

Information Technology and the Dynamics of Firm and Industrial Structure: The British IT Consulting Industry as a Contemporary Specimen

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The internet is often anticipated to have disruptive competitive impacts, causing upstart firms to overthrow incumbent market leaders. This paper uses the UK IT consulting industry as a test case to see whether such competitive impacts of the internet might already be occurring. Comparable possible impacts of the introduction of personal computers are also considered. Findings regarding the entry, exit, growth, and technology-related areas of business for new entrants and incumbents over a period of three decades suggest that the internet did not have such a radical effect on market structure by the year 2000.

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Recent discussion about impacts of the internet on business suggests radical benefits of early entry into pioneering new electronic markets. Firms that lag in adoption of internet sales and services may be left behind, as competitors take over the electronic markets and non-electronic markets contract. Traditional market leaders could lose out, after failing to build up the relevant electronic expertise and customer networks.

These ideas about potential impacts of the internet on industry competition echo a recent academic literature on how the leading firms in an industry can lose their positions to new entrants and small firms. Christensen (1997), for example, uses hard-disk manufacturers and other companies to illustrate how incumbent firms often succumb to competition by innovative entrants. He argues that businesses must be continually wary, ready to grasp enabling new technologies or lose ground in the fierce competition that follows radical technological change. Similarly, a succession of authors before him have analyzed why incumbent firms fail to respond adequately to major new technologies, and hinted at strategies for entrants and incumbents in the face of potential technological revolution.

If the internet is to have such revolutionary impacts, might any of those impacts be visible already? This paper uses a service industry with high computer and internet usage to check for possible impacts of new IT on firm and industry structure. The industry analyzed is computer consultancies in the United Kingdom. The evidence indicates that the rise of the internet has not substantially increased exit or market leadership turnover among UK computer consultancies. This finding is counter to the notion that the internet is (so far) causing a shift in firm survival patterns to benefit

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innovative new firms. Although new firms have been more likely to do business involving networking and the internet, entrants with these types of business have not been systematically more likely to survive and grow. Thus, at least in one IT-intensive service industry, the internet appears not yet to have had the sort of competitive impacts predicted for radical new innovations.

Radical Technological Change and Competition

Notwithstanding many early, highly aggregated studies to the contrary, computerization is yielding enormous productivity gains for firms. In 1999, US firms invested some \$510 billion in IT equipment and software, with upstream information technology-producing industries contributing about 8% of price-weighted US economic output for the year (US Department of Commerce, 2000). Indeed, firms' total investment in information technology may be as much as ten times higher (Brynjolfsson and Yang, 1997) when considerable co-investments in IT are considered. Relevant co-investments range from physical equipment to be used in conjunction with computers to training, organizational restructuring to take fuller advantage of new equipment and software, and managerial innovation to continually improve use of IT equipment and software.² Brynjolfsson and Hitt (2000), in their valuable review of the literature to date on how IT is affecting organizational form and performance, show that macroeconomic measurement problems have been obscuring the contribution of IT to economic growth and even the overall rate of GDP growth. Even before correcting for such major sources of mismeasurement, though, US productivity growth has doubled since 1995, and the increase has commonly been attributed to more and better use of information technologies. The US has taken a lead in information technology and use of the internet, but other countries clearly are also rapidly adopting these computer and communications changes.

Increased use of computing and the advent of the internet can be seen as radical technological changes with corresponding impacts on the industries that depend on these technologies. Technological changes have often been divided into two categories, *disruptive* changes that hamper the competitive abilities of incumbent firms, and *sustaining* changes that reinforce the advantages of incumbents. Disruptive technological changes frequently coincide with turnover in which firms hold the leading market shares, as new entrants take advantage of technologies in ways that incumbents cannot or do not exploit. Sustaining technological changes, in contrast, contribute to an exodus of less-established firms while leading incumbents reinforce their market leadership. The internet and new generations of computers have often been thought to have disruptive effects by creating new electronic markets that may displace existing markets, and by allowing more efficient work practices that are challenging for existing firms to adopt.

² Brynjolfsson and Yang's (1997) estimate of intangible IT investments relies on stock market valuations to assess the intangibles. Skepticism about the reasons for large stock market valuations of IT companies suggests caution in interpreting this figure, although Brynjolfsson and Hitt (2000a, p. 28) point to an empirical survey of resource planning projects that yields an even higher estimate of IT-related intangible investments. Better estimates await additional detailed empirical study.

Corporate Leadership Turnover

Tushman and Anderson (1986) argue that radical technological changes may be opportunities that new firms tend to exploit but to which incumbents tend to respond relatively badly or late.³ They use their point of view, based on implicit notions about the competencies of old and new firms in different technology areas, to draw out implications regarding entry, exit, market share, and other matters. In their view, radical technologies that are inconsistent with past technology are first commercialized largely by new entrants, with incumbents tending to exit after the introduction of the new technology. Consequently, entry and exit would be expected to rise temporarily upon the availability of the new technology, and large incumbent firms would be expected to contract unusually rapidly while small recent entrants would be expected to grow unusually rapidly. A similar view has been apparent in studies of many industries, including Majumdar (1982) and Schnaars (1994).⁴

Contrasting explanations exist as to why incumbent firms have failed to take advantage of the opportunities offered by major technological changes. Majumdar (1982), Tushman and Anderson (1986), and Anderson and Tushman (1990) seem to view the issue in terms of firms' core technological competencies, with firms not possessing the techniques and equipment needed to pursue the new technology unable to make the transition without a very high cost and indeed unable even to perceive the importance of the coming revolution. Henderson and Clark (1990) point to firms' R&D and engineering personnel, the people who deal with the technology most directly, and argue that these employees develop ways of thinking about the technology (both individually and as an organization) that are inconsistent with pertinent innovative approaches. Because of this limiting mindset, they fail to take advantage of the opportunities afforded by the new technological approach. Christensen and Rosenbloom (1995) point to firms' relationships with customers, and argue that incumbent firms tend to maintain their current technological approach because their customers demand products or services that initially can be best provided using the established technology. They fail to pay sufficient attention to the potential profits that could be obtained from new customers using the new technology, and they fail to realize that the new technology eventually may largely replace the old. Any of these reasons, along with others mentioned by Schnaars (1994), could be responsible for the sort of turnover of leading firms described by Tushman and Anderson (1986).

If radical technological changes act as these theories describe to cause market leadership turnover, several consequences should result. These hypothesized consequences provide a means to assess whether, to date, the internet is having large

³ Tushman and Anderson argue that this behavior occurs only for major technological changes that are at odds with previous approaches, not for changes that involve the existing technological approaches in a more efficient or effective way. The changes considered in this study, the use of personal computers and the advent of the internet as a medium for communication, appear in many ways to be radically different from the approaches previously in use, and have been labeled widely as discontinuities, thus fitting with the characterization given in the text for Tushman and Anderson's approach.

⁴ Audretsch (1991) promotes a related view in which he divides industries into two categories, ones with "routinized" and "entrepreneurial" technological regimes. In industries with routinized regimes, established firms have an advantage in R&D, whereas in industries with entrepreneurial regimes, new firms have the advantage in performing and implementing innovations, and these differences affect firm survival rates.

disruptive technological effects. The following competitive impacts would be expected in industries that begin to make use of the internet:

Consequence 1: Entry of new firms will increase following the technological change.

Consequence 2: The aggregate exit rate of firms will increase following the technological change.

Consequence 3: The exit rate of new firms will fall, and the exit rate of incumbent firms rise, following the technological change. The growth rate of new firms will rise, but the growth rate of incumbent firms fall, following the technological change.

Consequence 4: A greater percentage of new firms than old firms will use the disruptive technology.

Consequence 5: Firms using the disruptive technology will, *ceteris paribus*, have higher growth rates and lower exit rates than firms not using the disruptive technology.

These consequences are natural implications of a disruptive technology. Firms seek to take advantage of profit opportunities created by the new technology, causing more annual entry for a period following the advent of the new technology. Once new firms enter, they intensify market competition, eventually even overthrowing many or all of the incumbent market leaders. Hence the exit rate of all firms rises, at least eventually. The new firms, with the highest propensity to use the new technology, have a competitive advantage. Thus new firms have a higher growth rate and a lower exit rate relative to other eras, while incumbents disadvantaged by their outdated technology have relatively low growth and high exit. Technology, not newness, is the source of advantage, so these growth and exit consequences pertain to indicators of technology use as well as to newness. Consequences 2-5 above are similar to hypotheses 2, 5, and 7 of Tushman and Anderson (1986).

Reinforcing R&D and Exodus of the Weak

A contrasting competitive pattern would result from reinforcing technology. For example, Jovanovic and MacDonald (1994) argue that exogenous radical technological changes may lead to a drop-off in the number of producers in an industry, with incumbent firms benefiting from an early-entry advantage. Klepper (1996) proposes a related model, involving large numbers of ongoing technological changes, in which some early market entrants grow large and dominate the market in the long run through their dominance of R&D. That such *sustaining* technological changes are extremely important in many major industries is evidenced by a series of studies by Klepper and Simons (cf. 1997, 2000). These studies show that the common pattern of steady decline in number of companies in an industry, and eventual market concentration, is associated with lasting competitive advantage among a few early entrants that grow large. Moreover, the studies indicate that (at least in many industries) the leading firms dominate the R&D process for *sustaining* technologies, and their R&D success is directly associated with greatly enhanced growth and likelihood of survival. With reinforcing technology, exit rather

than entry would follow the technological change, and incumbents rather than entrants would tend to adopt the new technology and hence benefit from enhanced growth and survival rates.

Technology and Regional Industry Growth

Technology-driven industries, especially IT industries, are the hoped-for spur of economic growth in many lower-income countries. If the internet or computerization are disruptive radical technologies, they can be used to advantage – even in lower-income countries where IT infrastructure may not be well-established – to aid in the growth of IT-generating or IT-using industries. National and corporate policies might be adapted according to the effects of these technological changes.

Successes in several Asian economies have shown that developing countries can achieve strong IT industries, despite international competition. Growth of indigenous skills and technology has been crucial to these countries' success. In some industries, employee skill is the bottleneck. Good education allowed India's software subcontracting industry to boom, raising salaries for Indian citizens with strong technical education. In other industries, technological strengths are important. Semiconductor fabrication and packing, computer components, assembled computers, and pre-packaged software all have demanded to varying degrees the growth of large knowledge bases pertinent to specific industries. How are the relevant employee skills and technologies best acquired?

Technology development models for developing countries have fallen into two broad classes: linear versus leapfrog views. The successful linear approach is illustrated by the experience of Korea's Anam Industrial, the world's largest semiconductor packaging company. As Hobday (1995) characterizes based on interviews with senior staff, Anam went through successive phases of linear technology growth. Anam began packaging computer chips into plastic and ceramic cases in 1968-1980 with considerable help from US clients, which provided machinery, engineering assistance, product design information, and materials. By 1980-1985, the firm set up greater in-house process engineering, again aided by US companies such as Texas Instruments. With its new Engineering R&D Department, in the late 1980s into the 1990s Anam increasingly took charge of incremental process engineering and began to develop its own new approaches for production processes and designs for semiconductor packages. The gradual technology diffusion into Anam, followed by steady growth in in-house engineering capabilities, helped Anam to reach US \$1.8 billion of export sales by 1992.

The successful leapfrogging approach, in contrast, promises to allow firms rapidly to become internationally competitive. The chief designer of an internationally successful Chinese language printing system, developed by Founder of China, put it this way:

In high-tech areas, there are big lags between our country and advanced countries. Many new ideas and methods originate abroad.... However, we should not be satisfied with merely catching up because this would not come up with competitive products. It was inevitable that we would catch up for quite a long time. However, it was possible to leap forward based on our indigenous innovative capabilities. (Quoted in Lu, 2000, p. 132)

Founder succeeded at leapfrogging. If it had caught up more slowly, Founder likely would have failed, or at least been constrained by lack of funds, in the face of intense competition versus firms from the US, UK, and Japan. Founder was able to succeed at

leapfrogging because an opportunity existed for a disruptive new technology with sizeable potential market demand, and because it entered quickly and developed the leading-edge technology in the field.

Whether linear or leapfrog approaches can best succeed depends on the industry in question and the kinds of technological change ongoing. Where ongoing technological changes reinforce the strengths of incumbent firms, the leapfrog approach typically would require a daunting effort far too expensive to be worthwhile. Instead, market niches are often available to make a profit in some part of the industry, perhaps aided by low labor costs, national incentive schemes, or advantageous geography. Catching-up firms in lower-income countries may become loci of technology transfer, spurring growth as for Anam Industrial. Where ongoing technological changes are disruptive or create entirely novel markets, opportunities exist for firms to take a lead in pioneering new technologies. In lower-income countries, pockets of specialized knowledge and skill may provide the crucial head start to succeed at developing an internationally competitive version of the new technology. Founder, for example, benefited from early university research as well as unusual access to talented engineering graduate students at China's leading university. Financial investments for new firm development, when directed according to these principles, need not be large and can be arranged in ad-hoc ways so long as the firm retains the right incentives and freedoms.

Given claims about the radical impacts of the internet, one might expect that it will provide many opportunities for disruptive technological change in which clever firms might be able establish new markets or even take over leadership in important new markets. Thus, the internet might be expected to provide a variety of unusual opportunities that could be harnessed by firms in lower-income nations, spurring economic growth in the nations to which they belong. Whether the internet in fact has such impacts remains to be seen. This study therefore turns next to an examination of one particular industry in which any early competitive impacts of the internet might already be apparent.

IT Consultants in the United Kingdom

If computers and electronic communications really are radical technologies causing radical change in firm and industrial structure, and if they are already having an effect, how can these changes be detected? One can search for regularities associated with disruptive radical change, including increased entry and exit and a relative increase in growth of recent entrants versus incumbents. Given that most industries have so far experienced few impacts of the internet, it is desirable to choose a kind of industry in which usage of the internet – and potential impacts on work organization – are unusually high. The industry studied here is UK computer consulting, whose professionals make much use of the internet (even as a business market) and for which there is an extensive historical data source.

The computer consulting industry may be a better window on possible industry trends associated with computing and the internet than almost any other single industry. It is a service industry, and hence represents the majority (and much less studied relative to manufacturing) services component of the global economy. The service industries perhaps more than any others can take advantage of the IT revolution, because they tend to be less limited by physical production methods than manufacturing, resource

extraction, or agriculture. Computer consultants are among the leading adopters of computer equipment and novel work practices that work well with IT and communications technologies, and hence they may reflect impacts of IT, networking, and the internet earlier than firms in other industries.

Data

This study relies on data compiled in VNU Business Publications' (1969-2001) annual industry directory, *The Computer User's Year Book*. The *Year Book* has tracked British computer consultants since its inception.⁵ The *Year Book* made no claims to be complete, although it appears to have included a large percentage of firms in the industry. In addition to listing the firms involved, it provided detailed information on, among other matters, each firm's number of employees, its fees per day of work, and the types of applications with which it deals. The annual lists reported in this directory were matched to determine for each firm the years in which it was listed in the directory. Names and addresses of firms, among other information, were used to ensure that longitudinal records were (to a large degree) properly matched over time. Multiple branches of a firm were treated as a single entity, not as individual establishments.

The *Year Book* did not differentiate between consultancies and software houses in 1969 and 1970, nor did it indicate firms' numbers of employees or prices in those years. Therefore data are used from the 1971 edition onward. The 1984 edition of the directory could not be obtained, and entry and exit rates presented are corrected by dividing entrants equally across 1984 and 1985 and by dividing exits after the 1983 edition over the two years following 1983. The *Year Book* was generally compiled and published during the year preceding the date on its cover, yielding a time span of 1970-2000 excluding 1983. Circa the 1989 edition, the *Year Book* removed some types of software houses from the definition of consultants included in its lists, and added other types of consultancies, resulting in a structural break in the types of firms and services included. To lessen the impacts of this break, the (relatively few) firms that are indicated as having been software houses but that did not perform other types of consultancy have been excluded from analyses. The definition of consultancies included in the data has also broadened by a lesser degree at other points in time. Dates referred to hereafter pertain to the year of publication, just preceding the date on the cover of each *Year Book*.

International consultancies make up a small percentage of firms in the sample. Only firms with one or more branches in the United Kingdom have been retained in the data. The *Year Book* does not report market shares, but its figures on number of employees, available for most firms, provide information on the size distribution of companies. In 2000 the top ten full-time employers had 3260, 3000, 2500, 2000, 1500, 1000, 900, 900, 800, and 700 full-time employees respectively. This constitutes 40% of reported full-time employees in that year. The top ten in 2000 were all multinationals, six of them UK-originated. The bulk of the sample in contrast consists of small businesses. The mean and median numbers of full-time employees per firm in 2000 were only 29 and 5 respectively. It is such smaller, almost all UK-only, firms that have the largest effect in most analyses of the data.

⁵ Since Britain is one of the nations leading in adoption of IT technologies, it may serve as a model for the experiences that similar industries may follow in other countries.

The number of firms included in the analysis totals 7,332. The sample begins with 84 firms in 1970, and the number rapidly rises to much larger counts: 285 in 1975, 508 in 1977, 731 in 1979, and 1068 in 1981. Thereafter the number of firms remains roughly stable through 1985, and falls to 919 in 1986 and 879 in 1987. The number then rises suddenly given the break in the definition of firms listed in the *Year Book*. In 1988, 1515 firms are included, and the number thereafter rises and falls irregularly. By 1993, 1933 firms are included; the number falls to 1594 in 1998 and then jumps to 1902 in 1999 and falls again to 1677 in 2000. It is possible that these changes in sample sizes reflect industry trends, but the sample sizes may also reflect periodic shifts in data collection practices used to compile the *Year Book*.

Additional data used are time series of the number of internet hosts and UK annual percentage growth in GDP. The number of internet hosts is a measure of the size of the internet and is taken from the Domain Survey of the Internet Software Consortium.⁶ Internet host figures have been interpolated where necessary to pertain to July of each year. UK GDP growth statistics are based on the UK National Statistics Office dataset gvao: "Gross Domestic Product by Gross Value Added, 1948-2001," series YBEZ for all industries and series GDQS for all service industries. Percentage growth in the reported real values has been computed relative to the preceding year. Dummy variables are constructed for time periods of exogenous radical innovation equal to 1 in 1983-87 following the introduction of personal computers, or 1 in 1995-2000 for the rise of the internet, and 0 at all other times. The latter period coincides with the time when the number of internet hosts surpassed ten million.

Interactions between Entry, Growth, and Exit

Hypotheses relating radical IT changes to entry, exit, growth, and optimal firm size can be analyzed using the following three-equation model:

$$E_t = f(p_t, T_t) + \varepsilon_t \quad (1)$$

$$\frac{dS_{it} / dt}{S_{it}} = g(p_t, S_{it}, T_t) + \gamma_{it} \quad (2)$$

$$\text{Prob}(X_{it}) = h(S_{it}, T_t) \quad (3)$$

Equation (1) concerns the number of entrants E_t at each time t . Entry is a function of the industry mean price p_t , which serves as a measure of profit opportunity, and of recent exogenous technological change T_t , which equals 1 for a period after a major technological change and 0 at all other times. The random term ε_t allows for random variation in E_t , which for statistical analyses will be assumed to follow a negative binomial distribution. Equation (2) concerns the percentage growth rate in the size S_{it} of firm i at time t . Each firm's growth rate is assumed to be a function of p_t , T_t , and S_{it} . For statistical analyses, a normally-distributed random term γ_{it} is also included. Equation (3) concerns the probability of exit X_{it} by firm i at time t , where $X_{it} = 1$ if the firm exits and 0 otherwise. The exit probability is a function of the firm's size and of recent exogenous

⁶ <http://www.isc.org/>

technological change. For statistical analyses, exit will be modeled using a logistic model.⁷

Price depends on industry-wide output Q_t , which depends in turn on the production of individual firms: $p_t = D_t^{-1}(Q_t)$, $Q_t = \sum q_{it}(S_{it})$, where $D_t^{-1}(\cdot)$ is the inverse demand function at time t and $q_{it}(\cdot)$ is a production function that may vary across firms and time. Price and firm sizes are observed, but not industry-wide output, so the relationship between p_t and Q_t will not be analyzed statistically. Similarly, unmeasured changes in labor supply and hence in wages also affect the price charged by firms.

Statistical analyses used to supplement the analysis are carried out separately for the time periods before and after the structural change in the data. Analyses of entry exclude the year 1988, for which entry may result from change in the types of firms included. Analyses of exit exclude the year 1987, since firms that survived in 1987 might have been removed from the list in 1988 due to changes in classification. Analyses of growth likewise exclude comparisons between years before 1988 and later years.

Testing for Effects of Radical Technological Change

The theories about impacts of radical technological change, discussed in the previous section, yield widely contrasting implications for what should happen to entry, and exit following the technological change. For the computer consultancy industry, while several exogenous technological changes might be identified *a priori* as having potential effects on competition, the intent of this paper is to search for outstanding effects of IT on competition in ways that might also affect other industries. The primary focus here is therefore the advent of the internet. The rise in use of computer networks also may have yielded new competitive rules, particularly with the inception and growing use of the internet around 1992-94. In addition, the advent of personal computers has been implicated for market leadership shifts in the computer and hard disk drive industries (Tushman and Anderson, 1986; Christensen and Rosenbloom, 1995) and is sometimes suggested to have affected service industries, so the advent of personal computers in 1981 and 1982 will also be considered as a radical technological change.

The theories make specific predictions about entry and exit patterns following the time of the innovation relative to earlier years. And they yield contrasting predictions about the ability of new entrants to capture market share from incumbents, and hence the growth rates of small new entrants and small upstart firms versus incumbents, after the innovation.

Price Levels

Before examining possible effects of radical technological change on entry, exit, and growth, it is important to understand any possible confounding effects of shifting demand and labor supply. As demand increases or labor supply falls, the price charged by firms should rise. Sufficient price rise could encourage entry into the industry, spur firm growth, and reduce exit. The price level is thus the way in which demand and labor supply changes might affect entry, growth, and exit.

⁷ The three equations used here should not be confused with a simultaneous equation econometric system; they form a dynamic system of three equations that can be estimated independently.

To analyze price levels in the industry, the fees charged by firms per day of consultancy services were recorded periodically from the *Year Book*.⁸ Except in the early years of the *Year Book*, a majority of firms reported fees specifically for consultancy services, with 58% of firms reporting this information by 1976, 58% in 2000, and slightly higher percentages for most years in the interim.⁹ Relatively little information is available in 1988, when the *Year Book* was reorganized. Most firms gave a range of list prices rather than a single number, and in these cases the minimum list price is used. Maximum price levels were not used because they often went unreported (with firms instead using an open-ended price scale such as “from £300 per day”), and because the maximum figures may be less reliable in that they pertain to specialized employees or wishful thinking. Table 1 reports median and mean fees charged per day of consulting work using the minimum list prices of firms in the sample. The figures are not weighted according to size of firm, because the available size figures are not always reliable for the sample’s very large firms which would have the greatest influence on size-weighted means. Prices are discounted into 2000 £ using the Office for National Statistics’ retail prices index (dataset ST30611). The number of firms for which figures are available in each year, and the percentage of the sample composed by these firms, are indicated in the last two columns of Table 1. The figures presented in Table 1 appear to give a reliable assessment of trends in consultancy fees over the period 1970-2000. Comparisons may not be reliable between years up to 1987 versus 1988 onward, given the structural break in the data.

TABLE 1 ABOUT HERE.

Both the median and mean price levels show surprisingly little change in prices over time. The median price varied by only 22% of its maximum during the years 1970-85 and 19% during 1987-2000, and the mean price by only 17% and 14% respectively during the same two periods. Judging from both price indicators, real fees fell 17% from 1970 to 1974, rose 28% / 13% (median / mean) by 1980, then fell slightly by 1982 and rose again by 1985. The rise of PC usage thus coincides with a period when IT consultancy prices increased slightly, similar to the ups and downs seen in earlier prices. The median and mean prices show substantial increases in 1987, although it is difficult to know whether this comes from an actual price increase or from the *Year Book*’s reorganization of the data.

From 1988 through 2000, the price of IT consultancy remained nearly constant. The median price rose from 1988 to 1989, and then both median and mean prices decreased through 1991 before rising somewhat through 1995. Thereafter prices remained roughly constant through 2000, with the biggest variation in the data being a

⁸ Fees were collected at two-year intervals from 1970 through 1984, and then in 1985 and 1987 because the *Year Book* did not list fees for 1986. With the reorganization of the *Year Book* for 1988, data in both 1988 and 1989 were recorded given the low frequency of reporting in 1988, and thereafter data were collected at two-year intervals through 1999, and data for 2000 were added following publication. Two-yearly intervals were used to reduce data collection expenses.

⁹ In a few cases, fees were reported per hour, week, or month, and fees per day were computed assuming 8 working hours per day, 5 working days per week, or 20 working days per month. The few instances where fees were reported in non-British currencies were excluded from price calculations.

small temporary dip in the median price around 1997. The rise of internet usage in the late 1990s thus coincides with a period of fairly constant price.

The quite small changes in price suggest that shifts in demand and labor availability had little effect on competition among IT consultancies, simply because the shifts were minor. Moreover, comparisons will be made between firms that are smaller or larger, younger or older, and participants or non-participants in an area of business. To whatever extent demand and labor supply shifts affected entry, growth, and exit, only shifts that differentially affect these types of firms could influence the patterns studied below. Therefore, perhaps surprisingly, the forces of demand growth and skilled labor growth seem in net to have little effect on the competitive issues examined below.

Entry, Exit and Growth of IT Consultancies

Do entry and exit patterns coincide with the theories about disruptive technological change? Consider first entry, which should increase following the technological change as stated in Consequence 1 of the theories. Figure 1 plots the number of new IT consultancies included in the data in each year from 1970 to 2000 excluding 1988. The number of entrants remained low until the mid-1970s, averaging 39 firms per year in 1970-74, climbing to 149 firms per year in 1975-78, then rising to 185 firms in 1979, 293 in 1980, and 324 in 1981. After this time, and coincident with the advent of personal computers, annual entry fell back to an average of 159 firms per year in 1982-87. The number of entrants was rising somewhat in 1985 and 1987, consistent with a possible delayed impact of personal computers on entry. With the reorganization of the *Year Book's* listings for 1988, 842 new firms were included. Over the next five-year period, 1989-93, entry averaged 400 firms per year. The rise of the internet in general did not correspond to a rise in entry, although there is some sign of a rise in entry in 2000. In 1994 the number of entrants had fallen to 230, and although the number rose to 541 in 1995, it fall back again to an average of 215 in 1996-1999. Only in 2000 is there some sign of a rise in entry, with 265 new firms.

FIGURE 1 ABOUT HERE.

The data reveal little sign of increased entry following the introductions of the personal computer and the internet. Averaging over the years after these technological events, there is actually less entry than in the preceding years. The only sign of any increase in entry comes at the end of each of the two periods, but the rise in entry at these times is well within the range of typical fluctuations. Indeed, negative binomial regressions of entry on dummy variables for the radical innovation time periods yield insignificant effects of the radical innovations, and in fact a negative estimated effect of the internet on entry.¹⁰ When GDP growth is controlled, the regressions do yield a

¹⁰ As noted earlier, negative binomial regressions were estimated for entry data before versus after 1988, using as periods of radical innovation 1983-87 for the introduction of personal computers and 1995-2000 for the rise of the internet. Results pertaining to GDP growth are the same regardless whether growth is measured for all industries or for services, and GDP growth has a negative estimated coefficient (significant in the earlier time period). The negative binomial model fits significantly better than a Poisson model (which yields a significant positive coefficient for personal computers but a significant negative coefficient for the internet). Using the number of internet hosts in year t in place of the internet time period dummy yields a significant negative estimated relation between the rise of the internet and entry. The

positive and significant estimated association between the personal computer innovation dummy and entry, but a negative estimated association between the internet innovation dummy and entry. (Controlling for the interpolated mean real price of consultancy services, one reaches the same conclusions.) Thus there is mixed evidence that the personal computer might have yielded increased entry of UK IT consultancies in the 1980s, but the rise of the internet so far appears to have led to little if any increase in entry of IT consultancies.

Consider next the exit rate. As indicated in Consequence 2, the theories suggest that a rise in firms' exit rate will follow a disruptive technological change. As indicated in Consequence 3, the theories also have consequences for the relative success of incumbents versus new entrants. First, corporate leadership turnover driven by disruptive technology implies a rise in the probability of exit of incumbent market leaders relative to small and new firms. Second, it implies a decrease in the rate of growth of incumbent market leaders relative to new firms.

The annual percentage of IT firms that appear in a given year's register but exit permanently by the next year is shown by the solid curve in Figure 2. The exit rate was moderately high initially, fell throughout the 1970s, rose to an average of 17.2% in 1980-81, fell to an average of 9.6% in 1982-83, then rose again to an average of 17.7% in 1984-85 and 23.1% in 1986-87. Thus, no increase in firms' exit rate was apparent in 1982-83 immediately after the advent of the personal computer, but the exit rate rose substantially in 1984 through 1987. In 1988-90, after the reorganization of the *Year Book's* list, the exit rate remained high at 22.4%. In 1991-93 the exit rate averaged 15.0%, and it grew to 22.4% again in 1994 before falling back to an average of 15.1% in 1995-98 and then growing to 36.9% in 1999. The exit rate in 1999 was the highest ever, suggesting a potential very recent effect of the rise of the internet on exit; otherwise recent exit rates in the internet era have been modest. Logistic regressions of exit on the radical innovation variables, regardless of the introduction of pertinent control variables, show a positive and significant relationship between exit and the time of introduction of the PC but a negative and significant relationship between exit and the rise of the internet.¹¹ Thus there is evidence that the rise of the PC was associated with a rise of exit, but the growth of internet usage has coincided with no rise in exit other than the jump in 1999.

FIGURE 2 ABOUT HERE.

mean real fee reported in Table 1 was linearly interpolated to obtain values for all years (the only substantial differences occur when adding the variable to the model using internet hosts, in which case the hosts estimate remains negative but becomes insignificant, and when adding it to the second-period Poisson model, in which case the innovation dummy estimate becomes positive and insignificant.) Hence the findings reported above apparently are robust to alternative specifications.

¹¹ Control variables were introduced for the logarithm of firm total employment, GDP growth (overall and alternatively in services), and the linearly interpolated mean real fee reported in Table 1; none of the combinations of controls considered altered the observed significant relationships. Results for the rise of the internet are the same regardless whether the measure of internet growth is the 1995-2000 dummy or the annual number of internet hosts. Asymptotic Huber-White standard errors computed with clustering by year imply an insignificant relationship between innovation and exit in the latter time period, although still a significant relationship ($p < .05$) in the earlier time period falling to marginal significance ($p < .10$) as controls are introduced.

What about the relative exit and growth rates of incumbents versus new firms? Did the ratio of the exit rate of incumbents to that of recent entrants rise during the 1980s and the late 1990s, as the disruptive technology theories imply following a radical technological change? And did the ratio of the growth rate of incumbents to that of recent entrants decrease during the 1980s and late 1990s, as the theories imply?

If turnover of corporate leadership affected the exit rate as the theories imply at the time of the major technological changes, then the exit rate of incumbents would tend to rise, and/or the exit rate of recent entrants would tend to fall, after the times of the technological changes. These changes would be expected to occur beginning in 1982 following the advent of personal computers, although possibly any effects of PCs on firm survival might have occurred later. If use of the internet has already affected firms' survival, the period from 1995 onward should have had a similar shift in firms' survival.

Figure 2 indicates separately the exit rates of entrants in the four most recent years versus incumbents (earlier entrants). Recent entrants are indicated by the dashed curve with relatively high exit rates, while incumbents are indicated by the dashed curve with relatively low exit rates. The exit rates of recent entrants tend to increase or decrease in tandem with those of incumbents. But in some years the exit rates of the two groups lie far apart, signaling a strong advantage to incumbents, while in other years the exit rates lie close together, signaling a time of high success for recent entrants. The ratio of percentage exit of entrants divided by that of incumbents is indicated by the + symbol; a high ratio indicates a strong disadvantage to recent entrants. The times of high success for recent entrants relative to incumbents, judging by a ratio less than 1.5, are 1976-77, 1984, and 1986-87 before the reorganization of the data in 1988, and 1990-91, 1994, and 1998-99 afterward. This finding appears to be possibly consistent with the disruptive technology theories for personal computers, and consistent with the theories regarding impacts of the internet on competition by 1998-99. Logistic regressions of exit that incorporate age-innovation interactions yield positive and significant estimated effects of both radical innovations on exit, after the introduction of controls, suggesting that the observed patterns are consistent with the disruptive innovation theories for both the PC and internet eras.¹²

Table 2 reports the growth rates of surviving firms over four-year periods. Periods are used beginning in 1974, 1978, 1982, 1988, 1992, and 1996.¹³ Firms' sizes in

¹² Key variables for the age-innovation interactions are the innovation time period dummy (or alternatively the internet hosts variable), the recent entry dummy, and the multiple of these two variables. Control variables were introduced for the logarithm of firm total employment, GDP growth (overall), and the linearly interpolated mean real fee reported in Table 1. Without controls the interaction term is estimated to be statistically significant only in the later period and then only when the internet time period dummy is used rather than the number of internet hosts. The results are sensitive to specification. A random effects logit model yields positive estimates for the interaction variable for both the PC and the internet, but the estimate is statistically significant only for the internet. Using GDP growth in services rather than all sectors also causes the PC interaction estimate to become insignificant. In both periods the estimated relation between innovation and exit loses significance if a pertinent year (e.g. 1986 or 1999) is removed from the analysis and can change sign if a pertinent pair of adjacent years is removed from the analysis, leaving open the possibility that other period-specific events are at work.

¹³ The choice of years is dictated by the two periods of the sample, before the *Year Book's* reorganization in 1988 and in its reorganized form in later years, by the inability to distinguish recent entrants from incumbents circa 1970, and by the lack of information for 1983. The use of 4-year periods helps to remove

the base year and four years later are measured in terms of the number of consultants employed by each firm; firms lacking employment data in either year are excluded. In panel A of the table, mean exponential growth rates are shown in terms of the number of full-time employees, whereas in panel B the number of full-time plus part-time employees is used when measuring growth rates. In each panel of the table, firms are divided into two categories according to whether they entered the sample within the four most recent years. The table also reports standard errors, estimated by bootstrap methods to allow for the non-normality of the data.¹⁴

TABLE 2 ABOUT HERE.

The growth rates of firms in the table appear mainly to have fallen over time. They seem to lie in three distinct periods: high growth in the first four years, medium growth in the next eight years, and low growth after the structural break in the final twelve years. Such a slowdown in growth is normal for a new industry as it evolves over a period of time. The theories predict a possible shift in the relative growth rates of large and small firms in the periods following the advent of personal computers and the internet. The 1982-86 period following the advent of personal computers indeed exhibits a slight increase in the growth rate of recent entrants and a decrease in the growth rate of incumbents. The 1996-2000 period exhibits a substantial increase in the growth rates of both incumbents and recent entrants using full-time employment data, and a less substantial increase using part-time employment data. A measure of how much growth rates of entrants have increased compared to those of incumbents is:

$$\Delta = (r_t^E - r_{t-4}^E) - (r_t^I - r_{t-4}^I) \quad (4)$$

where r_t^E and r_t^I are the mean annual exponential growth rates of entrants and incumbents respectively in the four-year period beginning year t . Consequence 3 of the theories implies $\Delta > 0$ for $t=1982$ and $t=1996$ if the PC and the internet were disruptive technologies affecting competition at these times. Using full-time employment to measure growth, $\Delta = -.077$ for $t=1978$, $.024$ for $t=1982$, $-.006$ for $t=1992$, and $.002$ for $t=1996$.¹⁵ The positive and sizeable value of Δ for the PC era is consistent with a portrayal of the PC as a cause of disruptive competitive change, but for the internet era Δ is near zero. None of these values of Δ is significantly different from zero using 95% confidence intervals computed by bootstrap methods. Thus there is weak evidence that the PC era may have seen an increase in the growth rate of recent entrants relative to incumbents, but there is no such evidence for the internet era.

noise that would arise from the data using shorter periods and helps allow for the possibility that firm employment data may not have been updated every year by every firm. The focus on surviving firms is similar to that used in most comparable literature and in this case is dictated by the large standard errors that result when measuring growth of total employment across all firms and by the impracticality of computing measures of growth rates (such as the median) allowing for the $-\infty$ growth rate of the roughly 50% of firms that exit within four years.

¹⁴ All bootstrap analyses in this paper use a bootstrap sample size of 2,000, which is ample for computational accuracy.

¹⁵ Using total employment to measure growth, the conclusions are similar: $\Delta = -.104$ for $t=1978$, $.036$ for $t=1982$, $-.012$ for $t=1992$, and $.000$ for $t=1996$; and these values of Δ are in no case significantly different from zero.

Application Areas of Firms

If the advent of personal computers and the internet gave an advantage to entrants over incumbents, this may have shown up most directly through greater use of these technologies by new firms and enhanced survival and growth rates among firms that used the technologies. Fortunately, the *Year Book* reported which firms dealt with types of business involving MS-DOS (the main operating system for PCs) and the internet. A third category, network management and design, was also among the various categories reported by the *Year Book* and will be examined given its relatedness to internet applications.

Consequence 4 of the disruptive technology theories implies that recent entrants are relatively likely to use radical new technologies. To assess this prediction, Table 3 presents the percentages of recent entrants and incumbents that listed application areas for their businesses involving MS-DOS in 1987 and the internet in 1995. For MS-DOS, entrants were only slightly more likely than incumbents (36% versus 30%) to have this area of business, and the difference is only marginally statistically significant. For the internet, the difference between recent entrants and incumbents is a multiple of 1.5 times (19% versus 12%), and the difference is highly statistically significant.¹⁶ Thus recent entrants were about as likely as incumbents to choose areas of business related to personal computers, but were substantially more likely than incumbents to choose areas of business drawing on internet-related technology.

TABLE 3 ABOUT HERE.

Consequence 5 of the disruptive technology theories implies that the disruptive technology matters competitively. Firms that successfully make use of the technology should have lower exit rates and higher growth rates than similar firms that do not use the technology. To test whether these outcomes occurred, the firms listed in Table 3 are treated as samples, and regressions are carried out of exit over the following years (through the end of the sample) and of mean annual full-time employment growth over the following four years. As before, logistic regression is used for exit and OLS regression for growth. Results are reported in Table 4.

TABLE 4 ABOUT HERE.

Technological impacts on exit and growth are assessed separately for recent entrants (within four years) and incumbents. To do so, the regressions include three dummy variables equal respectively to 1 for recent entrants and 0 otherwise, 1 for firms with applications areas involving the technology and 0 otherwise, and 1 for recent entrants applying the technology and 0 otherwise.¹⁷ The omitted group is incumbents not applying the technology. Among firms not applying the technology, recent entrants not surprisingly experienced greater likelihood of exit and more rapid growth. This can be seen in the positive estimates for the first (Recent entry) coefficient, which is significantly greater than zero in the exit but not growth regressions. Among firms

¹⁶ In Table 3, p-values are computed using Fisher's exact test.

¹⁷ Controlling for log employment and (in the exit regressions) GDP growth and real mean fees does not alter the nature of the conclusions.

applying the technology, the patterns are more interesting. Incumbents had less chance of exit and *slower* growth if they applied the technology (since the Technology use coefficient is uniformly negative). This finding is statistically significant at the .05 level for exit following the application of PCs and marginally statistically significant at the .10 level for growth following internet applications, but insignificant in the other two regressions. In contrast, the Recent entry×Technology coefficient estimates are uniformly positive and larger in magnitude than the former coefficient, indicating that for recent entrants the effect of technology use was opposite that for incumbents. The difference between recent entrants and incumbents regarding effects of technology is significant at the .05 level for exit following the application of PCs and marginally statistically significant at the .10 level for growth following internet applications, but insignificant in the other two regressions. Thus the results certainly do not indicate the uniform benefits of technology use expected if the PC and internet have been typical radical disruptive technologies.

One interpretation of these findings is that incumbents with many application areas (including PCs and internet) tend to be better established than other incumbents, yielding the reduced exit and growth typical of large old firms, whereas recent entrants with applications related to PCs and the internet tend to be smaller or younger, yielding the heightened exit and growth typical of small new firms.¹⁸ This interpretation would suggest that the conclusions may be solely spurious and technology does not matter. To check whether this is so, the size and age distributions of each cohort of firms (recent entrants and incumbents) was compared between firms that did and did not apply the technology. As expected, recent entrants that used the technology tended to be smaller and younger, with a 58% smaller median number of employees in the PC regressions and a 39% lower mean age in the internet regressions. Among incumbents, the age distributions were comparable but firms with PC-related application areas were actually *smaller* by about 67% (judging from median full-time employment) while firms with internet-related application areas were indeed larger by about 25% (again judging from median full-time employment). Thus the interpretation seems valid except for incumbents in the PC era. PC-era incumbents seemingly may have reaped actual benefits from their choice of application area, whereas for other firms any benefits associated with applying the technology apparently seemingly were not powerful enough to override industry trends.

Conclusion

This paper has focused on one industry, the UK computer consulting industry, as a means to probe theories of how computing and communications technology, may so far have impacted firm and industry structure and the competitive process. The study intentionally focuses on an IT-driven (and IT-driving) industry that may signal changes in the competitive process substantially earlier than other IT-related industries. The competitive consequences of radical, disruptive technological change have been characterized by several theories that predict a resulting change in competitive leadership. This study searched for the telltale signs of such a competitive reversal due to disruptive

¹⁸ See for example Evans (1987); Dunne, Roberts, and Samuelson (1989); and Geroski (1991).

technology, in the 1980s for the personal computer and in the 1990s up to 2000 for the internet.

The findings do not match the telltale signs expected if the internet has been a radical disruptive technology, although there is modest support for the idea that the personal computer might have had such an effect. Entry was not much greater following the introduction of PCs or of the internet. Exit rose following the introduction of the PC, but following the introduction of the internet did not increase until in 1999 (the last year of exit data) there was a sudden surge of exit, which may or may not be attributed to the internet. Changes in exit of incumbents versus recent entrants are consistent with the idea that both new technologies gave an advantage to upstart firms over incumbents, but similar changes in growth rates suggested an advantage of upstart firms only in the PC era not the internet era. New firms were more likely than incumbents to choose internet-related areas of business (but not PC-related areas of business). However, the evidence does not show consistent survival and growth advantages associated with either PC or internet applications; any advantages appear to have been mainly swamped by other effects such as (incompletely-controlled) age and size effects (there is some evidence of PC application reducing exit of incumbents). Thus, what modest support there is for the idea that the PC and the internet have been disruptive technologies in the sense described by competitive theories accrues mainly to the PC.

These findings have important limitations, but nonetheless add substantially to the limited existing research base about IT impacts on firm and industry structure. This study has no source of direct evidence as to why and how PCs and the internet may have affected competition. This study also considers one particular industry, is subject to data error that reduces ability to discern technology effects, and has a limited time span in which to investigate possible competitive consequences of PCs and the internet. The focus on a single industry might be avoided by studying multi-industry data panels, as Hitt (1999) and Brynjolfsson and Hitt (2000) do to find evidence of falling firm sizes associated with greater IT use. However, multi-industry panels may conflate industry life cycle effects with the phenomenon of study unless such effects are accounted for; this bias is complicated to address and has not been fully addressed in existing studies of IT and industry structure. Case studies provide means to probe why and how new technologies have their effect, but to date such studies of the internet have been limited to a small number of firms, obstructing systematic study of whether and why corporate leadership turnover is spurred by the internet or other disruptive technologies. Thus hopefully this study will help to advance in its modest way the emerging stream of research on ramifications of computers and the internet for firm and industry structure.

Will the internet have major effects on market structure in future? Such changes are entirely possible, but perhaps they will not have the form indicated by theories of disruptive technology causing market leadership turnover. Indeed, the chairman of CMG, the largest full-time employer among UK IT consultancies in 2000, writes about the e-commerce opportunity that:

“This is a very significant integration challenge and one that favours the breadth of skills, resources and experience that companies such as CMG can offer. Indeed, the majority of major organisations are already turning to well-established systems integrators for this work, rather than newer so-called Internet integrators.” (CMG Annual Report, 2000, p. 7.)

This interpretation coincides with Porter's (2001) argument that the internet will not change the dynamics and strategies of business competition, but merely intensify them and make current strategic concerns all the more relevant. The truth is still a matter to debate, as attested by the pages of letters in response to Porter's *Harvard Business Review* article, but at least so far the internet does not seem to have had the sort of disruptive technology impacts described by theories of corporate leadership turnover.

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Table 1. Trends in real median and mean fee per day of IT consultancy work, at minimum list prices, UK, 1970-2000

Year	Fee, real £ per day		Sample size	
	median	mean	N	% of firms
1970	396	441	10	12%
1972	391	372	16	14%
1974	331	363	47	28%
1976	361	392	233	58%
1978	388	404	451	74%
1980	425	410	733	77%
1982	386	399	820	76%
1984	398	396	821	77%
1985	412	434	813	77%
1987	517	524	620	71%
1988	413	468	628	41%
1989	459	463	891	56%
1991	419	451	1,006	63%
1993	424	457	1,278	66%
1995	459	476	1,119	64%
1997	434	482	1,115	68%
1999	461	484	1,242	65%
2000	450	488	972	58%

Table 2. Mean % Exponential Growth Rates of Surviving Firms over Four-Year Periods, by Entry Time (Standard Errors in Parentheses)

A. Based on Full-Time Employment*

Firms' Years of Previous Experience

Year	0 to 3		4+	
1974	23.4	(3.0)	13.7	(3.6)
1978	5.5	(0.9)	3.4	(1.7)
1982	6.3	(0.9)	1.9	(1.3)
1988	3.2	(0.9)	-0.2	(1.3)
1992	1.6	(0.6)	-1.2	(0.8)
1996	3.7	(0.8)	0.6	(0.5)

* Excludes firms with no full-time employees in base year.

B. Based on Total Employment

Firms' Years of Previous Experience

Year	0 to 3		4+	
1974	26.1	(2.9)	14.2	(4.0)
1978	5.0	(0.9)	3.4	(1.7)
1982	6.1	(0.9)	0.9	(1.3)
1988	2.8	(0.8)	-0.9	(1.2)
1992	2.7	(0.6)	0.2	(0.8)
1996	3.5	(0.9)	0.9	(0.5)

Table 3. Application Areas of Incumbents and Entrants

Application	% with Application Area		Sample Sizes		p-val.
	Recent Entrants	Incumbents	Recent Entrants	Incumbents	
MS-DOS 1987	35.8%	30.0%	455	424	.073
Internet 1995	19.0%	12.4%	914	831	2x10 ⁻⁴

Table 4. Exit and Growth Regressions Following Technology Application

	Exit following application to:				Growth following application to:			
	PCs		Internet		PCs		Internet	
Recent entry	0.30	(0.10)	0.30	(0.07)	0.011	(0.025)	0.011	(0.009)
Technology use	-0.31	(0.13)	-0.15	(0.15)	-0.003	(0.027)	-0.028	(0.016)
Entry×Technol.	0.38	(0.18)	0.24	(0.19)	0.026	(0.042)	0.037	(0.022)
Constant	-1.86	(0.07)	-1.86	(0.07)	0.018	(0.016)	0.010	(0.006)
N	4856		6614		301		783	

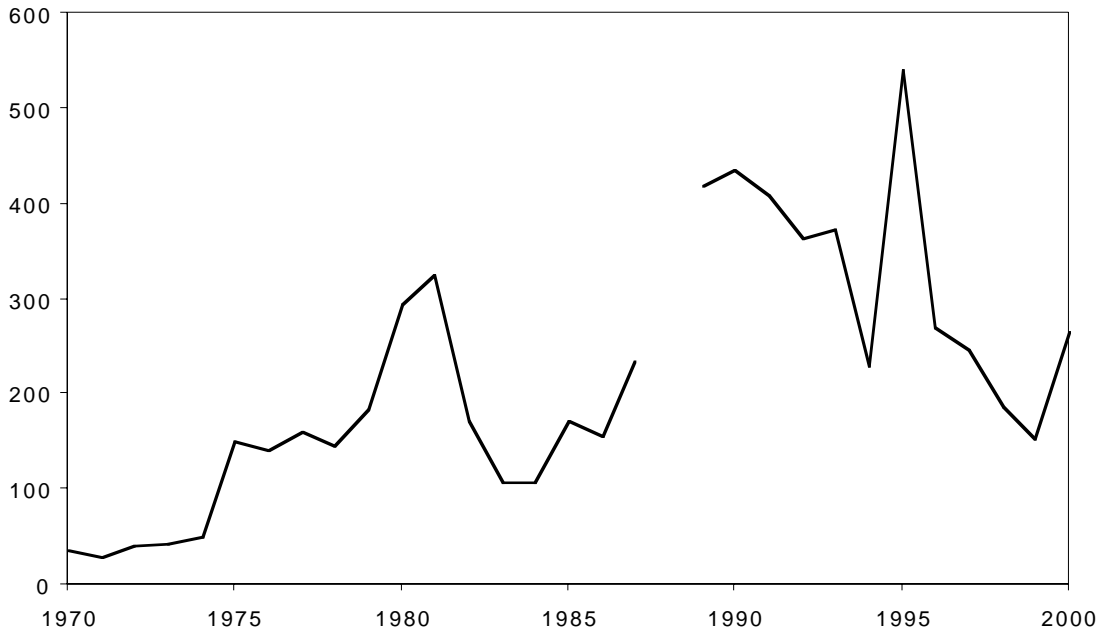


Figure 1. Entry of IT Consultancies (firms per year).

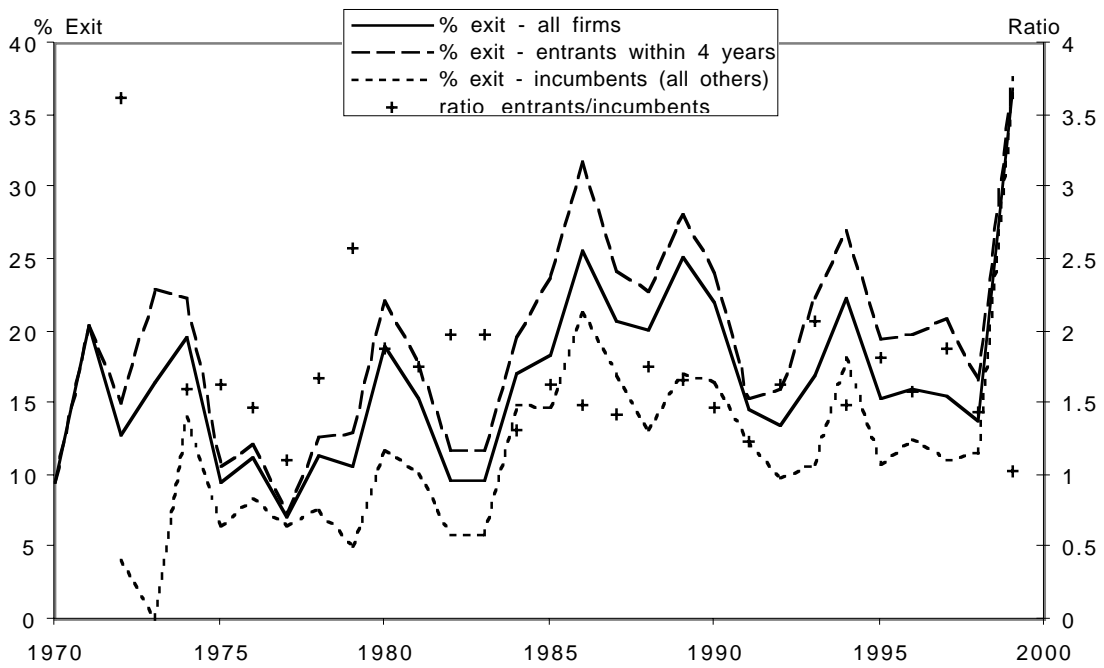


Figure 2. Annual Percentage of IT Consultancies Exiting.