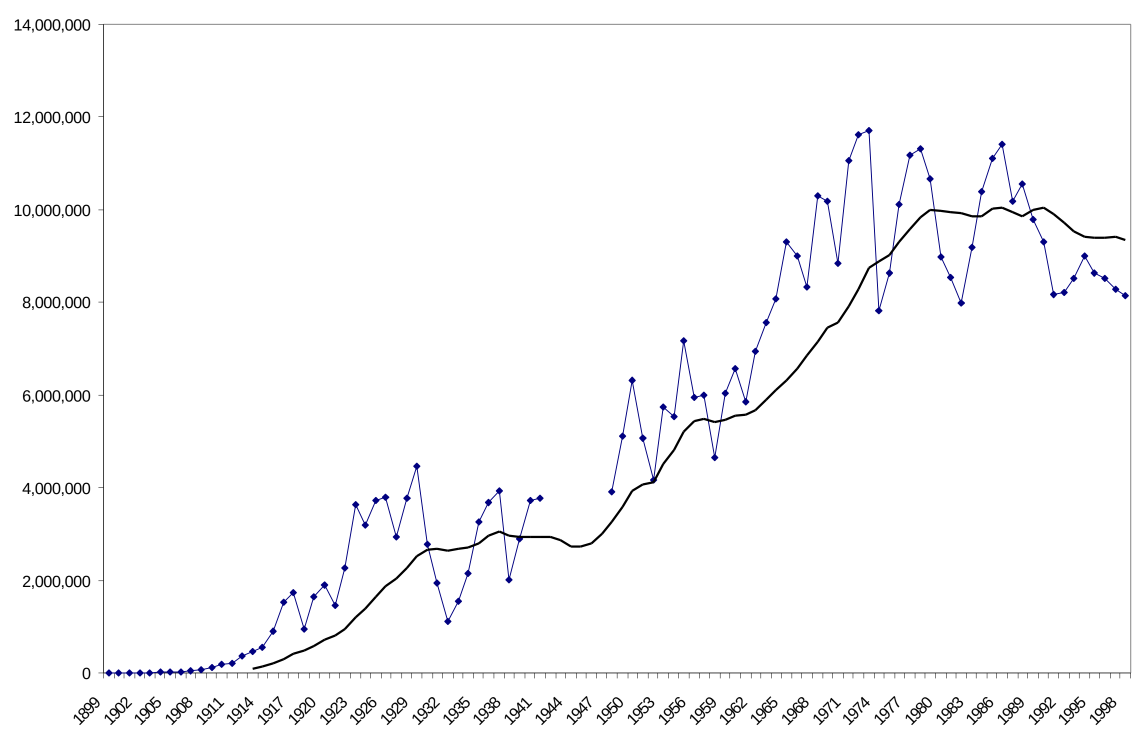

FIGURE 3

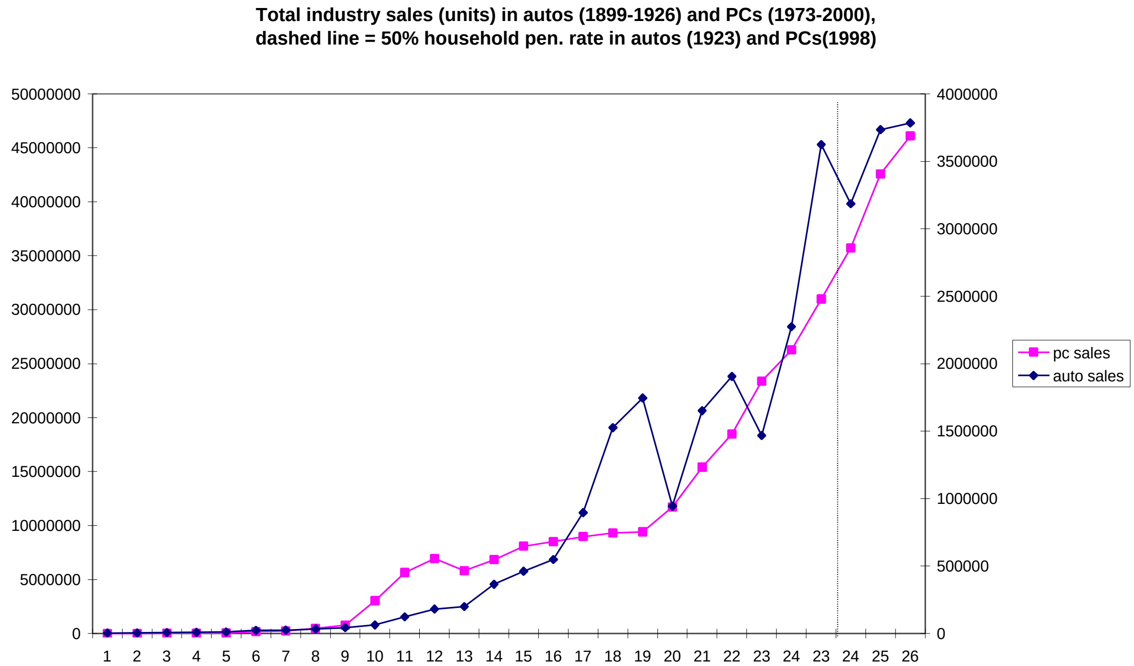
Total industry sales (units) in autos (1899-1926) and PCs (1973-2000), dashed line = 50% household pen. rate in autos (1923) and PCs(1998)
50000000
45000000
40000000
35000000
30000000
25000000
20000000
15000000
10000000
5000000
0
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 23 24 25 26
pc sales
auto sales

FIGURE 4

Entry and Exit in the US Automobile Industry (1899-1930)

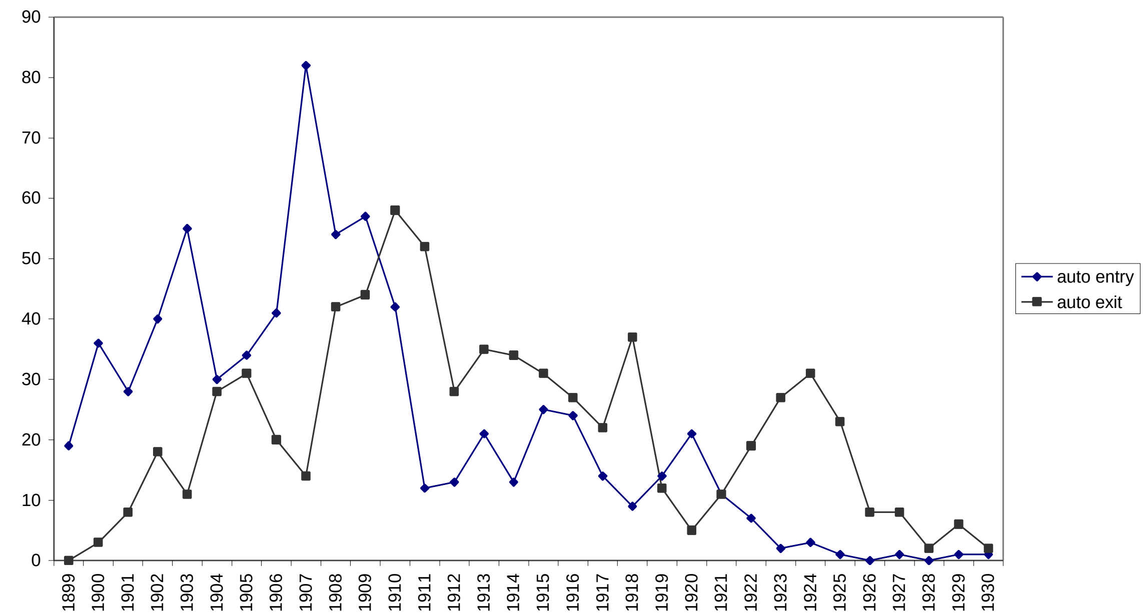

FIGURE 5

Entry and exit in the US PC industry (1973-1995)

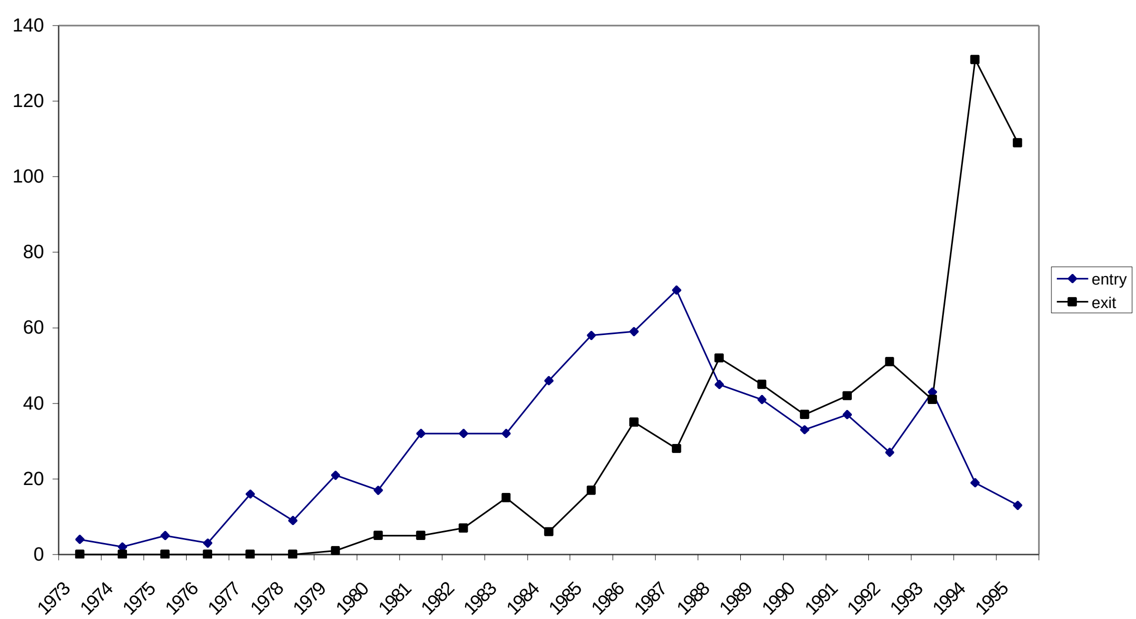

FIGURE 6
(source: Epstein, 1926)

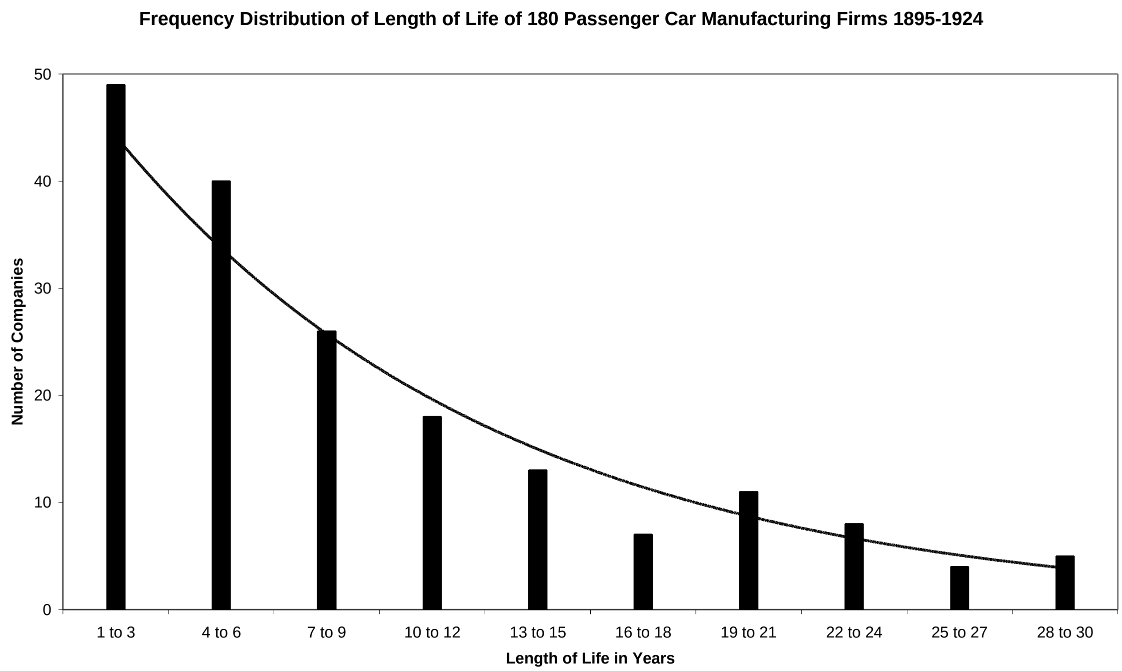

FIGURE 7
(source: IDC shipments data rearranged by the author)

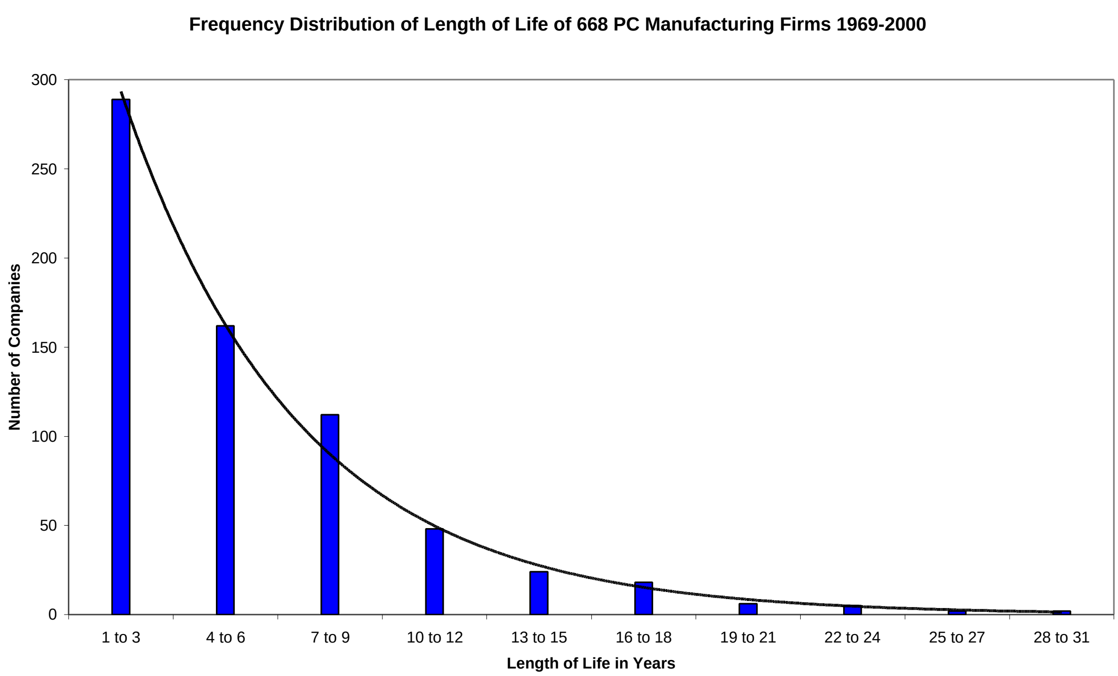

FIGURE 8

(source: Raff and Trajetenberg, 1997 and Bureau of Economic Analysis)

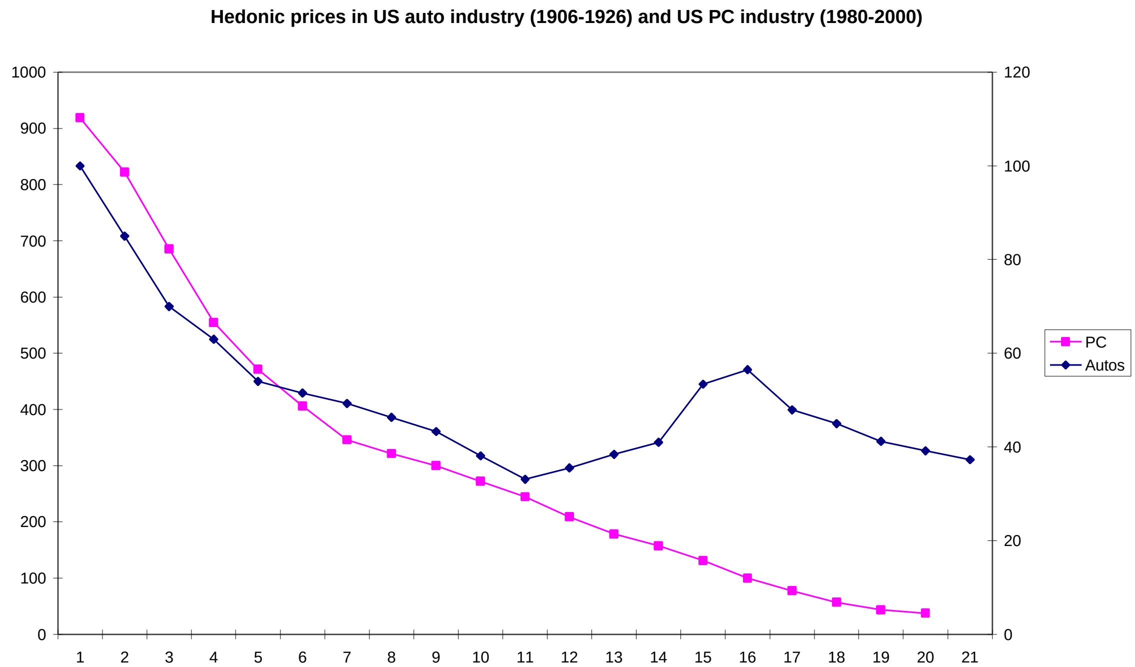

FIGURE 9

(source: Abernathy et al. 1987)

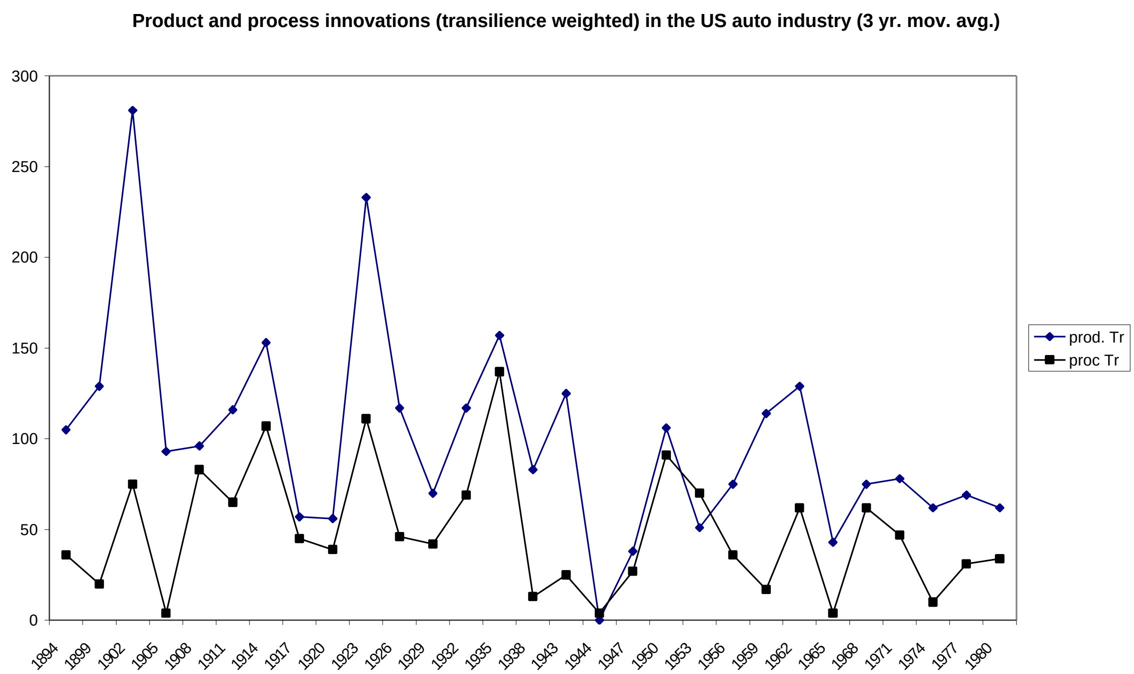

FIGURE 10
(source: Raff and Trajtenberg, 1997)

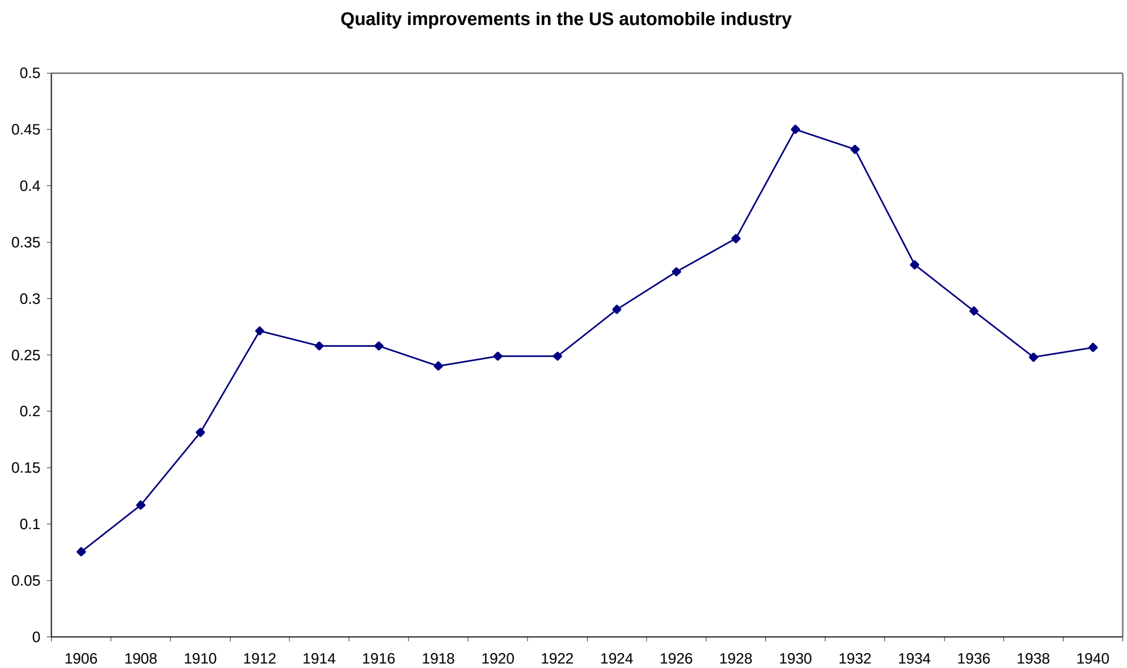

FIGURE 11
(source: Filson, 2000)

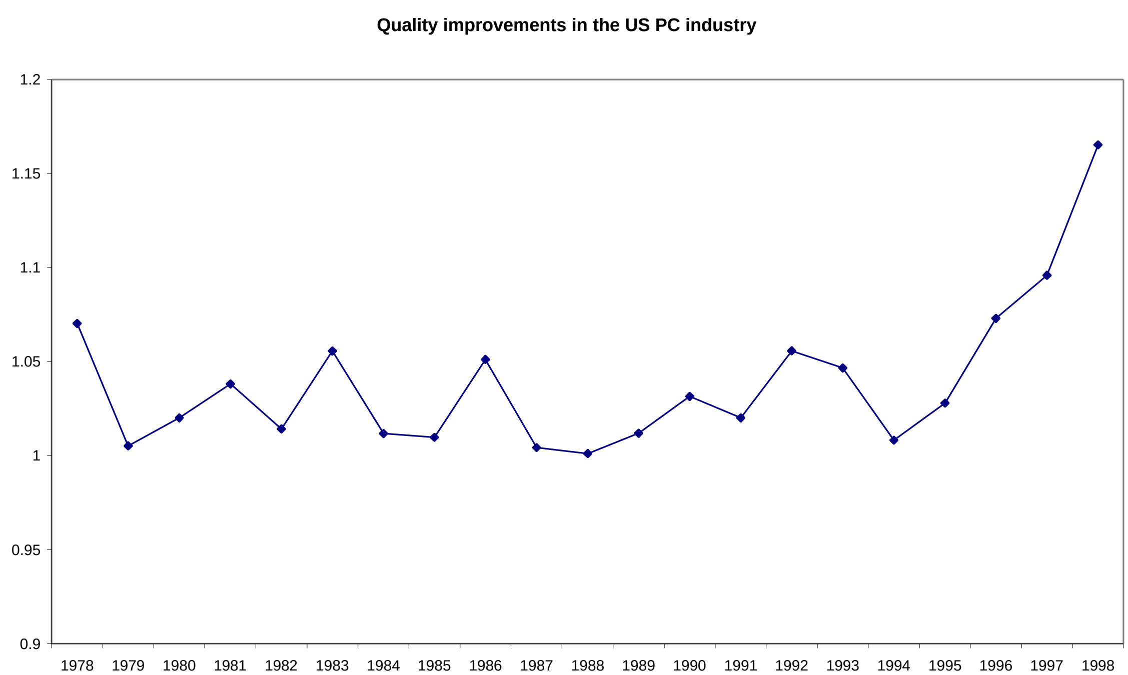

FIGURE 12

Market share instability and concentration in the US automobile industry

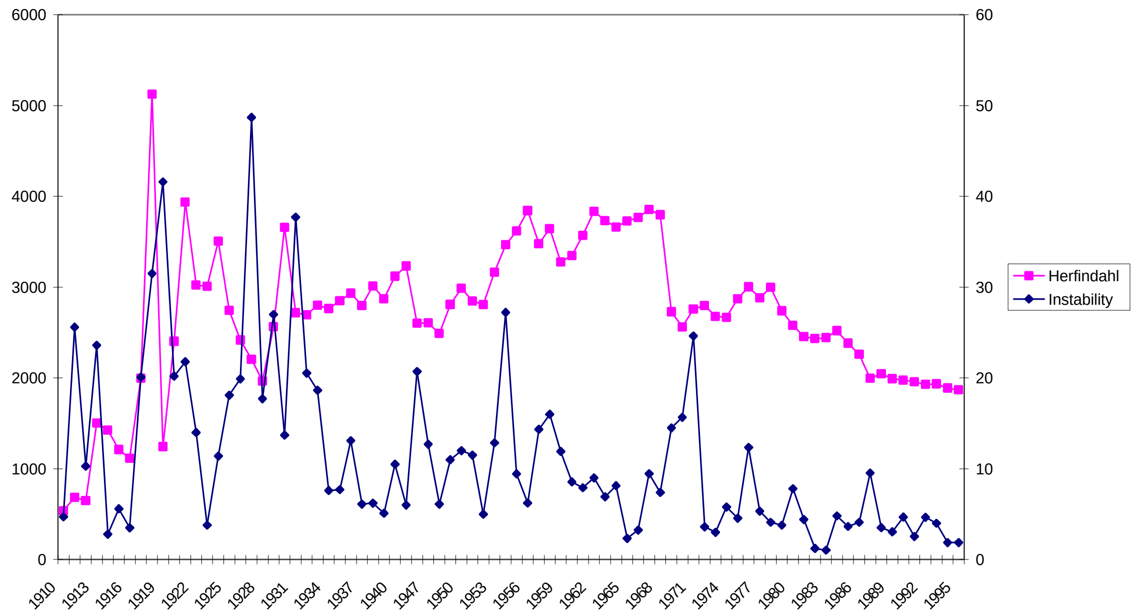

FIGURE 13

Market share instability and concentration in the US PC industry

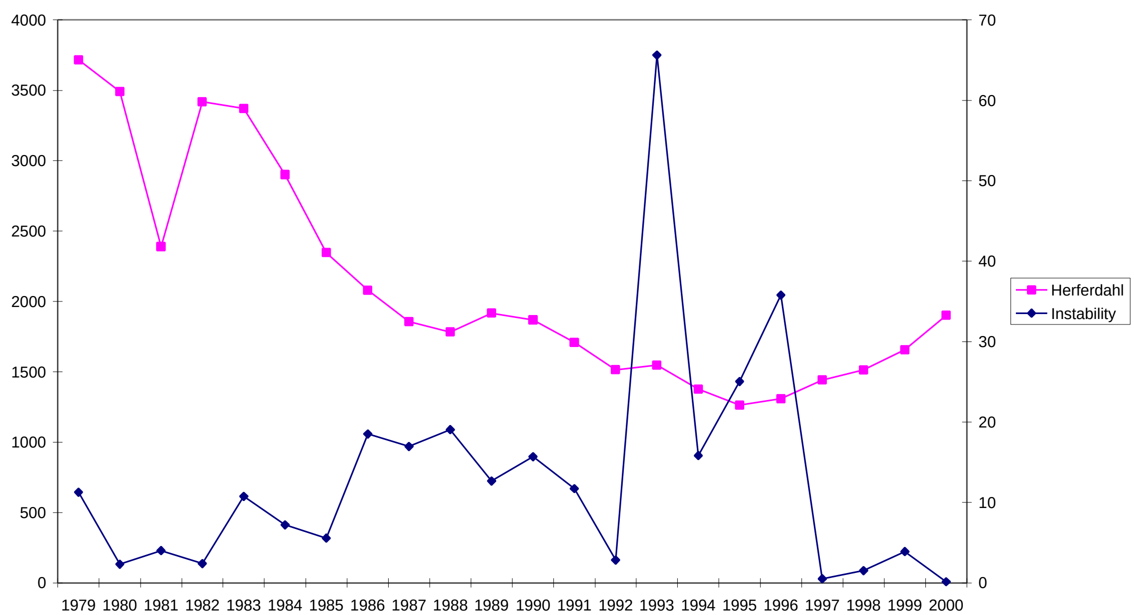

FIGURE 14

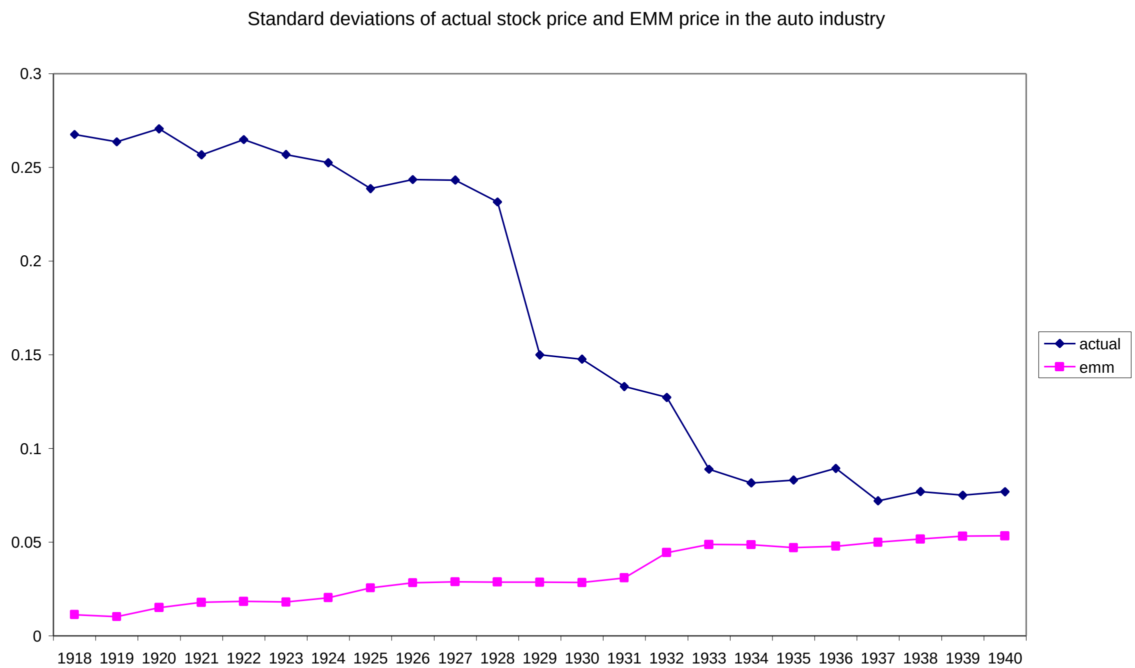

FIGURE 15

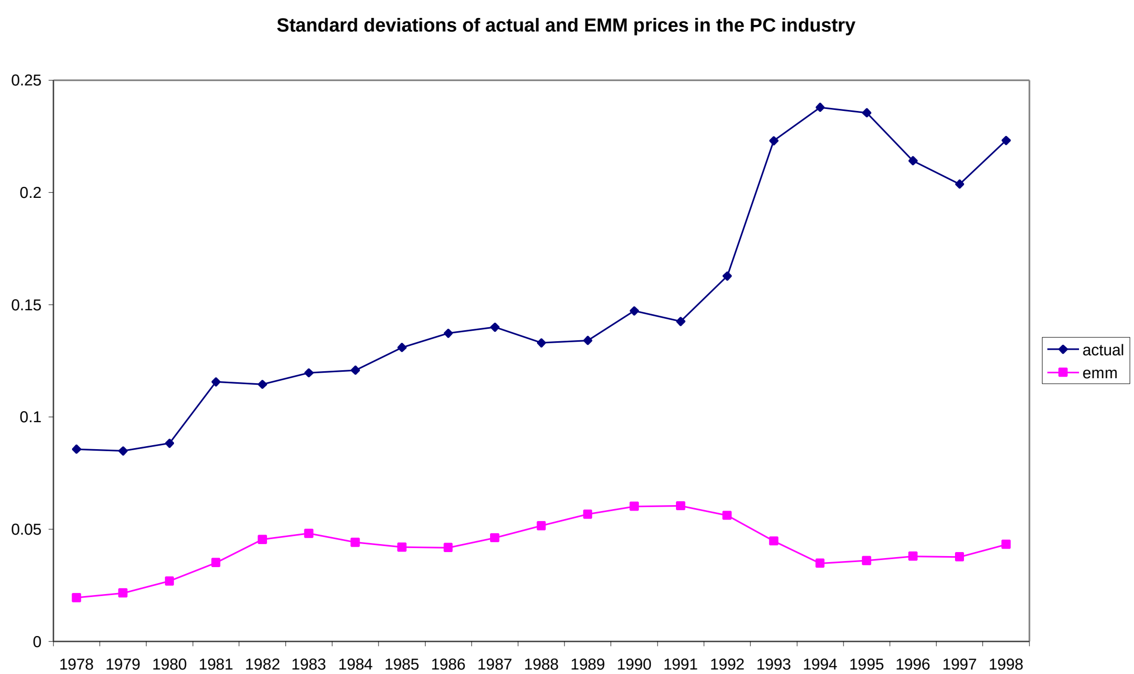

FIGURE 16

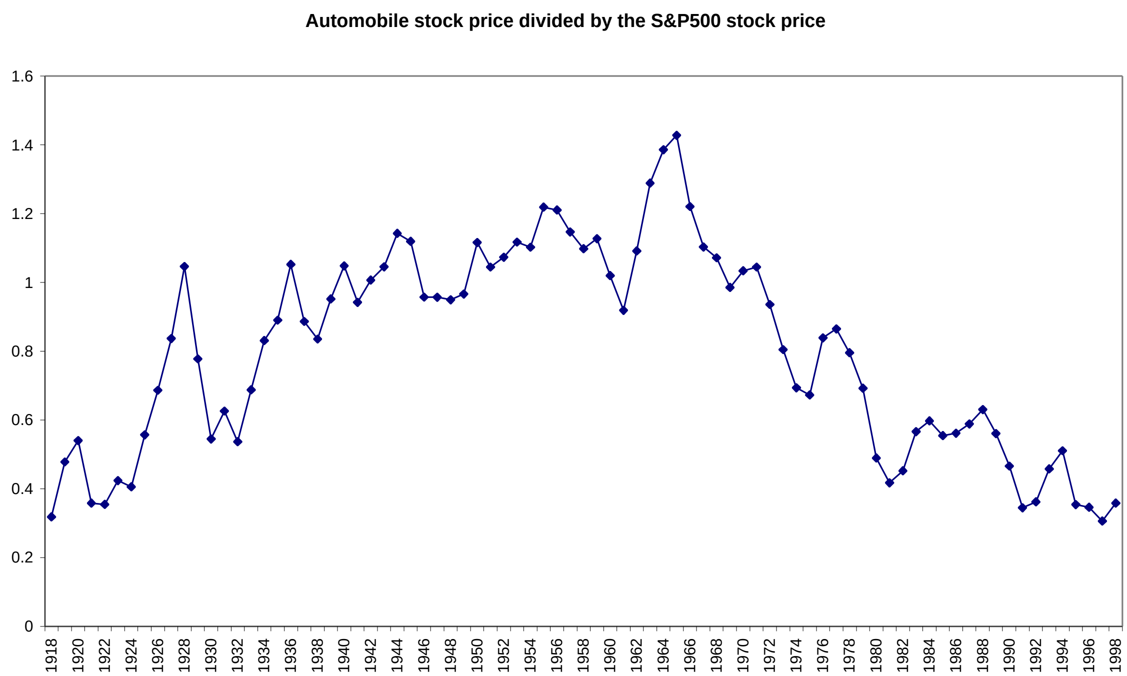

FIGURE 17

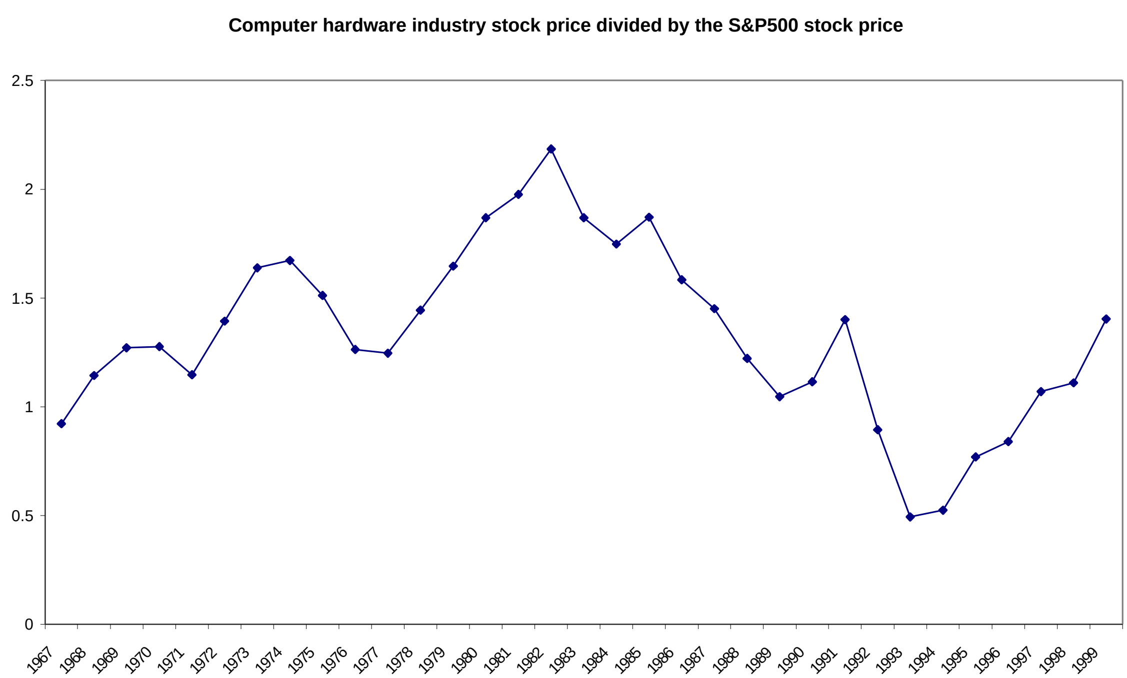

FIGURE 18

Recursive OLS from co-integration test of auto industry returns with market returns

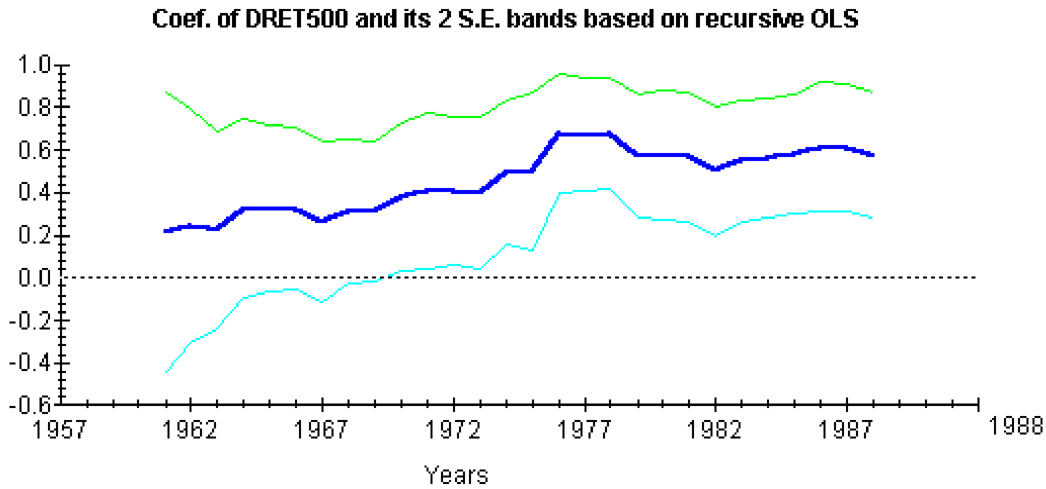

TABLE 1

Aggregate business failure rate vs. failure rate in autos and PCs.

	Agg.%	Auto%
1903	0.9	4
1904	0.9	3
1905	0.8	5
1906	0.7	2
1907	0.8	0
1908	1.1	4
1909	0.8	1
1910	0.8	26
1911	0.8	4
1912	0.9	12
1913	0.9	10
1914	1	9
1915	1	7
1916	1	9
1917	0.8	7
1918	0.6	7
1919	0.4	5
1920	0.5	6
1921	1	1
1922	1.2	10
1923	1	15
1924	1	19

	Agg. %	PC %
1984	0.9	3.4
1985	1.0	7.7
1986	1.1	14.0
1987	1.0	8.7
1988	0.9	18.4
1989	0.8	15.7
1990	1.0	13.3
1991	1.4	14.2
1992	1.5	20.4
1993	1.3	15.4
1994	1.1	88.2
1995	1.1	50.5
1996	1.1	21.7
1997	1.2	12.7

TABLE 2

Analysis of the statistical properties of the series (processes) of units produced by US and foreign firms: DF and ADF tests

Firm	*Sample*	*selected by*	*reference test*	*Test stat.*	*95% crit. value*	*Process*
Chrysler	1925-1941	SBC	ADF(1)+drift+t	-2.6184	-3.7612	I(1)
	1948-1998	SBC	DF+drift	-3.1572	-2.919	I(0)
Ford	1904-1941	SBC	DF+drift	-4.0172	-2.9446	I(0)
	1925-1941	SBC	ADF(1)+drift	-3.3364	-3.0522	I(0)
	1948-1998	SBC	DF+drift	-3.3243	-2.919	I(0)
GM	1909-1941	SBC	DF+drift	-1.6327	-2.9591	I(1)
	1925-1941	SBC	DF+drift	-2.0393	-3.0522	I(1)
	1948-1998	SBC	DF+drift	-3.1688	-2.919	I(0)
Hudson	1910-1926	SBC	ADF(1)+drift	-3.6729	-3.7612	I(1)
	-	-	-	-	-	
Nash	1917-1926	SBC	DF+drift+t	-2.1548	-4.1961	I(1)
	-	-	-	-	-	
Packard	1904-1926	SBC	DF+drift+t	-2.4551	-3.6454	I(1)
	-	-	-	-	-	-
Reo	1905-1928	SBC	DF+drift+t	-2.3108	-3.6331	I(1)
	-	-	-	-	-	
Studebacker	1911-1941	SBC	DF+drift	-1.8746	-2.9665	I(1)
	1925-1941	SBC	DF+drift	-1.5779	-3.0522	I(1)
	-	-	-	-	-	
American	-	-	-	-	-	-
	-	-	-	-	-	-
	1948-1985	SBC	ADF(1)+drift	-2.5329	-2.94	I(1)
Total units (US)	1899-1941	SBC	ADF(1)+drift	-2.3311	-2.9339	I(1)
	1925-1941	SBC	DF+drift	-1.9753	-3.0522	I(1)
	1948-1998	SBC	DF+drift	-4.2927	-2.919	I(0)
Honda	1971-1998	SBC	DF+drift	-6.7257	-2.9798	I(0)
Mazda	1985-1998	SBC	DF+drift	-1.2576	-3.1485	I(1)
Mitsubishi	1985-1998	SBC	DF+drift	-2.6298	-3.1485	I(1)
Nissan	1965-1998	SBC	DF+drift	-4.9077	-2.9558	I(0)
Toyota	1966-1998	SBC	DF+drift+t	-6.174	-2.9591	I(0)
Volkswagen	1965-1998	SBC	DF+drift	-1.4288	-2.9558	I(0)

note:
DF = Dickey-Fuller Test, drift stands for intercept, t for trend
ADF = Augmented Dickey-Fuller Test, drift stands for intercept, t for trend
SBC = Schwarz Bayesian Criterion (based on ML)
I(1) = Integrated process of order 1, or Difference Stationary (DS)
I(0) = Stationary process, or Trend Stationary (TS)

TABLE 3

Descriptive statistics of units (logs of differences) in the US auto industry

		1918-28	1918-41	1948-00	1948-70	1970-00	1970-80	1980-90	1990-00
gm	st. dev	0.1745	0.1548	0.0798	0.0933	0.0732	0.1114	0.0502	0.0229
	mean	0.0597	0.0579	0.0052	0.0153	-0.0088	-0.0029	-0.0158	-0.0162
ford	st. dev	0.2734	0.2307	0.0837	0.1045	0.0572	0.0735	0.0683	0.0359
	mean	0.0011	0.0173	0.0072	0.0283	-0.0103	-0.0277	-0.0054	-0.0161
chrysler	st. dev	0.1035	0.1415	0.0897	0.1149	0.0615	0.0717	0.0708	0.0536
	mean	0.1019	0.0654	0.0006	0.0130	-0.0089	-0.0210	-0.0090	-0.0155
amc	st. dev		0.2039	0.1067	0.1136	0.0913	0.0673	0.1288	
	mean		0.0971	0.0021	0.0182	-0.0192	-0.0135	-0.0197	
studeb	st. dev	0.1565	0.1639	0.3023	0.3023				
	mean	0.0409	0.0470	-0.1038	-0.1038				
packard	st. dev	0.1936	0.1936						
	mean	0.0262	0.0262						
hudson	st. dev	0.2549	0.2549						
	mean	0.1178	0.1178						
nash	st. dev	0.1784	0.1784						
	mean	0.1169	0.1169						
industry	st. dev	0.1569	0.1500	0.0638	0.0759	0.0523	0.0768	0.0428	0.0231
	mean	0.0305	0.0378	0.0070	0.0172	-0.0034	-0.0050	-0.0054	-0.0088

TABLE 4

DF-ADF tests for logs of units produced in the US PC industry

Firm	*Sample*	*selected by*	*reference test*	*Test stat.*	*95% crit. value*	*Process*
Apple	1979-2000	SBC	DF+drift	-7.127	-3.004	I(0)
Hewlett-Pack	1979-2000	SBC	ADF(1)+drift+t	-2.725	-3.633	I(1)
IBM	1979-2000	SBC	ADF(1)+drift	-2.101	-3.004	I(1)
NCR	1979-2000	SBC	DF+drift+t	-0.16	-3.659	I(1)
Unisys	1979-2000	SBC	ADF(1)+drift	-2.628	-3.012	I(1)
Commodore	1979-1994	SBC	DF+drift+t	0.169	-3.735	I(1)
Compaq	1985-2000	SBC	DF+drift+t	-2.045	-3.735	I(1)
Dell	1987-2000	SBC	ADF(1)+drift+t	-6.435	-3.792	I(0)
Gateway	1986-2000	SBC	ADF(1)+drift	-1.586	-3.082	I(1)
Toshiba	1983-2000	SBC	DF+drift	-1.747	-3.04	I(1)
Wang	1979-1993	SBC	DF+drift	-1.228	-3.082	I(1)
Wyse	1986-1994	SBC	DF+drift+t	-1.686	-4.081	I(1)
All firms	1979-2000	SBC	DF+drift	-3.358	-3.004	I(0)

note:
DF = Dickey-Fuller Test, drift stands for intercept, t for trend
ADF = Augmented Dickey-Fuller Test, drift stands for intercept, t for trend
SBC = Schwarz Bayesian Criterion (based on ML)
I(1) = Integrated process of order 1, or Difference Stationary (DS)
I(0) = Stationary process, or Trend Stationary (TS)

TABLE 5

Descriptive statistics of units (logs of differences) in the US PC industry

		1970-00	1970-80	1980-90	1990-00
apple	st. dev	0.7958	0.6847	0.4118	0.1132
	mean	5.7186	4.1964	5.7176	6.2251
compaq	st. dev	0.6717		0.3192	0.4843
	mean	5.9325		5.3333	6.3406
dell	st. dev	0.8999		0.4933	0.6501
	mean	5.6426		4.7283	6.0815
everex	st. dev	0.2038		0.2768	0.1932
	mean	4.7409		4.6979	4.7762
gateway	st. dev	1.5397		0.9631	0.5243
	mean	4.9947		3.3857	6.0170
hpackard	st. dev	1.1976	0.4852	0.3910	0.7145
	mean	4.7415	3.2614	4.8468	5.8018
ibm	st. dev	1.3390	0.4552	0.8164	0.1464
	mean	5.3104	3.3484	5.6838	6.3037
nec	st. dev	0.3437			0.3437
	mean	6.1557			6.1557
toshiba	st. dev	1.1964		1.0799	0.3587
	mean	4.9549		4.0701	5.7926
unisys	st. dev	0.6569	0.3242	0.4711	0.6040
	mean	4.1503	3.3528	4.3014	4.4822
industry	st. dev	0.1758	0.2062	0.1884	0.0357
	mean	0.1504	0.2432	0.1450	0.0646

TABLE 6

Analysis of the statistical properties of the series (processes) of the real stock prices (logs) by US firms: DF and ADF tests

Firm	*Sample*	*selected by*	*reference test*	*Test stat.*	*95% crit. value*	*Process*
Chrysler	1925-1941	SBC	DF+drift	-1.6451	-3.0819	I(1)
	1948-1997	SBC	DF+drift	-1.2896	-2.9202	I(1)
Ford	-	-	-	-	-	-
	-	-	-	-	-	-
	1956-1998	SBC	DF+drift	-1.0184	-2.9339	I(1)
GM	1918-1941	SBC	DF+drift	-1.85	-3.0039	I(1)
	1925-1941	SBC	DF+drift	-1.4806	-3.0522	I(1)
	1948-1998	SBC	DF+drift	-1.5644	-2.919	I(1)
Hudson	1922-1941	SBC	DF+drift+t	-2.4929	-3.6921	I(1)
	1925-1941	SBC	ADF(1)+drift+t	-3.747	-3.7119	I(0)
	-	-	-	-	-	-
Nash	1922-1941	SBC	DF+drift+t	-4.2651	-3.6921	I(0)
	1925-1941	SBC	DF+drift+t	-3.9201	-3.7119	I(0)
	-	-	-	-	-	-
Packard	1917-1941	SBC	ADF(1)+drift+t	-5.1512	-3.6592	I(0)
	1925-1941	SBC	ADF(1)+drift+t	-4.7759	-3.7119	I(0)
	-	-	-	-	-	-
Studeback	1920-1941	SBC	ADF(1)+drift	-3.516	-3.0199	I(0)
	1925-1941	SBC	ADF(1)+drift	-3.2718	-3.0522	I(0)
	1948-1966	SBC	DF+drift	-2.2482	-3.0294	I(1)
American	-	-	-	-	-	-
	-	-	-	-	-	-
	1954-1986	SBC	ADF(1)+drift+t	-2.9128	-3.5615	I(1)
Industry	1918-1941	SBC	DF+drift	-1.4876	-3.0039	I(1)
	1925-1941	SBC	DF+drift	-2.8846	-3.0522	I(1)
	1948-1998	SBC	ADF(1)+drift	-2.181	-2.919	I(1)
S&P500	1913-1941	SBC	DF+drift	-2.3482	-2.975	I(1)
	1925-1941	SBC	ADF(1)+drift	-3.0079	-3.0522	I(1)
	1948-1998	SBC	DF+drift	-0.083576	-2.919	I(1)

note:

DF = Dickey-Fuller Test, drift stands for intercept, t for trend

ADF = Augmented Dickey-Fuller Test, drift stands for intercept, t for trend

SBC = Schwarz Bayesian Criterion (based on ML)

I(1) = Integrated process of order 1, or Difference Stationary (DS)

I(0) = Stationary process, or Trend Stationary (TS)

TABLE 7

Descriptive statistics of stock prices (logs of differences) in the US auto industry

		1918-28	1918-41	1948-00	1948-70	1970-2000	1970-1980	1980-1990	1990-2000
gm	st. dev	0.170964	0.147147	0.095173	0.080395	0.107536	0.096764	0.147021	0.038757
	mean	0.055331	0.043339	0.006101	-0.000395	0.00716	-0.017501	0.016151	0.01551
ford	st. dev			0.107571	0.08662	0.116013	0.125156	0.096478	0.128755
	mean			0.006197	0.008201	0.004956	-0.040533	-0.000331	0.036639
chrysler	st. dev	0.469634	0.248602	0.14847	0.08969	0.187895	0.154917	0.215675	0.185247
	mean	-0.080296	-0.000182	-0.001796	-0.016302	0.001725	-0.084603	0.03748	0.018132
amc	st. dev			0.170042	0.19818	0.13688	0.092815	0.188094	
	mean			-0.001156	0.020099	-0.027492	-0.020019	-0.038167	
studeb	st. dev	0.206597	0.195977	0.280321	0.280321				
	mean	-0.006913	-0.007087	0.011368	0.011368				
packard	st. dev	0.223114	0.187234	0.107029	0.107029				
	mean	0.057746	0.011162	-0.041811	-0.041811				
hudson	st. dev	0.200407	0.186195	0.098529	0.098529				
	mean	0.095105	0.010527	-0.01907	-0.01907				
nash	st. dev	0.390304	0.316962						
	mean	0.028112	0.017133						
industry	st. dev	0.145861	0.139372	0.079111	0.067126	0.088107	0.08955	0.088704	0.081875
	mean	0.093952	0.062004	0.029882	0.033595	0.024391	-0.019957	0.030865	0.045813

auto stock prices divided by the S&P500 stock price

		1918-28	*1918-41*	*1948-00*	*1948-70*	*1970-00*	*1970-80*	*1980-90*	*1990-00*
gm	st. dev	*0.213194*	*0.172266*	*0.05879*	*0.066352*	*0.051239*	*0.044026*	*0.072389*	*0.02192*
	mean	*0.003571*	*0.002638*	*-0.01278*	*-0.02173*	*-0.00648*	*-0.00982*	*-0.00759*	*-0.00803*
ford	st. dev			*0.050352*	*0.046057*	*0.052478*	*0.063024*	*0.052042*	*0.045389*
	mean			*-0.0074*	*-0.00587*	*-0.00717*	*-0.02108*	*-0.0123*	*0.001149*
chrysler	st. dev	*0.444806*	*0.243829*	*0.065299*	*0.040836*	*0.079745*	*0.064677*	*0.097673*	*0.073517*
	mean	*-0.18241*	*-0.05268*	*-0.01673*	*-0.0318*	*-0.00736*	*-0.04255*	*0.007565*	*-0.00414*
amc	st. dev			*0.095735*	*0.120111*	*0.064283*	*0.042164*	*0.088971*	
	mean			*-0.00584*	*0.00264*	*-0.01593*	*-0.01062*	*-0.02475*	
studeb	st. dev	*0.207561*	*0.167586*	*0.18901*	*0.18901*				
	mean	*-0.04401*	*-0.03154*	*-0.01761*	*-0.01761*				
packard	st. dev	*0.187661*	*0.145828*	*0.07082*	*0.07082*				
	mean	*0.020267*	*-0.01436*	*-0.04794*	*-0.04794*				
hudson	st. dev	*0.188132*	*0.130295*	*0.079557*	*0.079557*				
	mean	*-0.0045*	*-0.0456*	*-0.0423*	*-0.0423*				
nash	st. dev	*0.392557*	*0.312088*						
	mean	*-0.08453*	*-0.10006*						
industry	st. dev	*0.125784*	*0.108988*	*0.035248*	*0.037218*	*0.033578*	*0.040372*	*0.038819*	*0.027427*
	mean	*0.061789*	*0.035215*	*-0.00204*	*0.000273*	*-0.00369*	*-0.01134*	*-0.00555*	*-0.00424*

TABLE 8

DF-ADF tests for the logs of real stock prices in the US PC industry

Firm	*Sample*	*selected by*	*reference test*	*Test stat.*	*95% crit. value*	*Process*
Apple	1983-2000	SBC	DF+drift	-2.333	-3.04	I(1)
Hewlett-Pack	1979-2000	-	-	-	-	-
IBM	1979-2000	SBC	ADF(1)+drift	-1.822	-3.003	I(1)
NCR	1979-2000	-	-	-	-	-
Unisys	1979-2000	SBC	ADF(1)+drift+t	-3.855	-3.633	I(0)
Commodore	1979-1993	SBC	DF+drift	-2.071	-3.081	I(1)
Compaq	1985-2000	SBC	DF+drift	-2.117	-3.066	I(1)
Dell	1990-2000	SBC	DF+drift+t	-1.746	-3.927	I(1)
Gateway	1995-2000	SBC	DF+drift+t	-4.683	-4.581	I(0)
Toshiba	1992-1997	SBC	ADF(1)+drift	-1.498	-3.551	I(1)
Wang	1979-1998	SBC	DF+drift	-2.613	-3.019	I(1)
Wyse	1986-1988	SBC	DF+drift	-0.393	-4.706	I(1)

note:
DF = Dickey-Fuller Test, drift stands for intercept, t for trend
ADF = Augmented Dickey-Fuller Test, drift stands for intercept, t for trend
SBC = Schwarz Bayesian Criterion (based on ML)
I(1) = Integrated process of order 1, or Difference Stationary (DS)
I(0) = Stationary process, or Trend Stationary (TS)

TABLE 9

Descriptive statistics of stock prices (logs of differences) in the US PC Industry

						stock prices divided by the S&P 500			
		1970-00	**1970-80**	**1980-90**	**1990-00**	***1970-00***	***1970-80***	***1980-90***	***1990-00***
apple	st. dev	0.209303		0.238666	0.19128	*0.083065*		*0.09724*	*0.073131*
	mean	0.043676		0.064494	0.005768	*0.009145*		*0.020582*	*-0.00922*
compaq	st. dev	0.225305		0.230429	0.218546	*0.089324*		*0.099345*	*0.078982*
	mean	0.091429		0.135991	0.068572	*0.032226*		*0.057387*	*0.018271*
dell	st. dev	0.370061		0.694571	0.350854	*0.138582*		*0.281417*	*0.131854*
	mean	0.201428		0.190106	0.247106	*0.072183*		*0.086022*	*0.089015*
everex	st. dev	0.239683		0.296755	0.104951	*0.09334*		*0.117415*	*0.034097*
	mean	-0.129761		-0.052906	-0.199099	*-0.05629*		*-0.02735*	*-0.08481*
gateway	st. dev	0.337883			0.337883	*0.107928*			*0.107928*
	mean	0.080564			0.080564	*0.019431*			*0.019431*
hpackard	st. dev	0.132265	0.134861	0.135744	0.150659	*0.059641*	*0.070197*	*0.061558*	*0.063048*
	mean	0.043979	0.025972	-0.000603	0.081044	*0.011006*	*0.013164*	*-0.0052*	*0.019333*
ibm	st. dev	0.122494	0.098844	0.103189	0.147733	*0.054581*	*0.053856*	*0.056612*	*0.052748*
	mean	0.027457	0.005942	0.022224	0.050709	*0.001435*	*0.004051*	*-0.00277*	*0.004831*
nec	st. dev	0.265431	0.307358	0.295656	0.171236	*0.123413*	*0.152363*	*0.140936*	*0.056444*
	mean	0.050035	0.275437	0.019097	0.007448	*0.015864*	*0.1347*	*-0.00042*	*-0.00681*
toshiba	st. dev	0.298498			0.298498	*0.119026*			*0.119026*
	mean	0.077906			0.077906	*0.02701*			*0.02701*
unisys	st. dev	0.237456	0.090132	0.262856	0.353007	*0.093811*	*0.054849*	*0.108797*	*0.133124*
	mean	-0.013906	-0.040914	-0.092654	-0.000323	*-0.01384*	*-0.01852*	*-0.05017*	*-0.00969*
industry	st. dev	0.090528	0.070891	0.066299	0.119646	*0.034966*	*0.029413*	*0.032475*	*0.044552*
	mean	0.02582	-0.004754	0.015488	0.058539	*-0.00383*	*-0.00399*	*-0.01369*	*-0.0003*

TABLE 10

Analysis of the statistical properties of the series (processes) of the real dividends (logs) by US firms: DF and ADF tests

Firm	*Sample*	*selected by*	*reference test*	*Test stat.*	*95% crit. value*	*Process*
Chrysler	1925-1941	SBC	DF+drift	-1.5616	-3.0819	I(1)
	1948-1997	SBC	DF+drift+t	-3.0655	-3.5005	I(1)
Ford	-	-	-	-	-	-
	-	-	-	-	-	-
	1956-1998	SBC	DF+drift+t	-3.1455	-3.5217	I(1)
GM	1918-1941	SBC	DF+drift	-4.368	-3.0039	I(0)
	1925-1941	SBC	DF+drift	-3.5828	-3.0522	I(1)
	1948-1998	SBC	DF+drift+t	-4.1592	-3.4987	I(0)
Hudson	1922-1941	SBC	ADF(1)+drift+t	-2.0859	-3.6921	I(1)
	1925-1941	SBC	ADF(1)+drift+t	-2.9512	-3.7119	I(1)
	-	-	-	-	-	-
Nash	1918-1941	SBC	DF+drift+t	-2.1926	-3.6921	I(1)
	1925-1941	SBC	DF+drift+t	-1.8594	-3.8731	I(1)
	-	-	-	-	-	-
Packard	1917-1941	SBC	ADF(1)+drift	-2.6589	-2.997	I(1)
	1925-1941	SBC	DF+drift	-2.0046	-3.0522	I(1)
	-	-	-	-	-	-
Studeback	1920-1941	SBC	DF+drift+t	-2.6264	-3.6746	I(1)
	1925-1941	SBC	DF+drift+t	-2.5698	-3.7119	I(1)
	1948-1966	SBC				

note:
DF = Dickey-Fuller Test, drift stands for intercept, t for trend
ADF = Augmented Dickey-Fuller Test, drift stands for intercept, t for trend
SBC = Schwarz Bayesian Criterion (based on ML)
I(1) = Integrated process of order 1, or Difference Stationary (DS)
I(0) = Stationary process, or Trend Stationary (TS)

TABLE 11

Descriptive statistics of dividends (logs of differences) in the US auto industry

	gm	ford	chrysler	studeb	packard	hudson	nash	industry
1918-1928								
mean	0.014397		0.110924	-0.023247	0.066026		0.013197	0.028383
sd	0.482548		0.019819	0.536553	0.467959		0.248424	0.323424
1918-1941								
mean	0.033447		0.076592	-0.013561	0.042445	0.037086	0.013197	0.033497
sd	0.390041		0.293965	0.454954	0.421882	0.605477	0.248424	0.260793
1948-2000								
mean	-0.009355	-1.35E-18	-0.007187	0.117701	0.174293	0.0546		-0.008183
sd	0.236352	0.183059	0.283631	0.41256	0.501824	0.316417		0.166783
1948-1970								
mean	0.002363	-0.001266	-0.024958	0.117701	0.174293	0.0546		0.000777
sd	0.217482	0.115859	0.302836	0.41256	0.501824	0.316417		0.166347
1970-2000								
mean	-0.018327	0.000633	-0.011149					-0.021017
sd	0.249796	0.2078	0.284339					0.169351
1970-1980								
mean	-0.013752	0.027978	-0.027366					-0.00438
sd	0.17152	0.121243	0.415832					0.135948
1980-1990								
mean	0.02803	0.02128	0.070741					0.040017
sd	0.300927	0.276309	0.253263					0.141594
1990-2000								
mean	-0.039131	-0.045216	-0.008671					-0.066232
sd	0.300438	0.185551	0.163264					0.238726

dividends divided by S&P500 dividends

	gm	*ford*	*chrysler*	*studeb*	*packard*	*hudson*	*nash*	*industry*
1918-1928								
mean	*-0.20397*		*-2.97376*	*0.002687*	*-0.38466*	*-1.85289*	*-1.43912*	*-0.53587*
sd	*1.970619*		*1.351719*	*2.158434*	*1.807524*	*1.927482*	*2.179365*	*1.351978*
1918-1941								
mean	*-0.24482*		*-1.03621*	*1.1693*	*0.554859*	*-1.85289*	*-1.12314*	*-0.14841*
sd	*1.783283*		*3.996167*	*3.064914*	*2.807317*	*1.927482*	*1.935122*	*2.216052*
1948-2000								
mean	*0.038245*	*0.021935*	*0.153166*	*-1.55441*	*-2.30179*	*-0.75077*		*-0.08632*
sd	*3.860647*	*0.260755*	*2.010349*	*8.667584*	*31.47605*	*2.343213*		*1.120368*
1948-1970								
mean	*0.137328*	*0.064747*	*0.280318*	*-1.55441*	*-2.30179*	*-0.75077*		*-0.1759*
sd	*6.268709*	*0.309609*	*2.877157*	*8.667584*	*31.47605*	*2.343213*		*1.672397*
1970-2000								
mean	*-0.02449*	*0.001267*	*-0.01519*					*-0.02433*
sd	*0.291131*	*0.233028*	*0.459053*					*0.189174*
1970-1980								
mean	*-0.03281*	*0.036619*	*-0.05477*					*-0.01699*
sd	*0.305296*	*0.171906*	*0.654712*					*0.218123*
1980-1990								
mean	*0.019654*	*0.010679*	*0.179367*					*0.04059*
sd	*0.324001*	*0.311346*	*0.371452*					*0.165079*
1990-2000								
mean	*-0.0331*	*-0.04334*	*-0.00831*					*-0.05725*
sd	*0.262582*	*0.160829*	*0.148537*					*0.20252*

TABLE 12

Descriptive statistics for logs of real dividends in the US PC industry

Firm	*Market*	*Sample*	*selected by*	*reference test*	*Test stat.*	*95% crit. value*	*Process*
Apple	US	1989-1996	SBC	DF+drift+t	0.856	-4.196	I(1)
Hewlett-Pack	US	1979-2000	SBC	DF+drift+t	-2.016	-3.633	I(1)
IBM	US	1979-2000	SBC	ADF1+drift+t	-2.54	-3.633	I(1)
NCR	US	1979-1991	SBC	DF+drift+t	-4.571	-3.828	I(0)
Unisys	US	1979-1990	SBC	DF+drift+t	-1.304	-3.873	I(1)
Wang	US	1979-1989	SBC	DF+drift	-2.876	-3.18	I(1)
Wyse	US	1979-2000	-	-	-	-	-

DF-ADF tests for E/S by firm

Apple	US	1980-2000	SBC	ADF(1)+drift	-3.498	-3.011	I(0)
Hewlett-Pack	US	1979-2000	SBC	DF+drift	1.905	-3.004	I(1)
IBM	US	1979-2000	SBC	ADF(1)+drift	-2.195	-3.004	I(1)
NCR	US	1979-2000	SBC	ADF(1)+drift+t	-2.505	-3.633	I(1)
Unisys	US	1979-2000	SBC	DF+drift	-3.618	-3.004	I(0)
Commodore	US	1979-1993	SBC	ADF(1)+drift	-2.46	-3.082	I(1)
Compaq	US	1983-2000	SBC	DF+drift	-4.611	-3.04	I(0)
Dell	US	1987-2000	SBC	DF+drift+t	0.815	-3.792	I(1)
Gateway	US	1992-2000	SBC	ADF(1)+drift+t	-4.993	-4.081	I(0)
Toshiba	US	1979-2000	SBC	DF+drift	-3.354	-3.004	I(0)
Wang	US	1979-1998	SBC	DF+drift+t	-2.613	-3.659	I(1)
Wyse	US	1983-1988	SBC	DF+drift	-1.696	-3.551	I(1)

TABLE 13

Descriptive statistics of dividends (logs of differences) in the US PC Industry

						dividends divided by the S&P 500 dividend			
		1970-00	**1970-80**	**1980-90**	**1990-00**	***1970-00***	***1970-80***	***1980-90***	***1990-00***
apple	st. dev	0.263737		0.20787	0.233295	*0.2505*		*0.2272*	*0.1972*
	mean	0		0.18809	-0.074697	*0.0279*		*0.2286*	*-0.0531*
compaq	st. dev	0.367919			0.367919	*0.3147*			*0.3147*
	mean	0.376664			0.376664	*0.3283*			*0.3283*
hpackard	st. dev	0.078744	0.05656	0.101334	0.040454	*0.1401*	*0.1227*	*0.1166*	*0.0387*
	mean	0.066423	0.08854	0.033962	0.085194	*0.1460*	*0.3103*	*0.0926*	*0.0886*
ibm	st. dev	0.116946	0.03359	0.017298	0.177071	*0.1255*	*0.0739*	*0.0193*	*0.1613*
	mean	0.008652	0.06962	0.013481	-0.040089	*0.0299*	*0.1375*	*0.0149*	*-0.0338*
nec	st. dev	0.159784	0.03196	0.232574	0.056952	*0.2020*	*0.0883*	*0.2796*	*0.0488*
	mean	-0.003193	0.05077	-0.017321	-0.00702	*0.0436*	*0.1812*	*0.0198*	*0.0107*
toshiba	st. dev	0.080092	0.08009			*0.1226*	*0.1226*		
	mean	0.047025	0.04702			*0.0756*	*0.0756*		
unisys	st. dev	0.125461	0.11623	0.09945		*0.1868*	*0.1933*	*0.0975*	
	mean	0.03501	0.11917	-0.013284		*0.0833*	*0.2308*	*-0.0065*	
industry	st. dev	0.1107	0.0663	0.0364	0.1689	*0.1161*	*0.1024*	*0.0425*	*0.1524*
	mean	0.0091	0.0567	0.0138	-0.0410	*0.0042*	*0.0663*	*-0.0096*	*-0.0443*

TABLE 14

	MS ins	units	stock price	dividend	*div S&P* ***stock price***	*div S&P* ***dividend***
AUTOS						
1918-1928	**22.609**	**0.1569**	**0.1458**	**0.3234**	***0.1257***	*1.3520*
1918-1941	17.858	0.15	0.1393	0.2608	*0.1089*	***2.2161***
1948-2000	7.641	0.0638	0.0791	0.1668	*0.0352*	*0.9974*
1948-1970	10.293	0.0759	0.0671	0.1663	*0.0372*	*1.5054*
1970-2000	5.603	0.0523	0.0881	0.1694	*0.0335*	*0.1772*
PC						
1970-1980	1.35	**0.2062**	0.0708	0.0663	*0.0877*	*0.1024*
1980-1990	11.51	0.1884	0.0662	0.0364	*0.1476*	*0.0425*
1990-2000	**17.86**	0.0357	**0.1196**	**0.1689**	***0.2635***	***0.1524***
1970-2000	28.93	0.1758	0.0905	0.1107	*0.1915*	*0.1161*

bold number=highest value

italics=divided by S&P 500 equivalent

ms ins=average market share instability index

units=standard deviation of growth rate of units

stock price=standard deviation of growth rate of stock price

dividend=standard deviation of growth rate of dividends

TABLE 15

Regression in the levels of the variables and residuals cointegration tests (Auto industry)

Dep var.	*Sample*	*Intercept*	*MKT return*	*trend*	*S.E. of R.*	*CRADF*	*CRADF order*	95% crit. val	*Res. DGP*
IND return	1919-98	1.5801	0.0911	-0.00462	0.18933	-3.7088	3	-3.9092	I(1)
IND return	1919-41	0.7936	1.4532	-0.02531	0.20778	-2.2102	4	-4.3508	I(1)
IND return	1948-98	0.9266	0.9722	-0.01419	0.08935	-2.8878	0	-4.0542	I(1)
IND return	1956-98	0.9216	0.4039	-0.00314	0.06811	-4.1512	1	-4.1366	I(0)
IND return	1956-98	0.9544	0.2229	-	0.06843	-4.5819	1	-3.5622	I(0)

Error-Correction Model representation for the cointegration regression (Auto industry)

		Coefficients:			Diagnostics:					
Dep var.	*Sample*	*Intercept*	*dMKT return*	*res(-1)*	*Rbar-sq*	*F-stat*	*D-W*	*LMA*	*LMN*	*LMO*
dIND return	1957-98	-0.0053	0.5764	-0.60253						
	t-value	*-0.5068*	*3.8931*	*-3.8375*	*0.5179*	*17.656*	*1.6162*	*3.279*	*0.2016*	*1.9232*

Note:
DW = Durbin-Watson statistic for first-order autocorrelation
LMA = Lagrange Multipliers test for Autocorrelation
LMN = Lagrange Multipliers test for Normality
LMO = Lagrange Multipliers test for Homoskedasticity

TABLE 16

Regression in the levels of the variables and residuals cointegration tests (PC industry)

Dep var.	*Sample*	*Intercept*	*MKT return*	*trend*	*S.E. of R.*	*CRADF*	*CRADF order*	95% crit. val	*Res. DGP*
IND return	1974-99	1.4021	0.11229	-	0.11609	-2.2162	0	-3.6421	I(1)

Note:
S.E. of R. = Standard Error of Regression
CRADF = Cointegration Rank Augmented Dickey-Fuller (critical values from McKinnon)
CRADF order = number of lagged dep variables in the auxiliary regression selected on the base of AIC
Residual DGP = Data Generating Process for residuals
t-values, F-stats and R-bar statistics are not reported because spurious for the presence of all I(1) variables in the regressions in levels

TABLE 17

Auto industry 1927-1951

Restricted SURE estimates (ML estimates for the Fixed Effect Panel)

Homogeneity restrictions for all the coefficients (variables in logs of first differences)

	int	StPrSP500	Div	Div SP500	MktSh	Nfirms	Herf
Chrysler	0.097211	-	-	-	-	-	-
t-value	1.802						
Gen. Motors	0.029421	-	-	-	-	-	-
t-value	0.36932						
Studebaker	0.092913	-	-	-	-	-	-
t-value	0.34865						
Hudson	-0.012132	-	-	-	-	-	-
t-value	-0.13587						
Packard	-0.048739	-	-	-	-	-	-
t-value	-0.11418						
FE Panel	0.0317348	1.1901	0.22154	-0.75814	1.6945	0.10523	-2.5164
t-value	0.453984	*6.7143*	*7.8966*	*-3.5449*	*4.3548*	*0.29019*	*-8.4993*
Wald-test for Homog restr (1)		1.28E+11					
Wald-test for Homog restr (2)		31.7782	8.01E+10	105.6889	2.28E+09	165.1449	3.53E+01
ML	-23.3301						
SBC	-38.2243						

Note: Wald Homogeneity restriction test (1): Homogeneity restrictions (equality) for the firm-level coefficients of all the regressors

Note: Wald Homogeneity restriction test (2): Homogeneity restrictions (equality) for the firm-level coefficients of the single variables

TABLE 18

Auto industry 1957-1997

Restricted SURE estimates (ML estimate for the Fixed Effect Panel)

Homogeneity restrictions for all the coefficients (variables in logs of first differences)

	int	StPrSP500	Div	Div SP500	MktSh	Nfirms	Herf
Chrysler	-0.071372	-	-	-	-	-	-
t-value	-1.406						
Gen.Motors	-0.042365	-	-	-	-	-	-
t-value	-1.316						
Ford	-0.063612	-	-	-	-	-	-
t-value	-1.8497						
FE Panel	-0.05911633	0.94722	0.061502	0.0043001	0.50341	0.11348	*0.26794*
t-value	-1.5239	*5.0049*	*2.2092*	*0.18261*	*0.70544*	*0.2642*	*0.75981*
Wald-test for Homog restr (1)		11,5370**					
Wald-test for Homog restr (2)		0,70006**	4,9081*	2,6299**	1,4789**	0,21925**	2,3759**
ML	7.7857						
SBC	-8.9254						

Note: Wald Homogeneity restriction test (1): Homogeneity restrictions (equality) for the firm-level coefficients of all the regressors

Note: Wald Homogeneity restriction test (2): Homogeneity restrictions (equality) for the firm-level coefficients of the single variables

TABLE 19

PC industry 1975-2000)

Restricted SURE estimates (ML estimate for the Fixed Effect Panel)

Homogeneity restrictions for all the coefficients (variables in logs of first differences)

	int	StPrSP500	StPrIND	dldivIND	Pr/Earn	MktSh	Nfirms	Herf
Apple	0.050832	-	-	-	-	-	-	-
t-value	*0.48397*							
H-P	0.062499	-	-	-	-	-	-	-
t-value	*1.0608*							
IBM	0.032559	-	-	-	-	-	-	-
t-value	*0.58648*							
NCR	0.10719	-	-	-	-	-	-	-
t-value	*1.7181*							
Unysis	-0.018619	-	-	-	-	-	-	-
t-value	*-0.13622*							
Panel	0.0468922	-0.36311	0.66459	-0.25689	0.063212	-0.083297	1.0726	-0.143
t-value	*0.742626*	*-1.963*	*7.091*	*-4.0585*	*2.3336*	*-1.8048*	*1.1707*	*-2.0388*
Wald-test for Homog restr (1)		1.73E+10						
Wald-test for Homog restr (2)		8,3355*	362.8003	10.7475	142.7652	170.9432	1.73E+10	9.9136
ML	-9.1565							
SBC	-26.4987							

Note: Wald Homogeneity restriction test (1): Homogeneity restrictions (equality) for the firm-level coefficients of all the regressors

Note: Wald Homogeneity restriction test (2): Homogeneity restrictions (equality) for the firm-level coefficients of the single variables