Entrepreneurial Entry and Information Technology Shocks:

The Unvarying Experience of IT Consultancies

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Abstract:

Two information technology (IT) shocks, the personal computer (PC) and the Internet, are examined among IT consultancies. Entry, exit, growth, and technology-related areas of business during three decades do not exhibit disruptive effects of these shocks by 2001. Rather, IT consultants' PC and Internet business services maintained established competitive relationships between entrepreneurial entrants and incumbents. Recent entrants most often provided PC and Internet related services, but this neither enhanced their growth nor reduced their exit. The industry's trade literature suggests why the PC and the Internet may rarely disrupt competition in any industry.

(Disruptive Technology; Market Structure; Internet; Personal Computers; Information Technology Consultancies)

1. Introduction

A double shock to information technology (IT) in the 1980s and 1990s followed the introduction of personal computers (PCs) and the Internet. Aided by legions of consultants, firms integrated desktop and laptop computers throughout their organizations, and tied internal activities together and to customers through networking – initially with intranets but quickly expanding in scope and capabilities with the Internet. Along with other ongoing changes in processing power and applications, these shocks to IT have had major economic ramifications. Using unique evidence on this double shock to IT, this paper examines the experience of the consulting businesses that mediated IT application, to probe how these IT shocks impacted IT consultancies and through them the more general economy.

The experience of these consultancies provides insight into patterns of entrepreneurial success as they relate to industry structure and evolving technological change. The paper tracks 7,488 IT consultancies, mainly recent entrants with a median size of five consultants. It asks whether entrepreneurial IT consultancies managed to wrest any unusual advantage from the IT shocks, or whether the rules of competition evolved as usual – albeit with continually changing business needs and requisite worker skills. Finding in favor of competition-as-usual, it further uses insights of the IT consultants themselves to reflect on why the competition-as-usual story is likely to apply as well in typical IT-using industries.

An examination of IT consultancies complements a growing literature that examines how IT impacts using industries. IT is considered by Bresnahan and Trajtenberg (1995), Helpman and Trajtenberg (1998), Brynjolfsson and Hitt (2000), and Jovanovic and Rousseau (2005) as a general purpose technology, which has broad impacts across economic sectors. A substantial literature has sought IT's economy-wide productivity impacts (e.g., Jorgensen, 2001; Bloom et al., 2007), while other literature has probed how adopting firms change when they make use of IT (Bresnahan and Greenstein, 1996; Brynjolffson et al., 2002; Brynjolfsson and Hitt, 2003). IT impacts on industry structure might take either of two forms, Schumpeterian creative destruction (Schumpeter, 1942) or business-as-usual application of new tools.

The creative destruction view suggests that entrepreneurs invent or use new technologies that let them take over existing markets. David (1990) conjectures that incumbents might have trouble adapting to IT, because of "a strong inertial component in the evolution of information-intensive production organizations" (p. 360). Hobijn and Jovanovic (2001) argue that the personal computer (PC) triggered waves of entry and incumbent-firm exit economy-wide, as incumbents' prior investments in equipment, skills, and organizational structure lost value and entrants used PCs for more competitive business models. Lipsey et al. (1998), suggest that computers led to decentralization of activities formerly done in single firms, and therefore reduced industry concentration. Evans and Wurster (2000) make a similar argument regarding the Internet, saying that incumbents must radically adapt or lose their leadership to new firms. Consistent with notions such as these, Chun et al. (2007) show that the most IT-intensive using sectors in the U.S. generally had the greatest stock return variation in the 1990s. However, it is clear that disruption does not follow every radical technological change (e.g., Tripsas and Gavetti, 2000; Hill and Rothaermel, 2003; Rothaermel and Hill, 2005), so *a priori* it seems equally plausible that there may be alternative industry dynamics.

The business-as-usual view suggests that although new forms of IT involve new markets and methods of application, they do not change the relative advantage of entrepreneurs versus incumbents. In some industries competence-enhancing technological advance aids incumbents by allowing them to readily apply new technologies (Tushman and Anderson, 1986), fueling their growth at the expense of entrepreneurs (e.g., Phillips, 1971; Klepper and Simons, 2000). In other industries, entrepreneurial entrants face no particular advantage or disadvantage, yielding a stasis in which the chances of survival and growth remain steady across successive generations of entrepreneurs. Bresnahan and Greenstein's (1996) analysis of mainframe computer use suggests that their corporate owners were not always substantially locked in to the technologies. Similar findings might be expected for firms using minicomputers once PCs arose, firms using pre-Internet information and communications technologies, and IT consultants serving established clients that faced these technology shocks.

Given the void of information about these IT impacts, it is valuable to examine how each of these views fits the experience of the IT consultancy industry, and to reflect on what this might mean for the broader set of industries that use IT tools. IT consultancies from the United Kingdom (U.K.) in the years 1969-2001 compose a sample used here to probe these issues. The personal computer is dated to 1982 following the August 1981 introduction of the IBM PC, and the Internet is dated to 1995 when the commercial Internet arose (National Research Council, 1999); conclusions drawn are robust to alternative dates.

Firms are divided into incumbents and recent entrants, and further into firms that do or do not provide consultancy services regarding PCs and later the Internet. The relative growth and survival rates of new versus incumbent firms, and of firms that do versus do not provide PC- and Internet-related services, provide direct means to assess the evolving experiences of entrepreneur entrants. Entrants benefited through neither growth nor survival, in both the PC and Internet eras.

Sections 2-4 of this paper lay out the rationale, methods, and empirical analyses that yield these conclusions. Section 5 uncovers reasons why, among IT consultants or in any industry, the PC and the Internet are unlikely to cause competitive disruption.

2. Disruptive Technological Change versus Business-as-Usual

Disruptive technological change versus business-as-usual depictions of IT shocks yield contrasting consequences for entry, technology use, growth, and survival in alternative cohorts of entering IT consultancies. The consequences of disruptive change are equivalent to a set of testable hypotheses, essentially alternative hypotheses that contrast with the business-as-usual null hypotheses of no effect or opposite effects. These consequences are delineated for the disruptive technology and business-as-usual characterizations in turn.

2.1 Disruptive Technological Change

The notion that incumbents might be less likely than entrants to adopt certain new technologies appears in vintage capital models of economic growth, R&D models such as Arrow (1962) and Reinganum (1983), and management of technology work by Tushman and Anderson (1986) and others. The latter work is of particular interest here because it characterizes implications for entry, exit, technological change, and other market indicators for industries in which many firms compete to put to use a new technology.

Tushman and Anderson (1986) argue that competence-destroying technologies, i.e. technologies that require competences not possessed by incumbents, tend to be exploited by new firms while incumbents tend to use the technologies late if ever. In an era of competition when new firms have the advantage, recent entrants grow unusually rapidly and exit relatively rarely, while incumbents experience reduced growth and enhanced exit. A similar view has been apparent in studies of many industries, including Majumdar (1982) and Schnaars (1994).[1]

Several explanations exist as to why incumbent firms fail to take advantage of disruptive technologies. Majumdar (1982), Tushman and Anderson (1986), and Anderson and Tushman (1990) address the issue in terms of core technological competencies. Firms not possessing the techniques, personnel, and equipment needed to pursue the new technology cannot make the transition without high cost, and even fail to perceive the importance of the coming revolution. Henderson and Clark (1990) argue that a firm's R&D and engineering personnel develop ways of thinking about the technology, both individually and as an organization, that are inconsistent with relevant innovative approaches. This limiting mindset causes them to miss opportunities afforded by the new technological approach. Christensen and Rosenbloom (1995) argue that incumbents maintain their current technological approach because their customers demand products or services that initially can be best provided using established technology. They are not sufficiently attracted by potential profits obtained from new customers using the new technology, and they fail to realize that the new technology eventually may replace the old. All of these reasons, along with others mentioned by Schnaars (1994), yield several identical implications for competitive dynamics.

The theorized consequences of a disruptive technology are the same consequences that have been suggested for the PC and Internet specifically. The consequences provide means to assess whether, to date, the PC and the Internet have triggered substantial disruptive technological effects. The following six competitive impacts would be expected in an industry that experiences disruptive impacts of the PC or the Internet.

In contrast to findings that experience enhances the probability of entry into a new technology area (cf. King and Tucci, 2002), a truly disruptive technology shifts the determinants of entry in favor of new firms. Entering firms may have experience with the technology, as for electronics firms entering production of calculators (Majumdar, 1982). Or they may simply lack organizational rigidities that prevent incumbent firm entry (Henderson and Clark, 1990; Christensen and Rosenbloom, 1995). In either case they enter and use the new technology, whereas incumbents are less prone to use the new technology:

CONSEQUENCE 1: *Entry of new firms increases following the technological change*.

CONSEQUENCE 2: *A greater percentage of new firms than old firms use the disruptive technology*.

The disruptive technology reduces cost, enhances quality, enhances provision of services, or otherwise yields an advantage. In addition to stimulating demand, the technology therefore gives the competitive advantage to its primary adopters, the upstart new-technology entrants (Tushman and Anderson, 1986). Compared to entrants from all eras at similar ages and sizes, recent entrants hence grow unusually rapidly and are less prone than usual to be forced out of the market. In contrast, incumbent producers tend to lose market share and to exit.

CONSEQUENCE 3: *The growth rate of new firms rises, relative to the growth rate of incumbent firms, following the technological change*.

CONSEQUENCE 4: *The exit rate of new firms falls, relative to the exit rate of incumbent firms, following the technological change.*

The advantage of entrants stems from their use of the disruptive technology. Incumbent firms also benefit from using the disruptive technology, in the rare cases when they make use of it. Hence for all firms the technology-related analogues of the previous two Consequences are:

CONSEQUENCE 5: *Firms using the disruptive technology, ceteris paribus, have higher growth rates than firms not using the disruptive technology.*

CONSEQUENCE 6: *Firms using the disruptive technology, ceteris paribus, have lower exit rates than firms not using the disruptive technology.*

Since technology is the sole reason for recent entrants' advantages in Consequences 3 and 4, controlling *perfectly* for technology adoption would be expected to eliminate the effects of entry time, undoing those Consequences. However, the technology adoption measures used here are dummy variables at one point in time, and reflect neither differences in firms' degree of technology use nor differences in timing of adoption. With these *imperfect* controls, Consequences 3 and 4 should still hold when technology use is included in statistical analyses.

2.2 Business-as-Usual

The business-as-usual view, in contrast, suggests that the above differences between firms either do not exist or are opposite those for disruptive technological change. They do not exist if entrepreneurial entrants face no particular advantage or disadvantage. They are opposite if competence-enhancing technological advance or other incumbent advantages fuel growing dominance by incumbents.

3. Method

The present study considers providers of services that embody a technology, just as Henderson and Clark (1990) and Christensen and Rosenbloom (1995) examine providers of goods that embody disruptive technologies for photolithographic alignment and hard disk drives respectively. However, IT consultancies differ from firms in previous studies of disruptive technology in that their clients can more readily provide the same services in-house, and in that they might make important use of the same technologies in-house to enhance their businesses.[2] Substitution of consultancy services by in-house IT services would be expected to disadvantage incumbents rather than entrants if indeed incumbent consultancies were slow to provide services related to new technologies, and hence would tend to skew findings to favor disruptive technological change. Similarly, inertia in in-house use of technology by consultants would tend to disadvantage incumbent firms when disruptive technology arises, making findings of disruptive technological change more likely. These traits therefore reinforce findings that entrant-favoring disruption did not occur in the provision of IT services to client firms.

3.1. Sample

Data were collected for most U.K. IT consultancies, annually from 1971 through 2002, using VNU Business Publications' (1969-2002) annual directory *The Computer User's Year Book*.[3] All consultancies in the *Year Book* were recorded along with dates, numbers of consulting employees, fees per day of work, and key types of business application. Entry dates were recorded beginning in 1969. Names and addresses of firms, among other information, were used to ensure that longitudinal records were properly matched over time. Multiple branches of a firm were treated as a single entity.[4] The sample contains 7,488 firms, with few firms in the earliest years but 1,047 firms by 1982 and a highest-yet figure of 1,911 firms in 1993.

A structural break in the data occurred in 1988, when the *Year Book* removed software houses from its definition of consultants and added other types of consultancies. To lessen the impacts of this break, the (relatively few) firms indicated as software houses that did not perform consultancy are excluded from analyses. Software houses cannot be distinguished in 1969 and 1970; hence the exclusion of these years from the panel data.

The industry definition includes all firms that provided consultancy related to the use of IT. It excludes firms that provided only computer repair, rental of computer time, IT training, or data preparation. Most firms in the sample produced computer software to suit clients' needs, despite the exclusion of pure software houses. IT consultancies' services dealt with, for example, outsourcing and project management, personnel management, finance and accounting, integrated business systems, networks, e-commerce, marketing, and top-level management strategy.

The data include some international consultancies, but only firms with UK offices are retained in the data. The largest firm in 2000 had 3,260 full-time consultants, and the top ten averaged 1,656 full-time consultants and totaled 40% of reported full-time consultants. However, the bulk of the sample consists of small businesses, with an overall sample mean of 29 and median of 5 full-time consultants in 2000.

3.2. Econometric Specification

To test robustly whether the PC and the Internet have caused disruptive industry outcomes, Consequences 1-6 were probed using parametric and nonparametric methods. Results presented in Section 4 use whichever methods most clearly and succinctly exhibit findings. Primary parametric models used to probe the Consequences are a standard count data model of entry, logistic regression of technology use, OLS model of growth, and logistic regression of exit:

$$E_t = \exp(\beta_0 + \beta_1 T_t) + \varepsilon_t^E \tag{1}$$

$$\frac{\Pr[U_{it} = 1]}{1 - \Pr[U_{it} = 1]} = \exp(\upsilon_0 + \upsilon_1 R_{it} + \upsilon_2 \log S_{it} + \upsilon_3 N_{it}) \tag{2}$$

$$\log\left(\frac{S_{it+1}}{S_{it}}\right) = \gamma_0 + \gamma_1 R_{it} + \gamma_2 U_{it} + \gamma_3 \log S_{it} + \gamma_4 \log A_{it} + \gamma_5 T_t + \varepsilon_{it}^S \tag{3}$$

$$\frac{\Pr[X_{it}=1]}{1-\Pr[X_{it}=1]} = \exp(\lambda_0 + \lambda_1 R_{it} + \lambda_2 U_{it} + \lambda_3 \log S_{it} + \lambda_4 N_{it} + \lambda_5 \log A_{it} + \lambda_6 T_t) \quad (4)$$

Here, E_t measures aggregate entry, T_t time periods with potential disruptive technology effects (1 for years 1982-87 or 1995-2001 in alternative regressions and 0 for other years), U_{it} technology application through business markets (1 indicates application and 0 non-application), R_{it} recent entry (as reported in tables), S_{it} firm size (in consultants), N_{it} no data on firm size (with firm size set to its mean), A_{it} firm age (starting at one year), and X_{it} firm exit (1 indicates exit and 0 survival); i indexes firms and t time; and ε_t^E and ε_{it}^S are independently-distributed random terms.

In (1) the number of entrants in year t is a count (nonnegative integer) arising from an arrival process. Accordingly, E_t is assumed to follow a negative binomial distribution, with $\mathrm{Var}[E_t] = (1+\alpha)\mu(E_t)$. The parameter α allows for over-dispersion relative to a Poisson arrival process. Consequence 1 implies $\beta_1 > 0$, as business opportunities associated with the new technology cause a surge in entry.

In (2) use of the new technology is assessed in a single year t rather than a panel given available data. Recent entrants are most likely to use a disruptive technology according to Consequence 2, implying $\upsilon_1 > 0$. Firm age is excluded as a regressor in most such analyses since it is closely related to recent entry in cross-sectional data.

In (3) and (4), growth and exit are expected to depend on present size and age (cf. Dunne et al., 1989). Consequences 3 and 4 imply $\gamma_1 > 0$ and $\lambda_1 < 0$, after controlling for firm size and age, because entrants after arrival of the disruptive technology tend to grow faster and exit less than previous entrants at similar size and age. Consequences 5 and 6 imply $\gamma_2 > 0$ and $\lambda_2 < 0$, as advantages and opportunities associated with the new technology enhance growth and reduce exit among technology users. Major new technology has been hypothesized to enhance overall market growth and perhaps to increase aggregate exit (Tushman and Anderson 1986), and the T_t term allows for these effects in analyses including data before the new technology arose (implying $\gamma_5 > 0$ and $\lambda_5 > 0$).

Statistical analyses are mainly carried out separately before and after the structural change in the data. Entry analyses exclude 1988, when entry may result from inclusion of new firm types in the *Year Book*. Exit analyses exclude 1987, when exit may result from removal of firm types. Growth analyses exclude 1987, when size changes may result from the structural change.[5]

3.3. Variables

Entry in year t is measured as the number of firms that first appeared in the *Year Book* in that year. In each year t, firm i's *growth rate* equals Log($size_{i,t+1}/size_{i,t}$); observations with missing data are excluded from analyses of growth. Firm size is measured using the total number of consultants employed by each firm. *Exit* for firm i in year t equals 1 if the firm permanently left the sample between years t and t+1, 0 otherwise.

Technology use is measured by the application (business service) areas of firms, collected from the *Year Book* in specific years. The earliest year in which data seemingly could be collected reliably on application to personal (micro)computers is 1984, and the earliest year with a listing of firms having Internet applications is 1995. Dummy variables *PC apps. 1984* and *internet apps. 1995* equal 1 if a firm dealt with areas of business related to the technology in the specified year or 0 if it did not.

Recent entry after a disruptive technological change is operationalized using dummy variables: *entrant 1982-87* and *entrant 1995-01* equal 1 for firms that entered in the indicated years, or 0 for all other firms. Time periods T_t are defined as *year 1982-87* and *year 1995-01*, equal to 1 in the specified years or 0 at all other times. The IBM PC was released in October 1981, hence the use of 1982 for the first effects of the PC.[6] The Internet surpassed ten million Internet hosts in 1995, which is when it became commercially provided (National Research Council, 1999) and approximately when its commercial potential began to spring up (cf. Fabiani et al., 2005), hence the use of 1995 for the first effects of the Internet. The relation of other entry times to success, for example to compare entrants by the early 1970s versus later entrants, can be seen in Section 4.4. Alternative measures are addressed in Section 4.5.

Firm size and age are embodied as *log size* and *log age*, since the logarithmic form explains most of the effects of size and age. Size data are not available for some firms in some years, in which case *log size* is set to the sample mean among data points used in each statistical analysis, and *no size data* equals 0 or 1 for firms that did or did not have size data respectively in each year. Age equals 1 in the firm's first year in the data, and 2, 3, …, in subsequent years.

Additional control variables are considered in the sensitivity analyses of Section 4.5.

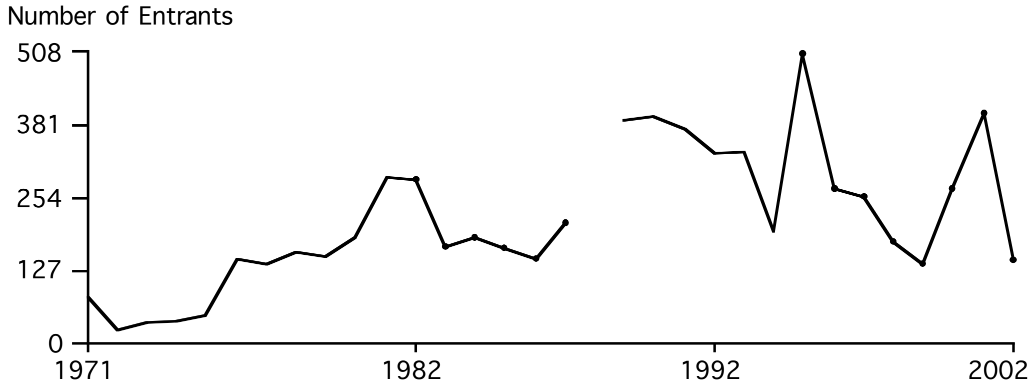
4. Results

Empirical tests of Consequences 1-6 are carried out to investigate whether, and when and how, the PC and the Internet yielded disruptive benefits to entrepreneurial entrants over incumbents.

4.1. Entry

Consequence 1 indicates that entry increases after a disruptive technological change. Figure 1 shows annual entry of IT consultancies. The years 1982-87 after the advent of the PC, and 1995-2002 after the rise of the Internet, bear dots to indicate when entry might be expected to be high. In fact, entry was comparable in these years and immediately preceding years.

Figure 1. Annual Entry of UK IT Consultancies

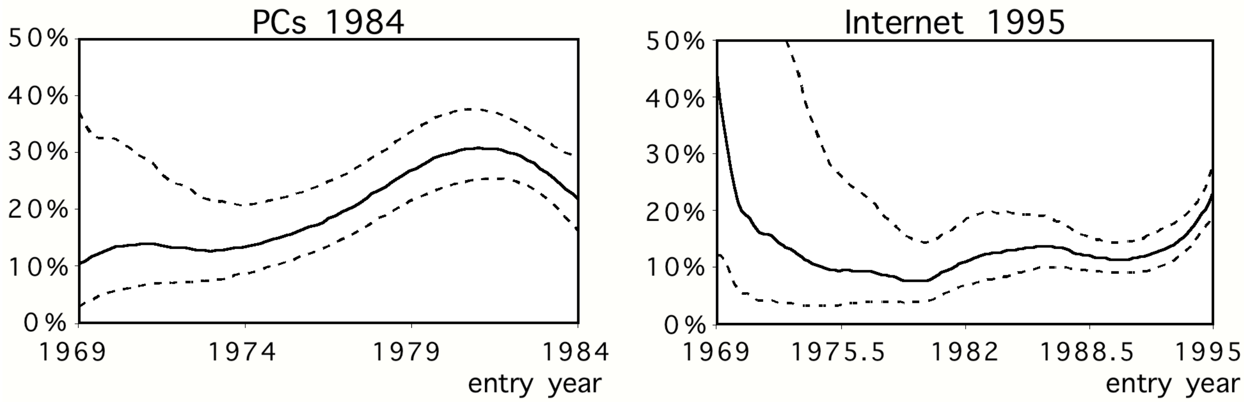


Conclusions are more ambiguous if one allows for long time periods of comparison or controls for time trends. In negative binomial regressions of entry as described by equation (1), positive coefficient estimates of post-technology entry were obtained for the PC era if 1982-87 entry was compared to entry in *all* previous years, or for the Internet era (comparing 1989-95 versus later entry) if a control was added for increasing price of IT consultancy. In the latter case results may not be meaningful since the estimated coefficient of the price index is negative, opposite the entry attraction one might expect, but the results reveal the sensitivity of this short time series analysis to possible time-series controls. Thus the evidence regarding Consequence 1 might be deemed ambiguous, and certainly does not show a clear jump in entry.

4.2. Technology Use

Consequence 2 concerns technology use by entrants and incumbents. Did incumbents lag behind recent entrants in adopting the PC and the Internet for areas of business? I constructed non-parametric estimates of technology use by entry time, using the well-established maximum local likelihood method for binomial processes (Loader, 1999).[7] Figure 2 presents the estimates, which are a smoothed version of actual usage rates.

Figure 2. Technology Use by Entry Date



Estimated probability of use and 95% confidence intervals.

The two panels show the estimated percentage of surviving entrants from each year that dealt with personal (micro)computers in 1984 and the Internet in 1995. For PCs, recent entrants appear to have had relatively high usage rates, although entrants shortly before the introduction of the IBM PC had the highest usage rates. For the Internet, the relationship is non-monotonic: both the earliest entrants and the most recent entrants had the highest usage rates.

The 95% confidence intervals shown are quite broad and do not show the statistical significance of inter-period differences, so Fisher's exact test was used. Comparing PC application among 1982-84 versus earlier entrants and Internet application among 1995 versus earlier entrants, the greater use by recent entrants is significant only for the Internet. Thus there is weak evidence for the PC and strong evidence for the Internet that recent entrants were most likely to advertise areas of business involving the PC and the Internet, although the few surviving very early entrants also had high use of the Internet.

One hypothesis why recent entrants often adopted PCs and the Internet for areas of business is that small firms are most likely to use new technology, and new entrants happen to be small. Parametric statistical analysis of equation (2) showed that for PCs, firm size (*log size*) was indeed negatively and significantly related to technology use, explaining 69% of the estimated effects of *entrant 1982-87*. However, exactly the opposite was true for the Internet; a positive and significant coefficient estimate indicated that larger firms most often applied the Internet through areas of business.

4.3. Growth and Exit

Consequences 3-6 of the theories pertain to growth and exit. Table 1 reports ordinary least squares regression estimates of equation (3), concerning firm growth rates from each year to the subsequent year. Table 2 reports maximum likelihood logistic regression estimates of equation (4), concerning firm exit between each year and the subsequent year. The first column in each table, column 1 or 5, pertains to the basic model of impacts of the PC. In column 1 the estimate of *entrant 1982-87* indicates that the expected growth rate of post-technology entrants was actually *lower*, indeed marginally significantly lower, than that of incumbents at similar size and age. In column 5 the estimate of *entrant 1982-87* indicates that the exit probability of post-technology entrants was actually *higher*, indeed marginally significantly higher, than that of incumbents at similar size and age. These findings are contrary to Consequences 3 and 4 of the theories, and imply that the PC did not act as a disruptive technology in this industry.

Table 1. OLS Regressions of Firm Growth, with Effects of the PC and the Internet

	PC		Internet	
	(1)	(2)	(3)	(4)
Entrant 1982-87$_i$	-0.038 † (0.020)	-0.026 (0.018)		
PC Apps. 1984$_i$		-0.030 † (0.017)		
Entrant 1995-01$_i$			-0.007 (0.007)	-0.007 (0.010)
Internet Apps. 1995$_i$				0.024 † (0.013)
Log Size (# of consultants)$_{it}$	-0.052 *** (0.005)	-0.045 *** (0.005)	-0.034 *** (0.002)	-0.022 *** (0.004)
Log Age$_{it}$	-0.017 † (0.010)	-0.020 † (0.012)	-0.017 *** (0.003)	-0.011 † (0.007)
Year 1982-87$_t$	-0.064 *** (0.016)			
Year 1995-01$_t$			-0.002 (0.006)	
Constant	0.248 (0.016)	0.165 (0.034)	0.117 (0.007)	0.081 (0.016)
N	6866	4338	16623	5219
Firms	1689	808	3833	1344
Restricted to years	1971-1986	1984-86 & 1988-01	1988-2001	1995-2001
Restricted to firms	all	present in 1984	all	present in 1995

†$p < 0.10$, * $p < 0.05$, **$p < 0.01$, ***$p < 0.001$, std errors in parentheses. Dependent: *Growth rate*$_{it}$.

In column 2 of Table 1 and column 6 of Table 2, *PC apps. 1984* is included to assess Consequences 5-6 as they pertain to the PC. The sample is restricted to firms present in 1984 and uses years 1984 onward. In each case the estimates of *entrant 1982-87* remain contrary to Consequences 3 and 4. The estimate of *PC apps. 1984* matches with Consequence 6 but not with Consequence 5; the technology users had lower expected exit but also *lower* expected growth than non-technology users.[8] This further questions whether the PC could act as a disruptive technology in the industry.

Table 2. Logistic Regressions of Firm Exit with Effects of the PC and the Internet

	PC		Internet	
	(5)	(6)	(7)	(8)
Entrant 1982-87$_i$	0.156 † (0.092)	0.060 (0.084)		
PC Apps. 1984$_i$		-0.170 * (0.086)		
Entrant 1995-01$_i$			0.004 (0.040)	0.105 (0.069)
Internet Apps. 1995$_i$				-0.013 (0.087)
Log Size (# of consultants)$_{it}$	-0.132 *** (0.025)	-0.056 * (0.027)	-0.007 (0.014)	-0.031 (0.026)
Log Age$_{it}$	-0.252 *** (0.049)	-0.163 ** (0.053)	-0.218 *** (0.019)	0.052 (0.043)
No Size Data$_{it}$	0.213 * (0.102)	0.219 † (0.121)	0.103 * (0.051)	0.124 (0.103)
Year 1982-87$_t$	0.376 *** (0.083)			
Year 1995-01$_t$			0.304 *** (0.038)	
Constant	-1.418 (0.078)	-1.250 (0.156)	-1.324 (0.043)	-1.626 (0.110)
N	9147	5893	23347	7092
Firms	2261	1056	5783	1729
Restricted to years	1971-1986	1984-86 & 1988-01	1988-2001	1995-2001
Restricted to firms	all	present in 1984	all	present in 1995

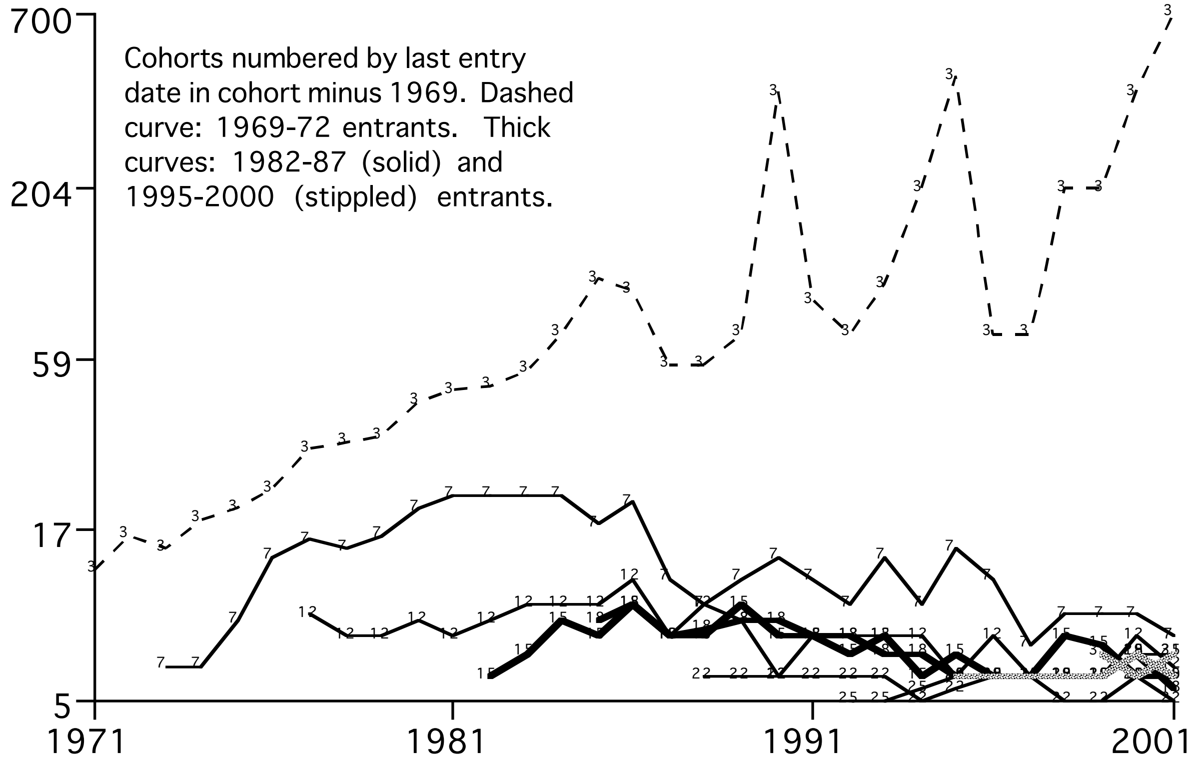
†$p < 0.10$, * $p < 0.05$, **$p < 0.01$, ***$p < 0.001$, std errors in parentheses. Dependent: $Exit_{it}$.

The remaining columns of each table pertain to impacts of the Internet. Columns 3 and 7 pertain to the basic model of impacts of the Internet, and hence provide the means to assess Consequences 3 and 4. The estimate in column 3 of *entrant 1995-00* indicates that growth of post-technology entrants was insignificantly different from, and if anything *lower* than, that of incumbents at similar size and age. The estimate in column 7 of *entrant 1995-00* indicates that exit of post-technology entrants was insignificantly different from, and if anything *higher* than, that of incumbents at similar size and age. These findings are contrary to Consequences 3 and 4 of the theories and imply that the Internet did not act as a disruptive technology in the industry.

In column 4 of Table 1 and column 8 of Table 2, *internet apps. 1995* is included to assess Consequences 5-6 as they pertain to the Internet. The sample is restricted to firms present in 1995 and years 1995 onward. In each case the estimates of *entrant 1995-00* remain contrary to Consequences 3 and 4. Moreover, the estimate of the impact of *internet apps. 1995* on growth is only marginally statistically significant, and the effects on exit are near zero and insignificant. Annual growth was estimated to be 2.4% higher for businesses with Internet applications, although this is only marginally significantly different from zero. Thus only by one measure, growth, is there any sign that firms with Internet business applications might have experienced a technology advantage, but this advantage did not yield enhanced growth for recent entrants, and in terms of the other measure, exit, there was no apparent advantage to Internet business application.

Control variables in the statistical analyses largely have the expected effects. Firm size and age are both negatively associated with growth, and in most cases are negatively associated with exit. In the logistic regressions of exit, firms for which no size data are available have higher exit than other firms of mean log-size. The variables *year 1982-87* and *year 1995-00* are negative (for the latter near zero) in the growth regressions, indicating that incumbents did not experience higher growth than in past, and positive and significant in the exit analyses, indicating that incumbents experienced greater exit than in past. This might be construed as evidence of new disadvantage to incumbents were it not for the fact that these coefficients affect all firms; the same trends also affected recent entrants. The explanatory power of the statistical analyses is low, even for variables such as firm size and age, and the relentless competition causing the feeble explanatory power will become more apparent in the nonparametric analyses of Section 4.4.

Figure 3. Median Employment of Entrants in UK Computer Consultancy

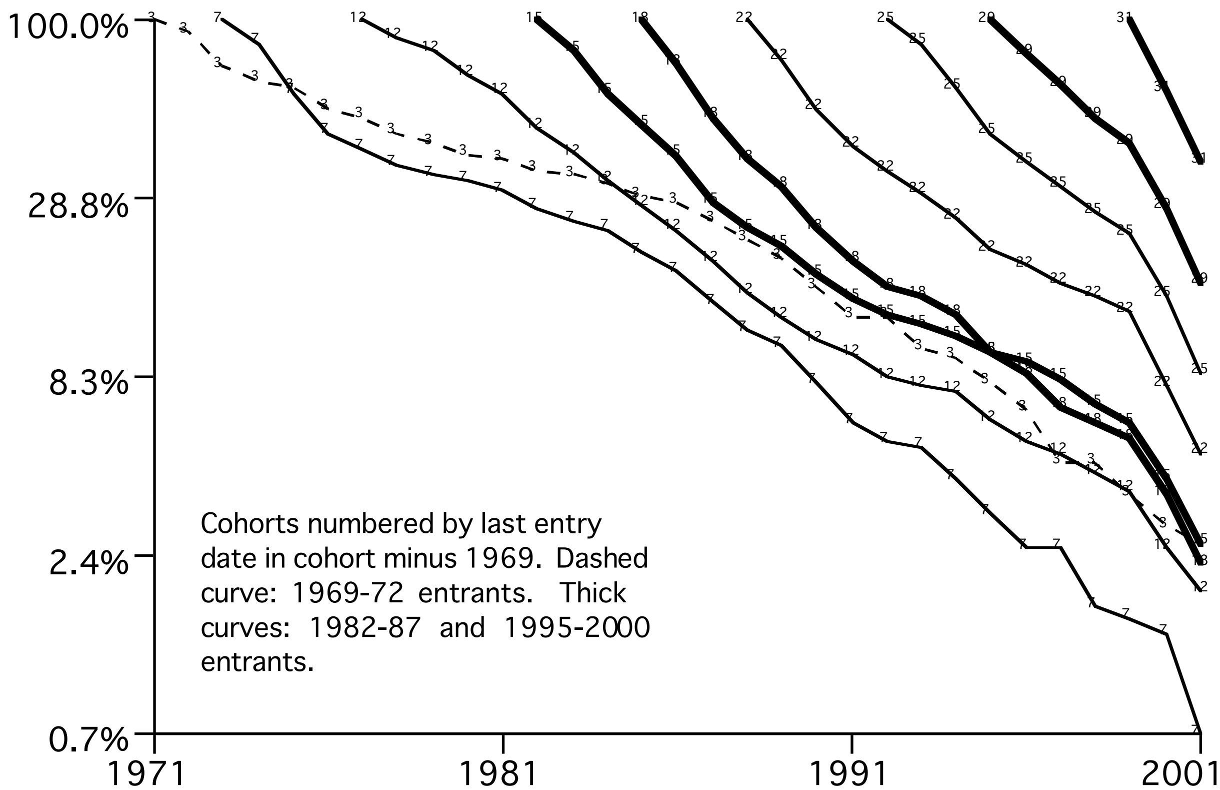


4.4. Growth and Exit by Entry Cohort

To better understand the apparent lack of advantage of post-technology entrants in growth and exit, Figures 3 and 4 exhibit the changing median size and percentage survival of successive cohorts of entrants.[9] Cohorts are identified by small numbers, equal to the last entry date in the cohort minus 1969, along each curve. The earliest entrants, in 1969-72 (small number 3), have a dashed curve. Subsequent cohorts are 1973-76 (7), 1977-81 (12), 1982-84 (15), 1985-87 (18), 1988-91 (22), 1992-94 (25), 1995-98 (29), and 1999-2000 (31). Entrants in the PC and Internet eras have thick curves, and in Figure 3 the Internet era entrants' curves are stippled for easy identification. Because the vertical axes are logarithmic, a given growth or exit rate has the same slope at every point on a graph, facilitating comparison between cohorts and times.[10]

The outstanding impression from Figure 3 is that the median early entrant remained much larger than later entrants and that this trend did not reverse after the rise of the PC and the

Figure 4. % Survival among Entrants in UK Computer Consultancy



Internet. Early entrants' growth was reasonably high relative to other firms even in the PC and Internet eras. Among other cohorts of firms the median size remained small and may even have contracted slightly during the mid-1990s (the bigger contraction in 1987 is presumably due to the *Year Book*'s reorganization of the data). The relatively late entrants, including those from the PC and Internet eras, apparently did little or no better at growth than entrants in other eras.

In Figure 4, the earliest cohort experienced less exit than later entrants, but otherwise exit rates appear to have been similar across cohorts, given the similar slopes of the curves. Neither during the PC era, nor during the Internet era, nor any time in between did the exit rates of recent entrants abate relative to the exit rates of incumbents. From 1999 to 2000 and again from 2000 to 2001 exit rates increased, but this period of high exit affected all cohorts, the only possible exception being the low exit of the few surviving earliest entrants. All cohorts of firms, except possibly the earliest, suffered alike from exit, and recent entrants did not appear to benefit from the PC nor from the Internet.

4.5. Sensitivity Analyses

The timing of disruptive technology impacts on competition, as well as other forces in competitive dynamics, could be specified in a range of ways. Therefore analyses were carried out using alternative formulations of parametric models (1)-(4). To check for any problems with the *PC apps. 1984* or *internet apps. 1995* measures, I collected measures for closely related technologies, MS-DOS applications in 1987 and network management and design in 1995 and tried using these as the basis for analyses. In case individual or small family businesses are driven by different business dynamics than larger firms (cf. Kim et al., 2002), I tried restricting the sample to firms with at least five full-time consultants in the first calendar year of each analysis (in 1984 for columns 1 and 5). I allowed for effects of time-series economic growth by adding a control variable for the rate of GDP growth or services GDP growth. I also added, separately or simultaneously, a price index constructed using firms' fee data to proxy for greater profit opportunity when demand and supply caused higher prices (companies should benefit from higher prices if employees fail to capture all increases as wages). The price index allows for possible shifts in labor supply and in the extent to which firms contract out IT work. In case the measures *log size* and *log age* might not fully pick up effects of firm size and age, I tried adding nineteen size and age category dummies in addition to *log size* and *log age*. I tried using later definitions of when the Internet had an impact, by either dating the impact of the Internet as beginning in 1999 instead of 1995 or using the worldwide number of Internet hosts to proxy for when the Internet should have an impact; these changes affected the measures of both recent entry and T_t. In case benefits of recent entry accrued in a continuous manner – rather than with a discontinuous shift in 1982 or 1995 – I replaced the recent entry measure with the firm's entry date, or with both entry date and squared entry date to capture possible non-monotonic effects.

The results of these analyses confirm the impressions already given. With two exceptions, the PC and the Internet are not estimated to benefit recent entrants as would a disruptive technology. The first exception is that allowing effects of the Internet to begin in 1999 or to be correlated with the number of Internet hosts, there is a statistically significant decrease in exit for recent entrants. However the benefit in terms of exit rates is small, as can be seen from Figure 4, and there is no significant estimated increase in growth. The second exception is that out of over a thousand variant models tried, recent entrants had a barely significantly (at the .05 level) lower exit rate than incumbents in one permutation of the above variations pertaining to the Internet era. However, in this case, the estimated effects of recent entry on growth are negative, contrary to consequences of disruptive technology. The analyses also confirm the findings reported above regarding benefits of technology use; in no case was a significant effect of technology use found with sign opposite that shown in Tables 1 and 2. Thus the sensitivity analyses confirm that disruptive technology effects of the PC and the Internet have not occurred.

5. Discussion

Why did application of the PC and the Internet not substantially benefit new IT consultancies? These firms appear to have put PC- and Internet-related technologies to use when benefits were likely to arise, but the benefits varied with time and with the market niches and work practices of individual firms. Internet-related activities increasingly are integrated throughout consulting firms' areas of business as specific Internet-related needs arise in each area (Ovum Holway, 2001). As an example, 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.)

Indeed, the pure e-commerce consultancy sector has shrunk with the apparent realization that e-commerce skills need to be tied with the range of traditional IT consultancy skills (Classe, 2001). Reaching a similar conclusion for the test-case GPT, electrification in the early 1900s, Goldfarb (2005) finds that late adoption cannot be blamed merely on laggardly or entrenched decisions, but rather firms in quite different situations adopted technology when and where appropriate.

Since IT consultants apply IT to all types of firms, the industry's trade literature provides insight into whether the PC and the Internet are likely to have disruptive impacts in *all* industries. First, the literature suggests that the PC was not a panacea. Large centralized computers continued to be used not just out of momentum and switching costs, but because high costs of administering distributed systems of PCs (about ten times the cost of the PCs themselves) often made networked PCs cost-ineffective, and because many needs required large mainframes (Goodwin, 1997a). Moreover, even as PCs and PC software improved, so did centralized mainframes become increasingly capable and cost-effective, keeping them appropriate for many applications; at times there have even been moves *away* from decentralized systems and back to central processing (Goodwin, 1997c). Large firms that delayed replacing mainframes with PCs, instead choosing other paths to improve their technology and operating procedures, may have benefited from the delay. Reaching a similar conclusion for the transition from mainframes to client/server systems, Bresnahan and Greenstein (1996) find that firms' differing software co-investment needs shaped differing adoption times.

Second, steady improvement in available Internet business software has helped to limit any disadvantage to late adopters of Internet business (Harrington, 1999). Firms benefited by waiting for the release of software and services such as Microsoft's BizTalk Server, Commerce One's automated supply chain tools, and Bigstep.com's electronic storefront and finance tools. Firms were usually better off buying Internet business software and integrating it with their business activities than creating their own software (cf. Whittle, 2001b). A survey of Internet business software for manufacturing firms suggests that it best suits large firms (ITconsultant, 2001a), actually providing some advantage to incumbents. The advantage to large businesses may disappear as software to facilitate Internet business develops (ITconsultant, 2001b), making Internet business competition depend not on Internet software adoption but on most of the traditional sources of competitive advantage.

Third, uses of the PC and the Internet are hardly the only ways firms have had to steadily improve their use of IT in order to maintain competitive levels of quality and efficiency. Internal networks have been important in improving business operations, seemingly even more important so far than external business-to-business or business-to-buyer Internet networks (Goodwin, 1997b). The construction and use of databases of customer-specific information (Harrington, 2001) and more general corporate data management (Whittle, 2001a) are other examples. IT consultancies' wide range of services, some of which were listed in Section 3.1, point to many other IT applications steadily being improved by firms. Reaching a similar conclusion for four manufacturing industries, Klepper and Simons (1997) find that even when a dramatic reshaping of industry structure occurred, not any one sudden technical change but enormous numbers of ongoing technological changes were crucial drivers of competition.

Fourth, general-purpose technologies are often thought to have effects only after decades of delay, but among IT consultancies the PC does not seem to have caused delayed disruption. Moreover, for all industries the insights from the IT consulting trade literature provide reasons to think that both the PC and the Internet are unlikely to cause delayed disruptive impacts. As an early example, despite the enormous market capital that has been available to e-commerce start-ups, "dot.com" companies have so far largely failed to wrest markets from incumbents.

6. Conclusion

This study has analyzed the UK IT consulting industry, which mediates the application of IT throughout the economy. Disruptive technology views versus business-as-usual views pose contrasting notions regarding how the PC and the Internet may have impacted industry structure and the fates of entrepreneurial entrants. This study searched for the telltale signs of a competitive reversal due to disruptive technology, in the 1980s onward for the personal computer and in the 1990s up to 2001 for the Internet.

The findings do not match the telltale signs expected if the PC and the Internet have been disruptive technologies. Entry was not much greater following the introduction of PCs or of the Internet. More recent entrants did enter PC- and Internet-related areas of business more frequently than incumbents. However, no systematic benefit of this use of technology was apparent in firm growth and survival rates. The PC and the Internet seemingly did not have disruptive effects among IT consultancies, but rather were appropriated into firms' business activities in a business-as-usual manner.

Perhaps the future will be different, as use of the Internet continues to spread? Consistent with Evans and Wurster's (2000) argument about changing firm boundaries, steadily developing software and services may replace parts of firms' operations including activities in finance and accounting, sales, and ordering. However, incumbent firms seem as able as entrants to take advantage of such changes, and presumably firms will be unable to buy software or services to replace the key product-specific parts of their business that provide critical competencies and competitive advantage. 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 IT consulting industry's experience and the more general insights from the trade literature (Section 5) likewise both suggest that the PC and the Internet should rarely have disruptive competitive impacts.

Notes

[1] Audretsch (1991) promotes a related view in which industries have "routinized" (incumbent-dominant) or "entrepreneurial" (entrant-dominant) technological regimes.

[2] The trade literature suggests that firms consulting regarding IT tools also implement them internally where appropriate (e.g., Walcot, 1997).

[3] Years indicated are when data were compiled and published. Up to 1983 the *Year Book*'s cover date was the compilation and publication date, in 1984 the practice was adopted of putting the next year's date on the cover, and from 2000 both dates were given (cf. 2000/2001).

[4] Data on acquisitions could not be collected systematically, but a review of industry sources including the annual *Holway Industry Report* suggested that mergers and acquisitions were infrequent except among the industry's large firms. Treating acquisition as continuation would

therefore indicate that large incumbent firms performed somewhat better than is reported here, reinforcing the negative conclusions of the study.

[5] Firm sizes fell most markedly in the preceding year, from 1986 to 1987, suggesting that the change in reporting of number of consultants took place in 1987 (the *Year Book* does not elaborate). Results were checked by excluding 1986 instead of 1987, or both years, in analyses of firm growth; these changes had little effect on the estimates.

[6] Hobijn and Jovanovic (2001) date the effects of microprocessors leading to PCs as becoming apparent in stock market valuations in the early 1970s, but their logic requires that these microprocessors had their effect through the use of (personal) microcomputers, and indeed they point to waves of entry and exit that did not happen until the 1980s. Therefore the dating used here is appropriate to their arguments.

[7] The number of technology users u_t among n_t entrants in year t is assumed to be binomial with probability r_t. The local weighted likelihood function defined for each time τ is

$$L_\tau = \sum_{t=\tau-b}^{\tau+b} \left(1 - \left|\frac{t-\tau}{b}\right|^3\right)^3 \binom{n_t}{u_t} r_t^{u_t}(1-r_t)^{n_t-u_t}, \text{ where } r_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2. \tag{5}$$

The summation is across years within $\pm$b of τ, and b=8 was chosen for adequate smoothing (smaller b yields similar findings). The first term in the summation is a weight that declines as t moves away from τ, and the remainder is a binomial probability. The usage rate r_t follows a quadratic function near τ, allowing for non-monotonic trends. For each τ the likelihood function is maximized by choosing the best fitting values of α_0, α_1, and α_2, and the estimated probability of technology use among entrants at τ is $\hat{\alpha}_0 + \hat{\alpha}_1\tau + \hat{\alpha}_2\tau^2$.

[8] Interacting technology use with recent entry, in both PC- and Internet-era analyses the interaction term is always statistically insignificant. Although its sign sometimes favors recent entrants, it can be seen from columns 1, 3, 5, and 7 – and from the nonparametric analyses in Section 4.4 – that this effect is small enough not to give recent entrants an advantage.

[9] Median sizes rather than means are used because they are robust to year-to-year shifts in whether the largest firms report employment data.

[10] The survival rates plotted are Kaplan-Meier nonparametric survival estimates.

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